Complementary and Alternative Medicine (CAM) Use in United States (US) Adults with Chronic Low Back Pain (LBP):

Examining the Effectiveness of Acupuncture on US Adults with Chronic LBP

A DISSERTATION SUBMITTED TO THE FACULTY OF THE UNIVERSITY OF MINNESOTA BY

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CHAPTER 1: BACKGROUND

Patterns of Chronic Lower Back Pain (LBP) in the US

Low back pain (LBP) is a widespread problem in the US population. According to national surveys, about 80% of adults have LBP at some time in their lives, and 8% experience persistent or chronic LBP. Overall, the prevalence of back pain derived from national data has remained consistent with estimates from earlier decades. (Deyo et al., 2006) Similarly, the proportion of all physician visits attributed to back pain has remained steady since 1990. (Deyo et al., 2006) However, costs resulting from chronic LBP have risen sharply over time. (Becker et al., 2010; Williams et al., 1998) This rise in costs is in part due to a greater proportion of adults suffering from chronic LBP seeking health care, greater "per patient" utilization of back pain therapies, and an increase in the proportion of patients receiving expensive medical treatments such as back and spinal surgery and steroid injections. (Freburger et al., 2009; Deyo et al., 2006)

Chronic LBP most commonly occurs in women and men who are 40 years and older. Among race/ethnic groups, American Indians and Alaska Natives have the highest prevalence of chronic LBP, while Asian Americans have the lowest. The occurrence of chronic LBP falls with increasing levels of education and income. (Andersson et al., 1999; Deyo et al., 2006)

Consequences of Chronic LBP

Economic

The management of individuals with chronic LBP is a challenge and often involves high cost medical treatments. In the US, back pain is the second most common reason for physician visits, the third most common reason for surgical procedures, and the fifth most common reason for admission to the hospital. (Andersson et al., 1999; Dagenais et al., 2008) In 2005, the total direct costs of chronic LBP related health care utilization was estimated to be $86 billion a year, a rise of 65% from 1997. (Deyo et al., 2006) Specifically, costs for inpatient services accounted for

the largest proportion of total expenditures (31%), followed by office-based visits (26%). Prescription drugs (16%) and outpatient services (13%) were also responsible for a sizable proportion of total costs. (Luo et al., 2004) On average, health care expenditures for individuals with back pain have been estimated to be about 60% higher than those without back pain. (Luo et al., 2004) Overall, a small group of people with LBP comprise the vast majority of the total back pain health expenditures in the United States, with reports estimating that approximately 5% of the people with back pain disability account for 75% of the costs associated with LBP. (Chou et al., 2007)

Productivity

In addition to resulting in high cost medical treatments, back pain hinders everyday activities of individuals in many ways and results in enormous losses in productivity. In 2005, Ricci et al. estimated the annual loss in productivity due to back pain in the United States to be approximately $16.9 billion. (Ricci et al., 2007) Chronic LBP is also the most common cause of job-related disability, resulting in over 83 million lost days of work, and is among the most common pain conditions - second to headaches - resulting in work loss days. (Stewart et al., 2003)

Emotional

Adults with back pain report lower levels of mental and physical health than those without back pain. Also, people suffering from chronic LBP report significantly higher levels of psychological distress, including feelings of anger and depression, as compared to people who have not experienced LBP. (Chou et al., 2007)

Causes of Chronic LBP

LBP is defined as pain, muscle tension, or stiffness, which is concentrated below the costal margin, or the bottom edge of the rib cage, and above the inferior gluteal folds. (Koes et

al., 2006) The most critical symptoms of LBP are pain and disability. Although the exact cause of the LBP cannot be determined in the majority of patients, most back pain is mechanical in nature, but can result from symptoms caused by range of health conditions such as rheumatoid arthritis, infection, osteoporosis, fracture, or tumor. Back pain also can commonly be caused by trauma to spinal bones and tissues of the lower back, from events such as a car accident or lifting a heavy load. (Koes et al., 2006) Occasionally, LBP may result from pain radiating from a disorder or injury elsewhere in the body. LBP can be classified as acute (pain lasting less than four weeks), sub-acute (pain lasting four to twelve weeks), or chronic (more than twelve weeks). Some acute pain syndromes can become more serious if left untreated, and chronic back pain is often progressive, increasing pain and decreasing functionality in patients. While about 80-90% of patients with LBP recuperate within twelve weeks, recovery after twelve weeks is slow and uncertain. (Andersson et al., 1999)

Diagnosis of Chronic LBP

The diagnostic process for LBP is focused on determining the severity of pain and other symptoms in order to prioritize the individuals with the greatest need to receive immediate medical treatment. Currently, a standard classification system does not exist to designate the severity of chronic LBP. Instead, patients are usually broadly categorized based on the origin and duration of their back pain. Non-specific LBP is defined by the occurrence of symptoms without a particular cause, while specific LBP is defined as symptoms caused by a known pathophysical origin. Approximately 90% of LBP patients are diagnosed with non-specific LBP. (Koes et al., 2006) Patients are further classified based on the duration of their pain - LBP is described as acute when it continues less than four weeks, sub-acute when it persists from four to twelve weeks, and chronic when it lasts longer than twelve weeks. (Koes et al., 2006)

Among healthcare professionals, there are large variations in use of triage decisions and

diagnostic tests for LBP. (Cherkin et al., 2006; Volinn et al., 1994) Recommended guidelines for clinicians caring for LBP patients in primary care settings include conducting a focused history and physical examination to help place patients into two broad categories: nonspecific LBP and LBP potentially associated with spinal complications or nerve root issues. (Koes et al., 2006) Table 1 shows a list of identified "red flag" risk factors for increased risk of spinal pathology and indicators for nerve root problems.

Table 1. Red flag conditions indicating possible underlying spinal pathology or nerve root problems (Koes et al., 2006)

Red flags	• Onset age <20 or >55 years • Non-mechanical pain (unrelated to time or activity) • Thoracic pain • Previous history of carcinoma, steroids, HIV • Feeling unwell • Weight loss • Widespread neurological symptoms • Structural spinal deformity
Indicators for spinal pathology or nerve root problems	• Unilateral leg pain > low back pain • Radiates to foot or toes • Numbness and paraesthesia in same distribution • Straight leg raising test induces ore leg pain • Localized neurology (limited to one nerve root)

A number of diagnostic tests for chronic LBP, such as magnetic resonance and computed tomography, are available for imaging patients with LBP. However, there is debate on the usefulness of imaging for LBP. LBP abnormalities found as a result of x-ray and magnetic imaging are equally prevalent in patients with LBP and in patients without LBP. Thus, some clinical recommendations advise restricting imaging in patients with non-specific back pain, and instead recommend providing imaging exclusively for patients with red flag conditions. (Koes et al., 2006) Consensus has not yet been reached on which imaging techniques are most accurate for diagnosing LBP conditions. However, some evidence indicates that magnetic resonance imagining is the best option for detecting certain causes of back pain, including radicular

symptoms, discitis, or neoplasms, while radiography is most effective for detecting structural deformities that may be resulting in back pain. (Koes et al., 2006)

Treatments for Chronic LBP

Medical Treatment Recommendations

Though some instances of LBP resolve naturally, many cases of chronic LBP can lead to permanent complications if not properly managed. Thus, a variety of medical treatments are used to manage the consequences and progression of LBP. Over 1,000 randomized controlled trials (RCTs) have been published evaluating various types of conservative, complementary, and surgical treatments for LBP commonly implemented in primary and secondary care. Koes et al. published a study summarizing the evidence on effectiveness of treatments of acute and chronic LBP from the Cochrane Back Review Group and systematics reviews. (Koes et al., 2006) Table 2

Effectiveness	**Acute low back pain**	**Chronic low back pain**
Beneficial	Advice to stay active, non-steroidal anti-inflammatory drugs (NSAIDs)	Exercise therapy, intensive multidisciplinary treatment programs
Trade off	Muscle relaxants	Muscle relaxants
Likely to be beneficial	Spinal manipulation, behavioral therapy, multidisciplinary treatment programs (for subacute low back pain)	Analgesics, acupuncture, antidepressants, back schools, behavioral therapy, NSAIDS, spinal manipulation
Unknown	Analgesics, acupuncture, back schools, epidural steroid injections, lumbar supports, massage, multidisciplinary treatment (for acute low back pain), transcutaneous electric nerve stimulation, traction, temperature treatments, electromyographical biofeedback	Epidural steroid injections, EMG biofeedback, lumbar supports, massage, transcutaneous electric nerve stimulation, traction, local injections
Unlikely to be beneficial	Specific back exercises	-
Ineffective or harmful	Bed rest	Facet joint injections

Table 2. Treatments for acute and chronic low back pain (Koes et al., 2006)

shows a summary of recommended clinical guidelines for the treatment of LBP.

Recommended treatments for chronic LBP include cognitive brain therapy, supervised exercise therapy, brief educational interventions, multidisciplinary (biopsychosocial) treatment, and short-term use of non-steroidal anti-inflammatory (NSAIDs) drugs and weak opioids. Treatments to be considered include back schools and short courses of manipulation and mobilization, noradrenergic or noradrenergic-serotoninergic antidepressants, muscle relaxants, and capsicum plasters. Not recommended for the treatment of chronic LBP are passive treatments (i.e. ultrasound and short wave) and gabapentin. In general, invasive, surgical treatments are not recommended for the treatment of chronic non-specific back pain. (Koes et al., 2006)

Effectiveness of Medical Treatments

Strong evidence shows that exercise and intensive multidisciplinary pain treatment programs are effective strategies to manage chronic LBP. Evidence also supports the use of behavioral therapies, analgesics, antidepressants, NSAIDs, back schools, and spinal manipulation. No evidence indicates the effectiveness of treatments such as steroid injections, lumbar supports, and traction. However, for even the most effective treatments for back pain, the effects are small and maintained over a very short time period. Most commonly used chronic LBP interventions lack evidence for clinically significant long-term effects. (Koes et al., 2006)

Joint Clinical Practice Guidelines from the American College of Physicians and the American Pain Society

In 2007, the American College of Physicians (ACP) and the American Pain Society (APS) published clinical guidelines for the treatment of LBP based on a review of studies investigating the effectiveness of conventional and complementary and alternative (CAM) treatments on LBP. (Chou et al., 2007) CAM is defined by the National Center for Complementary and Integrative Health (NCCIH) as a group of diverse medical and healthcare

systems, practices, and products that are not presently considered to be a part of conventional medicine. (Tindle et al., 2005) The guidelines developed by the ACP and APS were based on systematic reviews of conventional and CAM treatments published by the Cochrane Back Group and high quality meta-analyses. Based on the strong effectiveness evidence for a number of CAM interventions, the ACP and APS recommend that in addition to referring conventional medical treatments, physicians should refer patients for CAM therapies such as acupuncture, massage therapy, spinal manipulation, and yoga. The ACP and APS's detailed treatment recommendations for lower back pain are shown in Table 3 and Table 4.

Table 3. Treatment of Low Back Pain: A Joint Clinical Practice Guideline from American College of Physicians and American Pain Society

Recommendation 1: Clinicians should provide patients with evidence-based information on low back pain with regard to their expected course, advise patients to remain active, and provide information about effective self-care options (strong recommendation, moderate-quality evidence).
Recommendation 2: For patients with low back pain, clinicians should consider the use of medication with proven benefits in conjunction with back care information and self-care. Clinicians should assess severity of baseline pain and functional deficits, potential benefits, risks, and relative lack of long-term efficacy and safety data before initiating therapy (strong recommendation, moderate-quality evidence). For most patients, first-line medication options are acetaminophen or non-steroidal anti-inflammatory drugs (NSAIDs).
Recommendation 3: For patients who do not improve with self-care options, clinicians should consider the addition of nonpharmacologic therapy with proven benefits - for acute low back pain, spinal manipulation; for chronic or subacute back pain, intensive interdisciplinary rehabilitation, exercise therapy, acupuncture, massage therapy, or progressive relaxation (moderate recommendation, moderate-quality evidence).

	Duration	< 4 Weeks	> 4 Weeks
Self-care	Advice to remain active	•	•
	Books, handout	•	•
	Application of superficial heat	•	
Pharmacologic therapy	Acetaminophen	•	•
	NSAIDs	•	•
	Skeletal muscle relaxants	•	
	Antidepressants (TCA)		•
	Benzodiazepines	•	•
	Tramadol, opioids	•	•
Nonpharmacologic therapy	Spinal manipulation	•	•
	Exercise therapy		•
	Massage		•
	Acupuncture		•
	Yoga		•
	Cognitive-behavioral therapy		•
	Progressive relaxation		•
	Intensive interdisciplinary rehabilitation		•

• Interventions supported by grade B evidence (at least fair-quality evidence of moderate benefit, or small benefit but no significant harms, costs, or burdens). No intervention was supported by grade A evidence (good-quality evidence of substantial benefit).

Table 4. American College of Physicians and American Pain Society LBP Treatment Recommendations

Complementary and Alternative Medicine (CAM) Use for Chronic LBP

Overall CAM Use in the United States

Studies have found that CAM use is increasing in the United States. From 2002 to 2007, the proportion of respondents reporting the use of at least one CAM therapy increased 14.1%, from 25.7% to 29.4% according to an analysis of the 2002 and 2007 National Health Interview Survey (NHIS). (Su et al., 2011) Recent growth in CAM use was especially pronounced in the case of provider-based CAM therapies, specifically chiropractic care, massage, and acupuncture. However, the growth in CAM use is not evenly distributed across race/ethnic groups, with non-Hispanic Whites experiencing a sharper increase in CAM use than other groups. (Su et al., 2011)

The most commonly used CAM therapies in the US include relaxation techniques, herbal therapies, and chiropractic care. Back pain, followed by neck pain, are the most common conditions for which individuals seek CAM. (Sherman et al., 2004) Characteristics associated with high CAM rates include the female gender, non-Hispanic White race/ethnicity, and an annual income of $65,000 or greater. (Tindle et al., 2005) In addition, having unmet medical needs or delayed care due to cost is strongly associated with elevated CAM use. In 2007, 38.5% of those with unmet medical needs or delayed care due to cost reported use of at least one CAM therapy, and 28.1% of those who did not report unmet medical needs or delayed cost reported CAM use. (Su et al., 2011)

CAM Use for Chronic LBP

Since many patients have found conventional medical treatments to be ineffective and unreliable for treating chronic LBP, patients are increasingly turning to CAM to find relief from their pain. Although back pain is the most common condition for which patients use CAM, few studies have investigated patterns and predictors of CAM use within the chronic LBP adult population. Only two studies, by Sherman et al. and Kanodia et al., have specifically examined CAM use among chronic LBP patients. (Kanodia et al., 2010; Sherman et al., 2004)

In the study: *Complementary and Alternative Medical Therapies for Chronic Low Back Pain: What Treatments are Patients Willing to Try?,* Sherman et al. surveyed patients at a health care organization in order to determine CAM preferences for individuals with chronic LBP. They found that among patients surveyed, knowledge of CAM was low. The therapies used by the greatest proportion of respondents included chiropractic care (54%) and massage (38%). Among patients, massage was rated the most helpful CAM modality for treating back pain. Many respondents indicated they would be "very likely" to try acupuncture, massage or chiropractic for their back pain if they did not have to pay for treatment out of pocket and their physician thought it was an appropriate treatment option. (Sherman et al., 2004)

Perceived Benefit of CAM for Chronic LBP

In a study by Kanodia et al., the 2002 National Health Interview Survey (NHIS) was used to investigate associations between the perceived helpfulness of multiple CAM therapies for back pain. The authors concluded that over sixty percent of respondents who used CAM for back pain perceived a "great deal" of benefit. The percent of individuals who perceived a "great benefit" from using the six most commonly used CAM modalities is pictured in Table 5. Among those who used these six CAM modalities for back pain, the factors independently associated with the perception of a "great deal" of benefit included those with better self-reported health status and report of CAM use because "conventional medical treatment would not help." Factors associated with less benefit from CAM for back pain included referral for CAM by a conventional practitioner and poorer health status. Overall, among all subjects who used CAM in the past year, those who perceived greater benefit from CAM for their pain were more likely to be non-Hispanic white, currently employed, and nonsmokers. (Kanodia et al., 2010)

Table 5. Perceived Benefit of 6 Most Frequently Used CAM Modalities for Back Pain (Kanodia, 2010)

Modalities*	Those with Great Benefit from CAM (Weighted %)
Chiropractic (n=1,163)	66
Massage (n=196)	56
Yoga, Tai chi, Qi Gong (n=45)	56
Acupuncture (n=89)	42
Herbal therapies (n=78)	43
Relaxation techniques (n=76)	28
*The modalities listed are not mutually exclusive	

A 2006 study by Burke et al. specifically investigated acupuncture use and its perceived effectiveness within recent users. The most common conditions cited for acupuncture use were pain/musculoskeletal complaints, with 34% of respondents naming back pain as their reason for use. The responses of most participants regarding acupuncture were positive, with 46% claiming

acupuncture helped them "a great deal" with their primary condition being treated and 26% claiming it helped their primary condition "some." Recent acupuncture users were also asked if acupuncture had been important to them in maintaining their health and well being during the previous 12 months. Again, respondent reports were generally positive regarding acupuncture, with 65% reporting acupuncture was "very" or "somewhat" important. (Burke et al., 2006)

History of Acupuncture

Acupuncture as a treatment for chronic LBP is a central topic in this dissertation. Acupuncture has been practiced in China for over 3,500 years, and is practiced as a routine treatment in China, Japan, Korea, and Taiwan. (Sierpina et al., 2005) The use of acupuncture was spread to Europe in the 17th century through doctors and missionaries, and in the early 20th century, many doctors in the UK were experimenting with acupuncture in their patients. (Cadwell et al., 1998) There was a sudden interest in acupuncture in the 1970s in the United States, which is often credited to an article published in the New York Times, describing the account of a journalist who received an emergency appendectomy in China and attributed acupuncture with postoperative pain relief. In Asian countries, acupuncture is most often used for anesthesia, while in western countries, it is mainly used for pain relief, especially for musculoskeletal pain. (Cadwell et al., 1998)

The Practice of Acupuncture

Acupuncture treatment consists of inserting fine needles into selected body locations, or acupuncture points. Classic traditional Chinese medicine (TCM) texts describe 365 points located in a systematic fashion on meridians or "channels of energy flow" that are mapped onto the surface of the body. (Sierpina et al., 2005) The movement of energy, or Qi, is considered to be the crucial element of healing according to TCM. Imbalances in Qi are believed to cause disturbances in health. Acupuncturists focus on acupuncture points, where this Qi, or energy is concentrated, to stimulate or suppress energy flow, and restore balance to the body. (Cadwell et al, 1998) A typical acupuncture session includes a physical examination and history taking. Usually, treatments last 30 to 60 minutes, with five to ten sessions per treatment regimen. During a session, needles are generally left in the body for up to 20 minutes, with patients often reporting tingling sensations or mild aches stemming from the insertion sites. (Cadwell et al., 1998)

Mechanisms Behind Acupuncture

While the TCM explanation for acupuncture is based on a relationship between channels of energy that have an effect on body systems, studies have found the process of inserting needles into acupoints to release endorphins, enkephalins, and neurotransmitters that obstruct pain impulses. (Cadwell et al, 1998) Acupuncture has also been shown to increase IgG and IgA antibodies that fight viruses and bacteria, as well as increasing the number of T lymphocytes and B cells in the body. (Cadwell et al., 1998) Researchers have also suggested that acupuncture treatment causes changes in the electromagnetic fields of the body, resulting in changes in the behavior of cells and tissues (Sierpina et al., 2005).

Efficacy of Acupuncture

A recent review examined the effectiveness of a variety of CAM modalities on neck pain and low back pain and concluded that acupuncture was no better to moderately better than no

treatment or placebo acupuncture immediately or in the short-term (<3 months) after treatment. (Furlan et al., 2012) Another recent review that investigated the efficacy of acupuncture on chronic LBP found that for patients with chronic LBP, there was strong evidence acupuncture resulted in some pain relief and functional improvement compared to groups who received sham acupuncture at short-term follow-up (<3 months). However, both reviews concluded that there was limited evidence of pain relief and functional improvement for acupuncture compared to other treatments during longer-term follow-up periods. (Furlan et al., 2005 and Furlan et al., 2012)

PROBLEM STATEMENT

The goal of this thesis was to investigate patterns of CAM use among individuals with LBP, to complete a systematic review examining the effectiveness of acupuncture on chronic LBP, and to conduct a cost-effectiveness analysis of acupuncture for patients with chronic LBP. The specific aims are as follows:

1. To investigate patterns and predictors of CAM use in US adults with LBP using 2012 NHIS data.
    a. To compare the characteristics of the US back pain population by LBP status (limiting vs. non-limiting LBP).
    b. To describe the patterns and prevalence of CAM therapies used among people with low back pain by LBP status (limiting vs. non-limiting LBP).
    c. To examine the prevalence of the LBP population who used CAM specifically to treat LBP.
    d. To examine the perceived benefit of CAM among adults who used CAM to treat LBP.
    e. To evaluate the odds of CAM use within the LBP population by patient characteristics.
2. To complete an updated systematic literature review, using the framework of the Cochrane Collaboration, in order to investigate the effectiveness of acupuncture for chronic LBP.
3. To develop a Markov model over a two year time period synthesizing the best available cost and outcome data for acupuncture in addition to usual care as a treatment for US adults with chronic LBP. The objective of this model was to examine the costs and effectiveness of acupuncture in addition to usual care as compared to usual care alone in adults with chronic LBP.

SIGNIFICANCE OF STUDY

The use of many CAM therapies in public health care systems has been recommended by the World Health Organization (WHO). For example, in a report released in 2003, *Acupuncture: Review and Analysis of Reports on Controlled Clinical Trials*, the WHO listed back pain as a condition that has shown through RCTs to be treated effectively by acupuncture. (World Health Organisation Staff, 2002) Also, studies have shown the use of acupuncture in addition to conventional medical treatment has proved to be cost-effective in certain countries, such as England, Germany, and South Korea. (Haake et al., 2007; Kim et al., 2010; Ratcliffe et al., 2006) Similarly, other CAM therapies, such as chiropractic manipulation, therapeutic massage, and yoga, have been recommended to treat chronic back pain by the American College of Physicians and the American Pain Society. (Chou et al., 2007)

Although evidence supporting the effectiveness of CAM is growing, Medicare and Medicaid do not currently cover many CAM treatments in the United States. However, as CAM has moved closer toward the mainstream of health care, insurance companies have begun to recognize the benefits some forms of CAM have to offer and have started to integrate these therapies within their plans. According to a survey released in 2004 by the Kaiser Family Foundation, employer coverage for acupuncture increased 14% - to 47% - from 2002 to 2004, making it the fastest growing CAM therapy to be included as a covered service for American workers with health insurance. In addition, survey results showed 52% of Point of Service (POS) plans covered acupuncture, 47% of Preferred Provider Organization (PPO) plans offered coverage, 44% of conventional plans included an acupuncture benefit, and 41% of Health Maintenance Organization (HMO) plans provided coverage. (Gordon et al., 1998; Lafferty et al., 2006)

Although the United States public is paying for many CAM services out of pocket, there are a few countries, such as China, Korea, and Vietnam, where health insurance fully covers CAM treatment. Also, CAM coverage is growing rapidly, with many countries integrating CAM within their national health coverage policies, such as the United Kingdom, Japan, Germany, and Australia. For example, in the UK there is a growing trend for the National Health Service (NHS) to pay for the many services of complementary providers, such as chiropractic manipulation, acupuncture, and massage. (Bodeker et al., 2002)

While the use of CAM is increasing internationally, and is growing as a treatment for LBP in the United States, it is seldom regarded as the first choice of treatment by physicians and patients. (Wootton et al., 2001) Thus, further research should be done to determine whether CAM therapies may be useful as part of a multidisciplinary approach to the management of chronic LBP.

An important purpose of this dissertation was to investigate CAM use specifically within the LBP population of the United States. While CAM use among the general population of the United States has been frequently examined, little research has investigated patterns of CAM use among those with LBP – a group that has experienced limited pain improvement when treated by conventional medical methods. (Kanodia et al., 2010) In order to better understand patterns of CAM use within the US LBP population, analysis of a nationally representative data set was completed.

Next, the use of a specific CAM therapy – acupuncture – was focused on within the chronic LBP population. Among health conditions, LBP is the most common reason for acupuncture use, and insurers in the US are increasingly including acupuncture as a covered service for back pain. (Wang et al., 2005) Numerous RCTs have evaluated the effectiveness of acupuncture of LBP, through consensus has not yet been reached. (Furlan et al., 2005) Thus, a

systematic literature review and cost-effectiveness analysis was completed using information from published RCTs in order to update recommendations on the effectiveness of acupuncture for chronic LBP in the US.

As health care costs continue to rise, it is important to allocate limited resources toward therapies that offer the most benefit. In order to be considered by healthcare policymakers in the US, the use of CAM therapies and resultant outcomes must be understood. Through the secondary data analysis, systematic literature review, and cost-effectiveness analysis that were completed for this dissertation, information on the patterns of CAM use and effectiveness of a specific CAM therapy – acupuncture – was determined, giving policymakers, health practitioners, and patients in the US additional information on CAM use in the LBP population and the effect of acupuncture on chronic LBP.

CHAPTER 2: SECONDARY DATA ANALYSIS OF 2012 NATIONAL HEALTH INTERVIEW SURVEY (NHIS)

Background

Low back pain (LBP) places a heavy burden on health care systems in the United States, costing approximately $100 billion a year in costs related to health care utilization and being the fifth most common reason for physician visits. (Deyo et al., 2006; Ricci et al., 2007; Chou et al., 2007) LBP also causes enormous losses to the country's economic efficiency, resulting in over 150 million lost workdays per year and $16 billion annually in lost productivity. (Deyo et al., 2006; Ricci et al., 2007) Back pain is one of the most common health complaints in the United States – over 80% of adults in the US will experience it at some point during their lifetime. (Hoy et al., 2012)

LBP is also a major cause of functional limitations and disability. People with back pain suffer from worse physical and mental health than people without back pain - those with LBP are three times as likely to have limited functional ability as people without, and over four times as likely to experience serious psychological distress. (NCHS Chartbook, 2006) A key goal of health care for patients with chronic back pain is to maximize the functional status of patients, so that they are able to carry out activities of daily living. (NCVHS, 2012) Accomplishing this goal may greatly increase a patient's quality of life and reduce their health care costs. Thus, because functional status is highly valued by patients, it is an essential outcome of medical care, with measures of functional status having been found to predict health care expenditures, mortality, and quality of life for patients with pain. (Stewart et al., 1989)

Many people suffering from LBP have found conventional medical treatments to be ineffective and unreliable for treating their pain. Therefore, due to the high level of patient dissatisfaction with conventional treatments for LBP, back pain patients are increasingly turning

to complementary and alternative medicine (CAM) to find relief. (Sherman et al., 2004) CAM is a group of diverse medical and health care systems, practices, and products that are not generally considered part of conventional medicine. Complementary treatments are used in conjunction with conventional medicine, while alternative interventions are used instead of conventional medicine. (NCCAM, 2014) CAM pain management is based on the belief that blending traditional treatments with a range of CAM therapies—from acupuncture to chiropractic manipulation—is the best way to personalize the optimal health management plan for each patient. (Micozzi et al., 2006) A growing body evidence supports the use of CAM for improving back pain outcomes, with back pain being the most common condition for which patients use CAM. (Kanodia et al., 2010)

Although in recent years there has been growing interest in the use of CAM for the treatment of back pain, limited work has been done to investigate CAM use in a nationally representative sample of patients with back pain. Most surveys with information on CAM use within the back pain population are limited to select populations (e.g., cancer or maternity patients) and convenience samples. (McEachrane-Gross et al., 2006; Wang et al., 2005) A study by Kanodia et al. (2010) used a nationally representative population to examine CAM use in the back pain population. However, that study used older, 2002 National Health Interview Survey (NHIS) data, and focused on the perceived benefit of CAM use for back pain. Another study by Wolsko et al. (2003) used nationally representative 1997 data, but looked at CAM use primarily within a combined back and neck pain population. (Wolsko et al., 2003) In addition, no research has scrutinized CAM use in the back pain population by functional status. As CAM use for back pain in the US continues to grow, it is important to understand CAM usage patterns in the US LBP population - especially among those whose back pain is causing functional limitations - in order to help guide future research, practice, and policy on this topic.

Primary Study Objective: The purpose of this study was to understand CAM use among adults with LBP in the US using the most current nationally representative 2012 NHIS data. Specifically the study objectives were to: a) compare characteristics of the US back pain population by low back pain status (limiting vs. non-limiting LBP), b) describe the national prevalence and patterns of CAM use in back pain patients by LBP status, c) examine the prevalence of the LBP population who used CAM specifically for back pain and their perceived benefit from using CAM, and d) to evaluate, by patients characteristics, the odds of past year CAM use within the LBP population. This analysis was important in order to provide context for the topic of CAM utilization within the low back pain population in the US and to aid in the interpretation of the final results of chapters three and four.

Methods

Data Source

Data were from the 2012 NHIS. These data were released June 2013, and are the most current nationally representative data available on complementary and alternative health practices. The NHIS is a cross-sectional nationally representative household interview survey of the health and healthcare of the resident civilian non-institutionalized US population. Throughout the year, data are collected through an in-person household survey conducted in English or Spanish by the Center for Disease Control and Prevention's National Center for Health Statistics (NCHS). Households are selected using a multistage area probability sample design with representative sampling of households and non-institutionalized groups using clustering and stratification. Multistage sampling is a method that ensures households from all regions of the United States and people from all ethnicities and economic statuses are included in the survey. The initial stage of the NHIS sampling plan is comprised of 428 primary sampling units (PSUs) drawn from approximately 1,900 geographically defined PSUs, which include all 50 states and

the District of Columbia. The survey sample design oversamples Black, Hispanic, and Asian individuals. The final sample is drawn so that it is representative of the United States population when sampling weights are used.

The data collected by the NHIS vary from year to year. Since 1997, the NHIS has consisted of a basic module with three components: the Family Core, Sample Adult Core, and Sample Child Core. In 2012, the survey included an Alternative Health Supplement. The Family Core component collects data about all family members, including information about household structure, socioeconomic characteristics, health activity limitations, and access to and use of health care services. One adult (for the Sample Adult Core) and one child (for the Sample Child Core) member of each household is randomly chosen to answer additional questions regarding basic information about demographics, health status, and health behaviors. Information for the Sample Adult Core is self-reported if the adult is physically and mentally capable of answering questions, and information for the Sample Child Core is usually gathered from an adult – most frequently a parent - who is knowledgeable about the child's health. The 2012 Alternative Health Supplement was administered to the sample adults and sample children, and collected information on the use of CAM modalities, insurance coverage, and out-of-pocket costs for visits to CAM providers, reasons for and benefits of CAM use. (2012 National Health Interview Survey, 2012)

Subjects and Sample Selection

In 2012, NHIS interviews were completed in 42,366 households, which totaled 108,131 people in 43,345 families. A total of 43,323 adults were eligible for the Sample Adult questionnaire with data collected for 34,525 adults, resulting in a response rate of 79.7%. The target population for this analysis was US adults with LBP.

The US LBP population was identified according to respondents' answer to the following question in the 2012 NHIS, in which they were asked: "During the past 3 months, did you have low back pain?" Individuals were instructed to report pain that had lasted a whole day or more instead of reporting fleeting or minor aches or pains. People who answered "yes" to this question made up the LBP population in the analysis. Respondents were told to report pain that had lasted a while day or more and to not report any minor or brief aches or pains. Furthermore, people suffering from LBP were instructed to answer if their back pain caused function limitations or did not cause functional limitations. If respondents suffered any of the following limitations due to back pain, they were to answer that their back pain caused functional limitations:

"Have at least a little difficulty walking a quarter mile; walking up 10 steps without resting; standing/being on feet for about 2 hours; sitting for about 2 hours; stooping/bending/kneeling; reaching up over head; using fingers to grasp/handle small objects; lifting/carrying 10 pounds; pushing/pulling large objects; going out for things (shopping/movies/etc.); participating in social activities; or relaxing at home (reading/sewing, etc.)"

Respondents who answered "yes" to suffering functional limitations due to their LBP constituted the "limiting LBP" group. Individuals in the LBP population who answered "no" to their back pain causing functional limitations made up the "non-limiting LBP group." Much of this analysis compares differences between the "limiting LBP" and "non-limiting LBP" groups. (2012 National Health Interview Survey, 2012)

Primary Outcome Measures

CAM Use

The 2012 NHIS supplement on complementary and alternative medicine asked about 18 specific types of CAM therapies (See Table 6). The 18 therapies were organized into four broad

categories (alternative medicine systems, biologically based therapies, manipulative body therapies, and mind-body therapies) using the CAM taxonomy developed by the National Center for Complementary and Integrative Health (NCCIH) and as classified in a 2007 NCHS report by Barnes et al. (Barnes et al., 2007) The primary outcome for this analysis was CAM use. CAM use was operationalized in three ways:

1. A dichotomous yes/no indicator of any CAM use in last 12 months. Any CAM use indicates reported use of any of the CAM therapies reported in the 2012 NHIS.
2. Type of CAM use in last 12 months by a 4 category classification of CAM use according NCCAM's taxonomy of CAM therapies: Alternative medical systems, biologically-based therapies, manipulative body therapies, and mind-body therapies,
3. Use of 18 specific types of CAM practices within the last 12 months. The supplemental survey included the following 18 complementary and alternative therapies: acupuncture, Ayurveda, biofeedback, chiropractic, guided imagery, herbal therapies, homeopathy,

Table 6. Classification of CAM Types (Johnson, Ward, Knutson, & Sendelbach, 2012)

CAM Group	NHIS question	Specific CAM Therapies
Alternative Medical Systems	Saw practitioner for…	Acupuncture, Ayurveda, Naturopathy, Traditional healers *(i.e., Curandero, Espiritista, Hierbero or Yerbera, Shaman, Native American Healer/Medicine Man, Botanica, Sobador)*
	Used…	Homeopathy
Biologically-Based Practices	Used…	Herbal Supplements
Manipulative & Body-based	Saw practitioner for…	Chiropractic or Osteopathic, Massage, Movement Therapies *(i.e., Feldenkreis, Alexander Technique, Pilates, Trager Psychophysical Integration)*
Mind-Body Medicine	Saw practitioner for…	Biofeedback, Hypnosis
	Used or practiced…	Meditation, Guided Imagery, Progressive Muscle Relaxation, Yoga, Tai Chi, Qi Gong

hypnosis, massage, meditation, movement therapies, naturopathy, progressive muscle relaxation, qi gong, tai chi, traditional healers, and yoga. (A few CAM therapies found in the NHIS were excluded from the analysis: Special diets were excluded in order to be consistent with the CAM literature, energy healing and chelation were excluded due to low prevalence in the data, and vitamins excluded due to high prevalence due to reporting of general multivitamin use.)

Treatments used for back pain and their effects on back pain

The secondary outcomes were 1) use of CAM treatment specifically for back pain and 2) the effects of CAM treatment on the patient's perceived benefit. A close look was taken at patients with back pain who used CAM therapies in the past year to inspect if people suffering from back pain were using therapies primarily for back pain, or if CAM therapies were being used for other underlying or related conditions. It was possible to examine this because for each of the 18 CAM therapies mentioned in the supplemental CAM survey, respondents were asked for their top three modalities used, a series of follow-up questions: For what health problems, symptoms, or conditions did you use [modality]? Respondents could choose more than one from a list of 88 medical conditions. Choice number 82 was "back pain or problem." If respondents selected more than 3 medical conditions, they were asked to select the 3 that were most bothersome. Thus, since information was collected from survey respondents regarding their back pain having been treated with CAM for each of the available therapies, affirmative responses for back pain were aggregated to represent a variable indicating if CAM was used to treat back pain.

Another outcome investigated in the analysis was the perceived benefits of the CAM therapy. In the NHIS, the perceived benefits were collected through a multiple choice question asked for the top three therapies used in the past year. CAM respondents were asked, "How much do you think [modality] helped [reason]?" Choices included "A great deal", "Some", "Only a

little", "Not at all", "Refused", "Not ascertained" and "Don't know". Among the back pain population who were ascertained to have used CAM for the purpose of treating their back pain, the perceived benefit of CAM use was elicited by combining responses for the level of benefit these respondents stated. Reponses of "Refused", "Not ascertained" and "Don't know" were not included in the outcome.

Covariates

Based on previous literature about CAM use and the variables available in the 2012 NHIS, variables included in the analysis were: (1) sociodemographic factors; (2) health care access; and (3) clinical factors. Sociodemographic factors examined included sex, age, race/ethnicity, nativity, marital status, poverty level, education, region, and employment. Four age groups were created: 18-29 years, 30-49 years, 50-64 years, and 65 years and older. Race/ethnicity was comprised of five groups: Non-Hispanic White, Non-Hispanic Black, American Indian/Alaska Native (AIAN), Hispanic, and Asian and nativity was defined as US-born or foreign born. Marital status was classified into three categories: married, separated/divorced/widowed, and never married, and poverty status was made up of two groups: below 100% of the Federal Poverty Level (FPL) or above 100% FPL. Educational attainment was categorized into four groups: less then high school education, high school diploma, some college, and college degree, as was regional location: Northwest, Midwest, South, and West. Employment status was categorized as employed or unemployed.

The access variable examined insurance status and was categorized as insured or uninsured. Lastly, the clinical factors examined were self-reported health: less then excellent or excellent, and back pain status: non-limiting back pain vs. limiting back pain. The analytic sample included all adults, ages 18 and older, who had back pain, and complete data for race/ethnicity, nativity, language of interview, marital status, self-reported health, insurance status and CAM use. (2012 National Health Interview Survey, 2012)

Many variables in the NHIS contained missing data. For example, all answers of (7) Refused, (8) Not ascertained, and (9) Don't know were considered missing data. Missing data for selected demographic characteristics were imputed using the hotdeck procedure in STATA. Hotdeck imputation is a method to handle missing data. Assuming data are missing at random, the hotdeck procedure involves filling in missing data on variables of interest using observed values from similar respondents with complete data. Missing data of a recipient are replaced by values from similar respondents, or "donors," after being matched on a number of specific variables. Based on the variables chosen for matching a donor and recipient, one donor is randomly selected, and data from that donor will be selected to substitute for the recipient's missing data. (Andridge et al., 2010) Education status was imputed for respondents with missing variables by matching them to a pool of respondents based on age, sex, race/ethnicity, marital status, insurance coverage, and employment status in order to assign values for education among those for whom this information was not reported. Missing data on family income, personal earnings, and employment status in the NHIS were previously imputed by NCHS analysts using multiple-imputation methodology and provided in the imputed income files found as a supplement to the NHIS data. (2012 National Health Interview Survey, 2012)

Analysis Plan

First, we examined the extent to which background characteristics differed by LBP status (people with limiting LBP vs. people without limiting LBP) using cross-tabulations and design-based F-tests. Then, we determined the prevalence of past year use of CAM therapies among US adults by LBP status, the prevalence of CAM use specifically for treating back pain, and the perceived benefit of CAM for the most commonly used CAM modalities (any CAM, massage, chiropractic manipulation, yoga/tai chi/qi gong, and acupuncture). Cross-tabulations and design-based F-tests were used to test for differences for these analyses. Lastly, we estimated four

separate multivariate logistic regression models to determine the odds of 1) any past year CAM, 2) past year massage use, 3) past year chiropractic manipulation use, and 4) past year yoga/tai chi/qi gong use by LBP status (non-limiting vs. limiting) and a number of other patient characteristics (sex, age, race/ethnicity, nativity, marital status, educational attainment, insurance coverage, employment, poverty, self-reported health, region). Adjusted odds ratios and 95% confidence intervals were calculated for each logistic model. All models were adjusted for age, race/ethnicity, sex, nativity status, self-reported health status, insurance status, and geographic region. Finally, all analyses used STATA statistical software (SE version 12) and accounted for the NHIS's complex sampling design. (Statacorp, 2013)

Results

Sample characteristics

Table 7 presents the characteristics of adults with back LBP, stratified by severity (limiting LBP vs. non-limiting LBP). Overall, 29% of the low back pain population had limiting LBP while 71% did not have limiting LBP. Differences in back pain severity was found by all demographic characteristics examined except for sex and geographic region. Adults with limiting LBP were more likely to be older, US-born, unemployed, have a lower level of education, and have lower self-reported health than those without limiting LBP.

Past year CAM use

Table 8 shows the prevalence of past year CAM use within the LBP population. Overall, 41.2% of the US LBP population reported CAM use in the past year. The individual CAM therapies that adults with LBP used most commonly included herbal therapies (21.3%), chiropractic manipulation (14.6%), massage (10.5%), and yoga/tai chi/qi gong (10.1%). Adults with limiting LBP were found to be significantly more likely to have utilized CAM in the past year as compared to adults without limiting LBP (44.5% vs. 39.9%, $P < 0.003$). Chiropractic

manipulation (17.1% vs. 13.9%, P=0.020), acupuncture (3.1% vs. 2.1%, P=0.020), and herbal therapies (25.7% vs. 19.6%, P<0.001) were significantly more likely to be used by those with limiting LBP, while movement therapies were more likely to be used by those without limiting LBP (2.0% vs. 1.1%, P=0.011).

CAM use for back pain

Table 9 presents LBP-specific therapy use and perceived benefit of CAM within the low back pain population. Adults with LBP were examined to determine the proportion of this population that used the therapies specifically for the purpose of treating back pain. Of those adults with LBP who used a CAM therapy, 26.4% used CAM for the purpose of treating their back pain. Similarly, 25.3% of adults with LBP who used acupuncture and 27.6% of the back pain patients who used massage used those therapies in order to treat their back pain. Of the patients with LBP who used chiropractic manipulation, approximately half (49.1%) of individuals used the therapy to treat their pain, while only 8.1% of the adults with LBP who used yoga, qi gong, or tai chi, used the modalities in order to treat their LBP. Also examined in Table 3 was the perceived benefit of CAM use within the LBP population who used CAM to treat their back pain. Of those with LBP who used any CAM to treat their pain, 58.1% perceived CAM to have a "great" benefit while 4.4% believed it resulted in no benefit; 68.2% of patients who used acupuncture to treat their back pain believed it resulted in a "great" benefit, while 62.6% of those who used chiropractic manipulation to treat their pain believed it was a "great" benefit for their pain. Over half of LBP patients who used massage (55.9%) or yoga/qi gong/tai chi (53%), also believed using those modalities resulted in a great benefit to their pain.

Odds of past year CAM use

Table 10 shows the adjusted odds of past year CAM use by selected characteristics. People with limiting LBP had significantly higher odds of using any CAM, acupuncture,

chiropractic manipulation, and massage in the past year as compared to those without non-limiting LBP. However, those with limiting LBP had decreased odds of using yoga/tai chi/qi gong (AOR: 0.7, 95% CI: 0.6 - 0.8) as compared to individuals experiencing non-limiting LBP. For any past year CAM use and for any past year use of the four specific CAM modalities investigated in the regression, higher levels of educational attainment, income, insurance coverage, and self-reported health were positively associated with CAM use. Other important predictors included age, race/ethnicity, and region. For all types of CAM use examined except for chiropractic manipulation, females had significantly higher odds than men of using CAM. For past year acupuncture (AOR: 2.8, 95% CI: 1.9 – 3.9) and past year yoga/qi gong/tai chi (AOR: 2.0, 95% CI: 0.9 – 3.6), the Asian race/ethnicity group had the highest odds of use as compared to non-Hispanic Whites. The Hispanic race/ethnicity group had the lowest odds of chiropractic manipulation use, and for all other types of CAM examined, non-Hispanic Blacks had the lowest odds of use. For all CAM types examined, the highest odds of use occurred in the West region, with the lowest odds of utilization occurring in the South.

Discussion

About a third of US adults with LBP suffered from back pain that resulted in functional limitations. Over 40% of the US LBP population reported using CAM in the past year. Findings showed that those with limiting back pain were more likely to use provider-based therapies, such as acupuncture, massage, and chiropractic manipulation, while therapies requiring a higher level of mobility, such as movement therapies and yoga/tai chi/qi gong were more likely to be utilized by those with non-limiting LBP. Presumably, those with functional limitations are more likely to have limited dexterity and are in more pain than those without limiting back pain, which may have contributed to their utilization of CAM therapies requiring less movement. In addition, adults with limiting LBP are more likely to have lower levels of self-efficacy and elevated levels

of pain-related fear than adults without limiting back pain, which could result in their lower use of movement-based CAM therapies.[20]

The CAM therapies most commonly used among the LBP population were consistent with previous findings by Kanodia et al. using 2002 NHIS data, and by Wolsko et al. However, compared to previous findings, the prevalence of CAM use has grown significantly. Compared to data from 1997, yoga/tai chi/qi gong for back pain has increased 8-fold, while acupuncture for back pain has more than doubled.[12,15] The increased use of acupuncture may be due to increased insurance coverage for acupuncture in the US. According to a survey released in 2004 by the Kaiser Family Foundation, employer coverage for acupuncture increased 14%, to 47%, from 2002 to 2004, making it the fastest growing CAM therapy to be included as a covered service for American workers with health insurance. The number of licensed acupuncturists has also grown in the US. In 1997, there were 9,000 licensed acupuncturists, and in 2005 there were over 22,000. Thus, this growth in acupuncturists may be allowing patients easier access to acupuncture care.[12] Similarly, the doubling of yoga/tai chi/qi gong for back pain may be due to the growth in popularity for these practices – particularly yoga – in the United States. In 1997, only 400,000 health clubs offered yoga classes, and in 2002, over 1.2 million health clubs offered yoga classes.[21] Overall, chiropractic manipulation was the most prevalent CAM therapy used within the LBP population, with utilization remaining consistent compared to past studies.[15]

Our findings indicate that the majority of respondents (58.1%) who used CAM in the past year for back pain perceived a "great deal" of benefit. This is similar to results from previous studies.[12,15] Though it was not possible to ascertain the perceived benefit of conventional medical treatments on LBP through this analysis, the high levels of perceived benefit of CAM support the need for additional investigation into the mechanisms by which CAM approaches may help relieve LBP, studying the efficacy and safety of CAM therapies in specific back pain populations

or health care settings, and continued randomized trials with higher levels of methodological rigor.[22]

Similar to general population patterns, those with lower self-reported health used CAM less than those with higher self-reported health statuses. However, those with limiting LBP had higher CAM use than those with non-limiting LBP. These findings suggest that while those with overall poorer health are not seeking CAM treatment options as widely as those who are healthier, people facing limiting back pain are turning to CAM as an option for their health management at a higher level than those with less severe LBP. For people with severe LBP, turning to CAM may seem a better alternative due to its more conservative, non-invasive nature as compared to more conventional medical treatments, such as epidural steroid injections, surgeries, and prescriptive medications - all which may carry higher risks than CAM treatments.[23] Alternatively, those with severe pain may have exhausted all other possibilities and be looking for any possibility of relief. It may be important for policymakers to consider methods of improving access to CAM for individuals with poor health because of the potential of non-invasive, low-risk CAM options to manage their health.[24]

There are several study limitations. First, responses to the CAM use questions were self-reported and limited by survey respondents' willingness and ability to report CAM use and LBP status accurately. Since CAM use and LBP status were based on self-report, there was a potential for recall bias, which may have resulted in an underestimation or overestimation of CAM use and limiting LBP status. Additionally, because the recall periods differed for these two key variables, there may be some people for whom CAM use occurred before the reported LBP experience. However, we did look at CAM users to identify and distinguish those who used CAM specifically for their LBP. Moreover, the question on functional limitations combined limitations due to back or neck pain. It is possible that some proportion of our population was limited due to neck pain rather than back pain. Second, the outcome of perceived benefit of CAM for back pain was

subjective. It is possible that those who answered these questions were those who responded most favorably to CAM treatment. Third, the NHIS alternative health supplement is only collected every five years, and a single year of NHIS data restricts the sample sizes for some subgroup analyses. For example, we were unable to include individual Asian race/ethnicity subgroups in our analysis due to small sample sizes and instead had to create an aggregate Asian group. Lastly, the NHIS did not include information on different types of LBP (subacute, acute, and chronic), and instead our analysis focused on differences of CAM use by limiting LBP versus non-limiting LBP groups.

A major strength of this study was that it used a large, nationally representative survey of the US adult population with LBP, which included a comprehensive list of CAM therapies. By examining CAM usage in a nationally representative sample, findings will be helpful in facilitating future practice, policy, and research recommendations involving CAM for treating LBP in the United States. Our results indicate it may be useful for policymakers to develop strategies to improve access to CAM services for the LBP population, especially for those with poor health and/or limiting back pain. Also, due to the high perceived benefit of using CAM for back pain, it may be beneficial for health care professionals to be aware of the potential CAM types their patients may be using and be able to educate LBP patients about the CAM services that could be used to help manage their pain. In addition, future research should examine other validated self-reported outcomes within this population, such as back pain intensity, disability, and mobility, in order to determine how CAM therapies may be useful as part of a complementary and integrative healthcare approach to the management of LBP.

Conclusion

The results are indicative of CAM therapies becoming an increasingly important component of care for people with LBP. A large proportion of the population - over 40% - used a form of CAM in the past year, with higher use reported among those with limiting LBP. Among the most popular therapies used in the LBP population included herbal therapies, chiropractic manipulation, and massage. Differences in specific therapies used were found by LBP status – patients with limiting pain were more likely to use herbal therapies, acupuncture, and chiropractic manipulation, and patients with non-limiting pain were more likely to use movement therapies. Also, results showed that the majority of the LBP population used CAM specifically to treat back pain, and that most respondents who used CAM for their back pain perceived a great deal of benefit. Thus, CAM use appears to be an important and growing part of health care for the back pain population, and these results support the need for future studies within this population. Additional understanding of patterns of CAM use among the LBP population will help health professionals of back pain patients make more informed care decisions, will help policymakers to create frameworks for future policy implementation, and guide investigators in development of future back pain related CAM research.

Table 7. Selected characteristics (weighted %), LBP population, adults 18+, NHIS 2012

	Without Limiting Back Pain	With Limiting Back Pain	Total Back Pain	p-value
DEMOGRAPHICS				
Sex				
Male	44.6%	43.3%	44.2%	0.382
Female	55.4%	56.7%	55.8%	
Age Group				
18-29 years	19.2%	9.2%	16.4%	<0.001
30-49 years	36.1%	31.4%	34.8%	
50-64 years	27.2%	35.2%	29.4%	
65+ years	17.4%	24.2%	19.3%	
Race/ethnicity group				
Non-Hispanic White	70.4%	75.2%	71.8%	<0.001
Non-Hispanic Black	10.4%	10.3%	10.4%	
AIAN	1.1%	1.0%	1.0%	
Hispanic	14.2%	10.4%	13.1%	
Asian	3.9%	3.1%	3.6%	
Nativity status				
Foreign-born	15.8%	11.3%	14.6%	<0.001
US-born	84.2%	88.7%	85.4%	
Marital Status				
Married	53.5%	53.2%	53.4%	<0.001
Separated, Divorced, Widowed	22.1%	30.0%	24.3%	
Never Married	24.4%	16.8%	22.3%	
Educational Attainment				
Less than a H.S.	15.1%	18.7%	16.1%	<0.001
High School Diploma	27.2%	30.0%	28.0%	
Some College	21.2%	20.3%	21.0%	
College Degree	36.5%	31.1%	35.0%	
Insurance coverage				
Uninsured	17.0%	14.2%	16.2%	0.006
Insured	83.0%	85.8%	83.8%	
Employment Status				
Unemployed	42.0%	61.2%	47.4%	<0.001
Employed	58.0%	38.8%	52.6%	
Poverty Status				
Below 100% FPL	16.0%	19.2%	16.9%	0.002
Above 100% FPL	84.0%	80.9%	83.2%	
Self-reported health				
Less than excellent	80.7%	91.8%	83.8%	<0.001
Excellent	19.3%	8.2%	16.2%	
Census Region				
1 South	36.2%	38.8%	36.9%	0.232
2 Midwest	22.9%	22.6%	22.8%	
3 Northeast	17.9%	15.8%	17.3%	
4 West	23.1%	22.8%	23.0%	
SAMPLE SIZE				
Unweighted population	**6,835**	**2,830**	**9,665**	
Weighted population	**45,436,458**	**17,632,462**	**63,068,920**	

Note: Demographic data from NHIS Person file and Sample Adult file 2012

Table 8. Prevalence of complementary therapy use within the past 12 months, LBP population, adults 18+, 2012 NHIS

	Without Limiting Low Back Pain	With Limiting Low Back Pain	Total Low Back Pain	p-value
Any complementary therapy	39.9%	44.5%	41.2%	0.003
Alternative medical systems	3.5%	4.6%	3.8%	0.026
Acupuncture	2.1%	3.1%	2.4%	0.020
Ayurveda	0.1%	0.2%	0.1%	0.507
Naturopathy	0.7%	0.6%	0.7%	0.805
Homeopathy	0.5%	0.6%	0.5%	0.847
Traditional healers	0.8%		0.7%	0.487
Biologically based therapy	19.6%	25.7%	21.4%	<0.001
Herbal therapies	19.6%	25.7%	21.3%	<0.001
Manipulation-based therapy	21.2%	22.9%	21.7%	0.141
Chiropractic	13.9%	17.1%	14.6%	0.020
Massage	10.1%	11.9%	10.5%	0.125
Movement therapies	2.0%	1.1%	1.7%	0.011
Mind-body therapy	14.8%	15.1%	14.9%	0.782
Meditation	5.1%	24.4%	5.7%	<0.001
Guided imagery	2.4%	22.2%	2.5%	0.568
Progressive muscle relaxation	3.1%	29.0%	3.2%	0.395
Yoga	10.6%	9.0%	10.1%	0.062
Tai chi	1.7%	1.6%	1.6%	0.760
Qi gong	0.5%	0.5%	0.5%	0.923
Biofeedback	0.2%	0.4%	0.3%	0.342
Hypnosis	0.2%	0.3%	0.2%	0.539
Unweighted sample	**6,835**	**2,830**	**9,665**	
Weighted population estimate	**45,436,458**	**17,632,462**	**63,068,920**	

Note: Data from NHIS Sample Adult, Alternative Health Supplement file 2012

Table 9. Back pain-specific therapy use among respondents with LBP who used complementary therapies for specific conditions in the past 12 months, adults 18+, NHIS 2012

	Any CAM n = 3,892		Acupuncture n = 261		Chiropractic Manipulation n = 1,363		Massage n = 1,017		Yoga/Qi gong/Tai chi n = 905	
	Mean	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
% Used for back pain	21.1%	8.7%	19.5%	0.5%	40.7%	6.0%	22.2%	2.3%	8.1%	0.7%

	Any CAM n =796		Acupuncture n = 57		Chiropractic Manipulation n = 554		Massage n = 220		Yoga/Qi gong/Tai chi n = 62	
Perceived Benefit (of those who used CAM for back pain)										
Great	58.1%	2.2%	64.6%	7.5%	62.0%	2.5%	54.7%	4.0%	53.2%	8.3%
Some	29.1%	2.1%	16.4%	5.6%	27.2%	2.4%	30.8%	3.9%	36.8%	7.8%
Only a little	8.0%	1.1%	11.8%	4.4%	6.1%	1.2%	9.4%	2.3%	8.1%	4.3%
Not at all	4.8%	0.9%	7.2%	3.3%	4.8%	1.1%	5.2%	1.7%	1.9%	1.9%

Note: Data from NHIS Sample Adult, Alternative Health Supplement file 2012

Table 10. Adjusted odds of CAM use by selected characteristics, adults 18+, NHIS 2012

	Any CAM N = 3,892			Acupuncture N = 261			Chiropractic Manipulation N = 1,363			
	Adjusted OR	95% CI	P-value	Adjusted OR	95% CI	P-value	Adjusted OR	95% CI		P-value
BACK PAIN STATUS										
Non-limiting back pain	1.0			1.0			1.0			
Limiting back pain	1.1	(1.0, 1.2)	0.005	1.4	(1.1, 1.9)	0.005	1.2	(0.1, 2.3)	2.3	0.021
DEMOGRAPHICS										
Sex										
Male	1.0			1.0			1.0			
Female	1.2	(1.1, 1.3)	<0.001	1.5	(1.1, 1.9)	0.005	1.0	0.9	1.1	0.932
Age Group										
18-29 years	1.3	(1.2, 1.5)	<0.001	0.7	(0.4, 1.1)	0.107	1.1	0.9	1.3	0.406
30-49 years	1.5	(1.3, 1.7)	<0.001	1.4	(1.0, 1.9)	0.066	1.4	1.2	1.7	<0.001
50-64 years	1.3	(1.1, 1.4)	<0.001	1.0	(0.7, 1.4)	0.950	1.2	1.0	1.4	0.038
65+ years	1.0			1.0			1.0			
Race/ethnicity group										
Non-Hispanic White	1.0			1.0			1.0			
Non-Hispanic Black	0.4	(0.3, 0.5)	<0.001	0.5	(0.3, 0.8)	0.006	0.3	0.2	0.4	<0.001
AIAN	0.9	(0.6, 1.2)	0.432	1.5	(0.6, 3.6)	0.415	1.0	0.6	1.6	0.964
Hispanic	0.5	(0.5, 0.6)	<0.001	1.2	(0.9, 1.7)	0.251	0.5	0.4	0.6	<0.001
Asian	1.3	(0.7, 2.1)	0.456	2.8	(1.9, 5.9)	0.009	0.5	0.1	1.1	0.054
Nativity status										
Foreign-born	1.0			1.0			1.0			
US-born	1.3	(1.2, 1.5)	<0.001	0.6	(0.5, 0.8)	0.001	1.5	1.3	1.8	<0.001
Marital Status										
Married	1.0			1.0			1.0			
Separated, Divorced, Widowed	0.8	(0.7, 0.9)	<0.001	0.8	(0.6, 1.1)	0.260	0.8	0.7	0.9	<0.001
Never Married	0.9	(0.8, 1.0)	0.078	1.1	(0.8, 1.4)	0.749	0.7	0.6	0.9	<0.001
Educational Attainment										
Less than a H.S. Diploma	1.0			1.0			1.0			
High School Diploma	1.6	(1.4, 1.8)	<0.001	1.5	(0.9, 2.5)	0.117	1.8	1.5	2.3	<0.001
Some College	2.7	(2.4, 3.2)	<0.001	2.0	(1.2, 3.3)	0.007	2.4	1.9	3.0	<0.001
College Degree	4.4	(3.8, 5.0)	<0.001	3.5	(2.3, 5.5)	<0.001	3.2	2.7	4.0	<0.001
Insurance coverage										
Uninsured	1.0			1.0			1.0			
Insured	1.3	(1.1, 1.4)	<0.001	1.2	(0.8, 1.8)	0.222	1.5	1.2	1.7	<0.001
Employment Status										
Unemployed	1.0			1.0			1.0			
Employed	1.7	(1.5, 1.8)	<0.001	1.4	(1.1, 1.8)	0.007	1.9	1.7	2.2	<0.001
Poverty Status										
Below 100% FPL	1.0			1.0			1.0			
Above 100% FPL	2.1	(1.9, 2.3)	<0.001	1.8	(1.2, 2.5)	0.002	2.5	2.1	3.0	<0.001
Self-reported health										
Less than excellent	1.0			1.0			1.0			
Excellent	1.6	(1.4, 1.8)	<0.001	1.5	(1.1, 2.1)	0.006	1.5	1.3	1.8	<0.001
Census Region										
1 South	1.0			1.0			1.0			
2 Midwest	1.8	(1.6, 2.0)	<0.001	1.9	(1.2, 2.9)	0.003	2.1	1.8	2.5	<0.001
3 Northeast	1.4	(1.2, 1.6)	<0.001	2.6	(1.7, 3.9)	<0.001	1.3	1.1	1.5	0.009
4 West	2.3	(2.1, 2.6)	<0.001	4.4	(3.1, 6.3)	<0.001	1.7	1.5	2.0	<0.001

Note: Demographic data from NHIS Person file and Sample Adult file 2012

Table 10 (continued). Adjusted odds of CAM use by selected characteristics, adults 18+, NHIS 2012

	Massage, N = 1,017			Yoga/Qi gong/Tai Chi, N = 993		
	Adjusted OR	95% CI	P-value	Adjusted OR	95% CI	P-value
BACK PAIN STATUS						
Non-limiting back pain	1.0			1.0		
Limiting back pain	1.3	(1.1, 1.5)	<0.001	0.7	(0.6, 0.9)	<0.001
DEMOGRAPHICS						
Sex						
Male	1.0			1.0		
Female	1.5	(1.3, 1.7)	<0.001	2.1	(1.8, 2.4)	<0.001
Age Group						
18-29 years	1.5	(1.2, 1.9)	0.001	4.4	(3.4, 5.6)	<0.001
30-49 years	2.2	(1.8, 2.7)	<0.001	3.4	(2.7, 4.2)	<0.001
50-64 years	1.6	(1.3, 2.0)	<0.001	1.7	(1.4, 2.2)	<0.001
65+ years	1.0			1.0		
Race/ethnicity group						
Non-Hispanic White	1.0			1.0		
Non-Hispanic Black	0.6	(0.5, 0.7)	<0.001	0.5	(0.4, 0.7)	<0.001
AIAN	1.2	(0.7, 2.0)	0.472	0.7	(0.4, 1.3)	0.266
Hispanic	0.8	(0.6, 0.9)	0.010	0.6	(0.5, 0.8)	<0.001
Asian	1.0	(0.6, 2.3)	0.843	2.0	(0.9, 3.6)	<0.001
Nativity status						
Foreign-born	1.0			1.0		
US-born	1.0	(0.8, 1.1)	0.632	1.1	(1.0, 1.4)	0.151
Marital Status						
Married	1.0			1.0		
Separated, Divorced, Widowed	0.8	(0.7, 0.9)	<0.001	0.8	(0.7, 1.0)	0.011
Never Married	1.1	(0.9, 1.3)	0.360	1.7	(1.4, 1.9)	<0.001
Educational Attainment						
Less than a H.S. Diploma	1.0			1.0		
High School Diploma	1.8	(1.3, 2.4)	<0.001	1.8	(1.2, 2.5)	0.002
Some College	3.7	(2.8, 5.0)	<0.001	4.6	(3.3, 6.3)	<0.001
College Degree	6.1	(4.6, 7.9)	<0.001	9.2	(6.8, 12.5)	<0.001
Insurance coverage						
Uninsured	1.0			1.0		
Insured	1.4	(1.1, 1.7)	0.001	1.0	(0.8, 1.2)	0.979
Employment Status						
Unemployed	1.0			1.0		
Employed	2.1	(1.9, 2.5)	<0.001	2.1	(1.8, 2.4)	<0.001
Poverty Status						
Below 100% FPL	1.0			1.0		
Above 100% FPL	2.4	(2.0, 2.9)	<0.001	1.7	(1.4, 2.1)	<0.001
Self-reported health						
Less than excellent	1.0			1.0		
Excellent	1.7	(1.4, 2.0)	<0.001	2.2	(1.9, 2.6)	<0.001
Census Region						
1 South	1.0			1.0		
2 Midwest	1.4	(1.1, 1.7)	0.001	1.3	(1.1, 1.6)	0.638
3 Northeast	1.3	(1.1, 1.6)	0.008	1.5	(1.1, 1.8)	<0.001
4 West	1.9	(1.6, 2.3)	<0.001	2.0	(1.7, 2.4)	0.003

Note: Demographic data from NHIS Person file and Sample Adult file 2012

CHAPTER 3: SYSTEMATIC LITERATURE REVIEW EXAMINING THE EFFECTIVENESS OF ACUPUNCTURE ON CHRONIC LBP

Background

Back pain places an enormous burden on society and health care systems in the US. Back pain results in approximately $90 billion a year in costs related to health care utilization, and over $16 billion annually in lost productivity. (Deyo et al., 2006; Ricci et al., 2007) Chronic low back pain (LBP), or pain in the lower back that is present for at least three months, is especially burdensome since it is often progressive, can lead to complications, and recovery is challenging and uncertain. (Simpson et al., 2006) Since many patients have found conventional medical treatments to be ineffective and unreliable for treating chronic LBP, patients are increasingly turning to complementary and alternative medicine (CAM) to find relief from their pain. (Sherman et al., 2004) Chronic LBP is the most common medical condition for which patients use CAM, and acupuncture is among the most commonly used CAM modalities to treat chronic LBP. (Kanodia et al., 2010; Brinkhaus et al., 2006)

A number of studies have examined the effectiveness of acupuncture on chronic LBP. These studies have been reviewed most comprehensively by Furlan et al. in 2012 and by Furlan et al. in 2005. The 2012 review by Furlan et al. investigated the efficacy of a variety of CAM therapies on neck pain and chronic LBP and concluded that acupuncture was no better to moderately better than no treatment or placebo acupuncture immediately or in the short-term (<3 months) after treatment. (Furlan et al., 2012) They found limited evidence that acupuncture was more effective than no treatment at longer-term follow-ups. However, this review focused on adults with both neck and LBP and only included a subset of the published studies examining the effectiveness of acupuncture in adults with chronic LBP.

The 2005 systematic review by Furlan et al. examined 35 studies, published from January 1980 to February 2003. (Furlan et al., 2005) The authors of this study concluded that for adults

with chronic LBP, there was strong strength of evidence that acupuncture resulted in some pain relief and functional improvement immediately at the end of treatment and at short-term follow-up (<3 months) compared to groups who received sham acupuncture and moderate strength of evidence that acupuncture was more effective than no treatment at short-term follow-up. The review also concluded that there was limited evidence of pain relief and functional improvement for acupuncture compared to other treatments during follow-up periods greater than three months due to lack of statistically significant results, and reliance on low-quality studies with small sample sizes. (Furlan et al., 2005) However, results from this review relied on low-quality studies and were difficult to interpret.

The purpose of this chapter was to update the evidence on the effectiveness of acupuncture for nonspecific chronic LBP according to the Cochrane Collaboration's framework for completing systematic literature reviews by adding information from RCTs published from March 2003 – February 2014. This was completed in order to provide a comprehensive summary of the most current, best available evidence about the effectiveness of acupuncture on reducing pain intensity for the treatment of nonspecific chronic LBP in adults. Also, the results from this systematic review were used to inform the cost-effectiveness analysis completed in chapter four investigating acupuncture as a treatment strategy for adults with chronic LBP.

For this review, the following research questions were examined:

1. Is acupuncture more effective in reducing pain in patients with chronic LBP than no treatment or sham treatment?
2. Is acupuncture added to another intervention more effective in reducing pain in patients with chronic LBP compared to the intervention without acupuncture?
3. Is acupuncture added to another intervention more effective in reducing pain in patients with chronic LBP compared to the intervention + sham treatment?

4. Is acupuncture more effective in reducing pain in patients with chronic LBP than another active intervention?
5. Is individualized acupuncture more effective in reducing pain in patients with chronic LBP compared to standardized acupuncture?

To further refine our study questions, we determined population, intervention, comparator, and outcomes measure details, summarized in Table 11.

Table 11. RCTs Included in Literature Review

Population: Adults 18 years and older with nonspecific chronic LBP.

Interventions: RCTs investigating the effectiveness of acupuncture.

> **Definition of acupuncture**: A healing technique that involves the insertion of needles into the body to promote health. It can be traced back at least 1500 years as part of the healing system in China. "Acupuncture" means the "stimulation of points and channels" and traditional acupuncture theories describe the locations of points for a given patient concern. Needles are inserted into traditional meridian points, usually with the intention of influencing energy flow in the meridian. (Ezzo et al., 2000; Manheimer et al., 2005; Kim et al., 2013)

Controls/Comparators: No treatment, sham acupuncture, and other therapeutic treatments.

> **Definition of sham acupuncture:** An intervention intended to make patients believe they are receiving acupuncture. Usually this involves inserting needles superficially and/or at inappropriate sites, but not stimulating them, which is known as "penetrating sham." Blunt devices are occasionally used to apply pressure without penetration. (Manheimer et al., 2005)

Outcome Measures: The primary outcome examined was pain intensity. Adverse events were also examined.

Methods

The methods for updating the previous systematic literature review were guided by the Cochrane Collaboration's and Agency for Healthcare Research and Quality's (AHRQ) well-established guidance for completing systematic literature reviews. (Furlan et al., 2009)

Search Algorithms

The Furlan et al. 2005 review included literature published from January 1966 to February 2003. We updated their search by examining RCTs published from March 2003 to February 2014. RCTs in English were searched in MEDLINE, EMBASE, and the CBRG's Trials Registry. Medical Subject Heading (MeSH) words capturing acupuncture/electroacupuncture, low back pain/back pain/lumbar vertebrae, lumbosacral region, sprains and strain and randomized controlled trials/controlled clinical trials were used. Complete search strategies used for each database are shown in Appendix 1.

Inclusion/Exclusion Criteria

Population

Studies that enrolled adults 18 years or older with nonspecific chronic LBP were included. Studies examining patients with chronic LBP caused by specific causes such as infection, osteoporosis, fracture, or rheumatoid arthritis were excluded from the review, as well as those studies that included patients with pregnancy and postpartum-related back pain.

Interventions

Acupuncture treatment originating from all sources of stimulation (e.g., hand or electric stimulation) were included. Studies in which treatment did not involve acupuncture needling were excluded (e.g., acupressure or laser acupuncture).

Controls/Comparators

Studies were not excluded based on the chosen controls or comparators.

Outcome Measures

Studies must have collected information on pain intensity (e.g., visual analogue scale [VAS], Von Korff Pain Grade Scale). The primary outcome for this review was pain intensity, although adverse events were also examined.

Other Criteria

All included studies were required to be RCTs, written in English, and published from March 2003 to February 2014. Most academic journals ask for a bridge search of 3 to 6 months or less from the time of submission. If this chapter is submitted to a journal for publication, a bridge search will be completed.

Search Process

A reference librarian completed the screening process and generated a list of potential studies by querying electronic databases. Citations were downloaded into EndNote X7 and duplicate studies were identified by manually searching the reference list and removed from the final list of studies.

Study Identification

Next, two reviewers independently reviewed the titles and abstracts resulting from the electronic database search in addition to the studies included in the 2005 Furlan review to identify trials that met our specific inclusion criteria. The selection criteria were independently applied to each study. Reasons for exclusion were coded at the full text stage for each article. Consensus was used to solve disagreements concerning the final inclusion of RCTs, and a third reviewer was consulted if disagreements persisted. Full text articles were obtained for trials that made it through the first phase of study identification.

Data Extraction

Two reviewers independently abstracted data onto a standardized spreadsheet. A third reviewer was consulted in case of disagreements over abstraction details. The reviewers extracted characteristics of included studies including participants, setting, interventions, and outcomes.

Rating Risk of Bias – Study Level

We assessed the risk of bias (ROB) of each study using criteria recommended in the article: *2009 Updated Method Guidelines for Systematic Reviews in the Cochrane Back Review Group* (Furlan et al., 2009) The previous Furlan review used guidelines from the CBRG's 2002 recommendations for systematic reviews. (Van Tulder et al., 2003) We used the CBRG's updated 2009 guidelines, in which a twelfth ROB criterion was added. The additional guideline specified that "all randomized participants should be analyzed in the group to which they were allocated." (Furlan et al., 2009)

The CBRG's ROB criteria are shown in Table 12. More detailed descriptions of these criteria can be found in Appendix 2. Each item was scored as "yes," "no," or "don't know" based on the CBRG's definitions. The purpose of rating the methodological quality of the RCTs was to exclude studies with fatal flaws (such as drop-out rates exceeding 50%), and to classify the studies that passed the screening for fatal flaws as lower, medium, or higher quality. According to the CBRG, studies had a low risk of bias if nine or more of the criteria were met and no fatal flaws existed, a medium risk of bias if five to eight criteria were met and no fatal flaws existed, and a high risk of bias if four or less of the criteria were met or a fatal flaw existed. (Furlan et al., 2009)

Table 12. Operationalization of Criteria (Criteria for a Judgment of "Yes" for the Sources of Risk of Bias) (Furlan et al., 2009)	
	Sources of Risk of Bias
A	Was the method of randomization adequate?
B	Was the treatment allocation concealed?
C	Was the patient blinded to the intervention?
D	Was the care provider blinded to the intervention?
E	Was the outcome assessor blinded to the intervention?
F	Was the drop-out rate described and acceptable?
G	Were all randomized participants analyzed in the group to which they were allocated?
H	Were the groups similar at baseline regarding the most important prognostic indicators?
I	Were co-interventions avoided or similar?
J	Was the compliance acceptable in all groups?
K	Was the timing of the outcome assessment similar in all groups?
L	Are reports of the study free of suggestion of selective outcome reporting?

Analysis

The primary purpose of this systematic review was to investigate the effectiveness of acupuncture on the outcome of pain intensity, as compared to alternative treatments, The meta-analysis of pain was based on a pain intensity scale of 0 to 10, with 0 representing no pain and 10 representing the highest possible level of pain intensity. The mean and standard deviation was reported for each outcome. All results were continuous and measures were analyzed with weighted mean differences (WMD). We chose 20% as the minimally clinical important difference (MCID) for back pain intensity between treatment groups, according to recommendations from the CBRG. (Furlan et al., 2009) According to guidelines from the CBRG, the degree of clinical importance for observed differences in pain scores between treatment groups is: small (weighted mean difference [WMD] < 10% of the pain scale), medium (10% ≤ WMD < 20% pain scale), and large (WMD ≥ 20% of the pain scale). (Furlan et al., 2009; Furlan et al., 2012) Thus, we chose a WMD of 20% as the MCID between treatment groups. The inverse variance statistical method and random-effects model analysis was used to account for the expected heterogeneity of studies and to calculate pooled estimates of WMDs with 95% confidence intervals (95% CIs). Chi-squared tests, and the I^2 statistic (low: 25%, moderate: 50%,

high: 75.0%) where we were able to pool, were used to determine statistical heterogeneity. If an insufficient number of studies were in an analytic group and pooling was not possible, a qualitative analysis was done.

We analyzed RCT results grouped by study treatment arms (e.g., acupuncture, no treatment, sham acupuncture) and by follow-up time points (immediately post-treatment [<1 week], short-term follow-up [1 week to <3 months], intermediate follow-up [3 months to <9 months], and long-term follow-up [>9 months]). We determined the timing of measuring outcomes according to CBRG recommendations. (Furlan et al., 2009)

The primary analyses included:

a. Acupuncture versus no treatment
b. Acupuncture versus sham acupuncture
c. Acupuncture in conjunction with another intervention versus the intervention without acupuncture (e.g. physiotherapy, orthopedic therapy, inpatient rehabilitation program)
d. Acupuncture in conjunction with another intervention versus sham acupuncture + another intervention (e.g. physiotherapy, orthopedic therapy)
e. Acupuncture versus another intervention
    a. Acupuncture versus practitioner-based treatment (e.g. conventional therapy [drugs, physical therapy, and exercise], massage)
    b. Acupuncture versus self-care treatment (e.g. group exercise program, self-care education)
    c. Acupuncture versus invasive treatment (e.g. dibucaine hydrochloride trigger point injections, transcutaneous electrical nerve stimulation [TENS]
f. Individualized acupuncture versus standardized acupuncture

Analytic groups were formed based on treatment groups and timing of follow-up points. Details on analytic groups are listed in Table 13. We used Revman 5.3 software for data analysis.

(Review Manager Version 5.3. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014) Though our primary outcome of interest was pain intensity, we also examined harms by the treatment arms of each study.

Table 13. RCTs to be Grouped According to the Listed Criteria

1. Treatments
    a. Acupuncture versus no treatment
    b. Acupuncture versus sham acupuncture treatment
    c. Acupuncture + intervention versus intervention
    d. Acupuncture + sham acupuncture versus other intervention + sham acupuncture
    e. Acupuncture versus other intervention
        i. Acupuncture versus practitioner-based treatment
        ii. Acupuncture versus self-care treatment
        iii. Acupuncture versus invasive treatment
    f. Individualized acupuncture versus standardized acupuncture
2. Outcome measure
    a. Pain intensity (0-10 scale)
3. Timing of follow-up
    a. Immediately after the end of treatment – up to 1 week after the end of treatment
    b. Short-term follow-up – between 1 week and 3 months after the end of treatment
    c. Immediate-term follow-up – between 3 months and 9 months after the end of treatment
    d. Long-term follow-up – 9 months or longer after the end of treatment

Strength of Evidence

We rated the strength of evidence based on the CBRG's adaptation of the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach for back and neck pain reviews. (Furlan et al., 2009) Four domains were examined, including limitations of study design, consistency, directness, and precision. Publication bias was not examined due to an insufficient number of studies.

"Consistency" refers to the similarity of treatment effects for pain intensity across the trials. Evidence was graded as consistent when the effect, direction, and statistical significance across studies were similar. Consistency in effect size was determined when 75% of more of

studies showed a clinically important effect and consistency in direction was determined when at least 75% or more of the studies showed either a benefit or no benefit. Consistency was also evaluated using statistical measures such as the chi-squared test for heterogeneity and the I^2 statistic (low: 25%, moderate: 50%, high: 75.0%). A single study in an analysis was classified as unknown consistency.

"Directness" indicates the extent to which the patients, treatments, and outcomes in the included studies are comparable to those defined in our inclusion criteria. For example, questions about generalizability could arise if the majority of the subjects in our study consisted of a specific population (which would cause our results to be applicable to that population), or if results were based on indirect comparisons, such as if there was at least one intermediate step from study outcome to our final outcome of interest. However, our review was designed such that indirect studies were explicitly excluded.

"Precision" was determined by examining the number of study subjects, events and the width of confidence intervals. Data were considered imprecise if the confidence intervals around estimates were sufficiently wide to include different treatment conclusions. We interpreted the precision of the treatment effect by comparing our confidence intervals in relation to our chosen MCID value of 20% for back pain intensity. If the confidence interval for a treatment exceeded the MCID, we were more likely to suggest the treatment effect was precise. (Cook et al., 1995) The CBRG recommends that data should be classified as imprecise when only one study reported an outcome, regardless of sample size.

Consistent with EPC policy, two reviewers independently evaluated the limitations of study design, consistency, directness, precision, and overall strength of evidence for each outcome. All differences between reviewers were then reconciled through discussion with a third reviewer. Descriptions of the GRADE domains are provided in Appendix 3. Table 14 shows

strength of evidence grades and definitions as classified by the AHRQ and the GRADE Working Group. (Furlan et al., 2009)

Table 14. Strength of evidence grades and definitions (Furlan et al., 2009)	
Grade	**Definition**
High	High confidence that the evidence reflects the true effect. Further research is very unlikely to change our confidence in the estimate of effect. (At least 75% of the RCTs with no limitations of study design had consistent findings, direct and precise data, and no known or suspected publication biases.)
Medium	Moderate confidence that the evidence reflects the true effect. Further research may change our confidence in the estimate of effect and may change the estimate. (1 of the GRADE domains were not met.)
Low	Low confidence that the evidence reflects the true effect. Further research is likely to change our confidence in the estimate of effect and is likely to change the estimate. (2 of the GRADE domains were not met).
Insufficient No evidence	Evidence either is unavailable or does not permit estimation of an effect. (3 of the GRADE domains were not met.) No RCTS were identified that addressed this outcome.

Results

Study Characteristics

Our study investigated a total of 18 RCTs and 3,669 patients. All included RCTs had similar populations (pain location [low-back], duration of pain [chronic], and cause of pain [non-specific]) due to the specific inclusion criteria restrictions we placed in our search. There was some variability in the patient demographics. However, all participants were 18 years and older, and most trials had study populations with an average age of 40 years or older and were comprised of over 50% women. The final studies included in the systematic review are depicted in Figure 1.

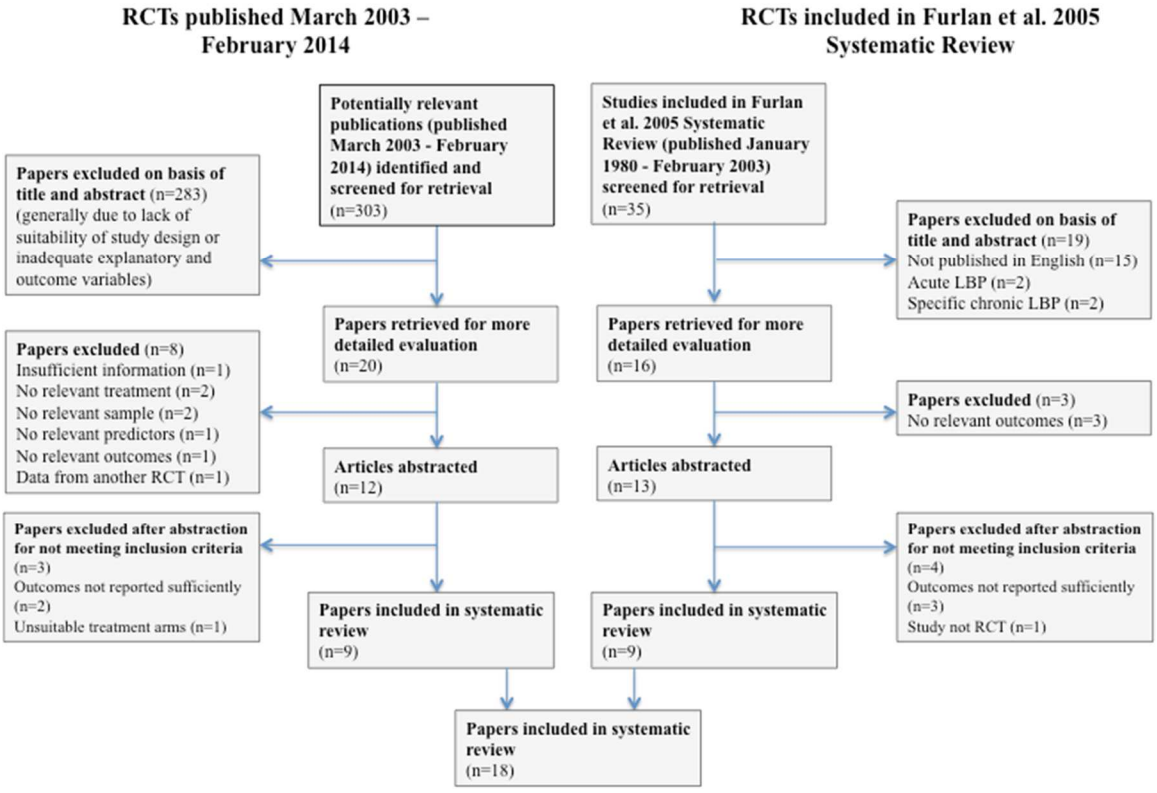


Figure 1. Flow diagram

A variety of control groups were included in these trials such as no treatment, sham acupuncture, physiotherapy, orthopedic therapy, inpatient rehabilitation, massage, group exercise,

self-care education, trigger point injections, TENS, and practitioner-based conventional therapy. One study compared the efficacy of two types of acupuncture techniques (individualized versus standardized acupuncture).

Eleven studies used the Visual Analogue Scale (VAS) on a 0 – 10 or 0 – 100 scale to collect pain outcomes and four studies asked patients to rate back pain intensity on either a 0 – 10 or 0 – 100 scale. The remainder used the Von Korff Chronic Pain Grade Scale (1 study, 0 - 100 scale), the McGill Pain Questionnaire (1 study, 0 - 50 scale), and the Nottingham Health Profile Pain Subscale (1 study, 0 - 100 scale) to rate LBP intensity. Details about the participants, setting, interventions, outcomes, and conclusions from these studies are provided in Table 15.

Table 15. Study Characteristics

Study	Participants and Settings	Interventions and Comparators	Outcomes	Study Reported Conclusions
Brinkhaus, 2006	298 patients 40 – 75 years old with chronic LBP (disease duration of more than 6 months), average pain intensity of 40 mm+ on 100 mm VAS. Mean age: 59 years; 68% female, 32% male Setting: 30 outpatient centers in Germany	1. Acupuncture (standardized points based on patient diagnosis and according to TCM until de Qi sensation produced) (n = 147) 2 sessions/week for first 4 weeks, then 1 session/week for next 4 weeks 2. Minimal acupuncture (needles were applied superficially in 6-10 non-acupuncture points, needles not applied in lower back) (n = 75) 2 sessions/week for first 4 weeks, then 1 session/week for next 4 weeks 3. Waiting list control (n = 79)	1. Back pain intensity (Visual Analogue Scale: VAS, 0 – 100 mm) 2. Back function (Hannover Functional Ability Questionnaire: HFAQ) 3. Pain Disability Index 4. Emotion aspects of pain 5. Depression scale (Allgemeine Depressionsskala) 6. Quality of life (SF-36)	Acupuncture was more effective in improving pain than no acupuncture treatment in patients with chronic low back pain, while there were no significant differences between acupuncture and minimal acupuncture.
Ceccherelli, 2002*	42 patients with continuous pain for more than 3 months with no signs of radicular compression. Mean age: 42 years; 30 males, 12 females	1. Deep acupuncture (1.5 cm) (n = 21) Total of 8 sessions over 6 weeks 2. Depth of insertion was only 2 mm in the skin (n = 21)	1. Pain: McGill Pain Questionnaire (0 – 50 scale)	Clinical results show that deep stimulation has a better analgesic effect when compared to superficial

	Setting: Pain clinic, University of Padova, Italy	Total of 8 sessions over 6 weeks		stimulation.
Cherkin, 2001*	262 patients who visited a primary care physician for LBP who had persistent pain for at least 12 weeks and bothersomeness of back pain less than 4 (on a 0-10 scale). Mean age: 44.9 years; 42% males, 58% females Setting: Health Maintenance Organization in Washington State	1. Traditional Chinese medical acupuncture (Mean of 12 needles, range 5 – 16, were inserted in each visit) (n = 94) Up to 10 visits over 10 weeks 2. Massage (n = 78) Up to 10 visits over 10 weeks 3. Self-care education: a book and 2 professionally produced videotapes (n = 90)	1. Pain (0 – 10 scale) 2. Function 3. Disability 4. Health care utilization 5. Costs 6. Satisfaction Mental and physical health	Massage is an effective short-tern treatment for chronic LBP, with benefits that persist for at least 1 year. Self-care educational materials had little early effect, but by 1 year were almost as effective as massage. If acupuncture has a positive effect, it seems to be concentrated during the first 4 weeks because there was little improvement thereafter.
Cherkin, 2009	638 patients 18 – 70 years with uncomplicated chronic LBP within the past 3 – 12 months, severity rating of at least 3 on 0 - 10 back bothersomeness scale Mean age: 47 years; 62% female, 38% men Setting: 2 research clinics in Western Washington and Northern California.	1. Individualized acupuncture (points chosen based on patients diagnosis, treatments averaged 10.8 needles) (n = 157) 2 treatments/week for first 3 weeks, then one treatment/week for next 4 weeks 2. Standardized acupuncture (8 acupuncture points stimulated considered effective by LBP experts, de Qi achieved) (n = 158) 2 treatments/week for first 3 weeks, then one treatment/week for next 4 weeks 3. Simulated acupuncture (needles applied superficially at 8	1. Disability (Roland Morris Disability Questionnaire: RMDQ) 2. Back pain intensity (0-10 scale) 3. Physical health (SF-36) 4. Mental health (SF-36) 5. Number of days spend in bed 6. Number of days lost from work or school	Acupuncture was found effective for chronic low back pain, but tailoring needling sites and penetration of the skin do not appear important in garnering therapeutic benefits. The findings raise questions about acupuncture's mechanisms of action. It remains unclear whether acupuncture or simulated methods of acupuncture provide physiologically important stimulation or represent

		acupuncture points used in standardized treatment) (n = 162) 2 treatments/week for first 3 weeks, then one treatment/week for next 4 weeks 4. Usual care (No study related care - routine care recommended by physician) (n = 161)		placebo effects.
Cho, 2013	130 patients, 18 – 65 years, with nonspecific chronic LBP and pain level of at least 5 on the 0-10 VAS scale. Mean age: 42 years; 84.5% female, 14.5% male Setting: 3 hospitals; Seoul, Korea	1. Acupuncture (perpendicular insertion, points chosen from3 groups of meridian patterns, 5 – 20 mm depth, until de Qi sensation induced) (n = 65) 2 treatments/week for 6 weeks 2. Sham acupuncture (semi-blunt needle without penetration; 8 non-acupuncture points) (n = 65) 2 treatments/week for 6 weeks	1. Pain bothersomeness (VAS, 0 – 10 mm) 2. Pain intensity (VAS, 0 – 10 mm) 3. Disability (Oswestry Disability Index: ODI) 4. Quality of life (SF-36) 5. Depression (Beck Depression Inventory: BDI) 6. Expectation	Results suggest acupuncture treatment shows better effect on the reduction of bothersomeness and pain intensity than the sham control in participants with chronic LBP.
Grant, 1999*	60 patients aged 60 years and older with a complaint of LBP of at least 6 months duration. Mean age: 73.6 years, 6 males and 54 females Setting: Outpatient clinic in the United Kingdom	1. Two sessions of manual acupuncture weekly for 4 weeks, i.e., 8 sessions total (n = 32) 2. TENS; the patient was given his/her own machine to use at home and instructed to use it during the day as required for up to 30 minutes per session to a maximum of 6 hours per day (n = 28)	1. Pain intensity 2. Pain subscale of the 38-item Nottingham Health Profile part 1 (0 – 100) 3. Analgesics consumption 4. Spinal flexion Complications	A 4 week course of either acupuncture or TENS had demonstrable benefits on subjective measured of pain and allowed them to reduce their consumption of analgesic tablets. The benefits of both treatments remained significant 3 months after completion, with a trend towards further improvement in the

				acupuncture patients.
Haake, 2007	1162 patients, 18 – 86 years old, with chronic LBP lasting at least 6 months; Von Korff Chronic Pain Grade score of grade 1 or higher and a Hannover Functional Ability Questionnaire score of less than 70% Mean age: 50 years, 40% men, 60% women Setting: 340 outpatient practices; Germany	1. Verum acupuncture (verum points, 5-40 mm depth insertion, induction of de Qi) (n = 387) 2 treatments/week for 5 weeks, 5 additional treatments for patients who experience a 10-50% reduction in pain intensity 2. Sham acupuncture (needles applied superficially, avoiding verum points & meridians) (n = 387) 2 treatments/week for 5 weeks, 5 additional treatments for patients who experience a 10-50% reduction in pain intensity 3. Conventional therapy (drugs, physical therapy, and exercise) (n = 388) 2 treatments/week for 5 weeks, 5 additional treatments for patients who experience a 10-50% reduction in pain intensity	1. Pain intensity (Von Korff Chronic Pain Grade Scale, 0 - 100) 2. Back-specific functional status (HFAQ) 3. Quality of life (SF-12) 4. Assessment of therapy effectiveness (1-6 scale) 5. Medication use 6. Adverse events	Low back pain improved after acupuncture treatment for at least 6 months. Effectiveness of both verum and sham acupuncture was almost twice that or conventional therapy.
Inoue, 2009	26 patients with low back pain Mean age of acupuncture group: 70.8 years, mean age of injection group: 73.6 years; 14 male, 12 female Setting: Department of Orthopedic Surgery, Meiji University of Integrative	1. Acupuncture (10 – 20 mm depth insertion using sparrow technique) (n = 13) 1 treatment/week for 4 weeks 2. Injection (10 – 20 mm depth insertion of dibucaine hydrochloride/5 ml solution) (n = 13) 1 treatment/week for 4 weeks	1. Pain intensity (VAS, 0 – 100 mm)	Both injection and acupuncture relieved pain, but acupuncture was superior for the immediate and sustained effects, suggesting that it is a useful treatment for low back pain.

	Medicine, Tokyo, Japan			
Kennedy, 2008	48 patients, 18 - 70 years, with an episode of non-specific LBP of up to 12 weeks duration Mean age: 45 years; 48% male, 52% female Setting: Primary care health center facility: South and East Belfast Trust, Northern Ireland	1. Verum acupuncture (unilateral or bilateral points chosen, until induction of de Qi) (n = 24) 3 – 12 treatments over a 4 – 6 week period 2. Sham acupuncture (non-penetrating needling) (n = 24) 3 – 12 treatments over a 4 – 6 week period	1. Disability (RMDQ) 2. Pain intensity (VAS, 0 – 100 mm) 3. Medication use	There was no significant difference between treatment groups on the RMDQ over time. For pain, the only statistically significant difference was at the 3 months follow-up on the VAS. At the end of treatment, the verum acupuncture group was taking significantly fewer tablets of pain control medication than the placebo group.
Kerr, 2003*	60 patients with chronic LBP (>6 months) with or without leg pain and with no neurological defects. Mean age: 41 years old; 28 males and 32 females Setting: Outpatient clinic in a hospital in Northern Ireland	1. Same set of acupoints for everyone, regardless of the distribution of their symptoms (n = 30) 6 sessions over 6 weeks 2. Placebo TENS: a nonfunctioning TENS machine was attached to 4 electrodes placed over the lumbar spine and the unit was placed so as to make it difficult to interfere with the apparatus (n = 30) 6 sessions over 6 weeks	1. Pain intensity (VAS, 0 – 100 mm) 2. SF-36 3. Physical examination: finger-floor distance 4. Global improvement measured at 6 months Complications	Although acupuncture showed highly significant differences in all the outcome measures between pre and post-treatment, the differences between the 2 groups were not statistically significant.
Leibing, 2002*	131 patients with chronic (>6 months) nonradiating LBP. Mean age: 48.1 years; 42% males, 58% females. Setting: Outpatient clinic;	1. 20 sessions of combined traditional body and ear acupuncture plus active physiotherapy over 12 weeks (n = 40) 2. Only active physiotherapy over 12 weeks	1. Pain intensity (VAS, 0 – 10 mm) 2. Pain disability 3. Psychological distress (Hospital Anxiety and Depression scale) 4. Spine flexion, fingertip-to-	Acupuncture plus physiotherapy was superior to physiotherapy alone regarding pain intensity, disability, and psychological distress at the end of

	Department of Orthopaedics, University of Goettingen, Germany	(n = 46) 3. Sham acupuncture plus active physiotherapy over 12 weeks. Sham acupuncture consisted of 20 sessions (each 30 minutes) of minimal acupuncture by the same physician. Sham acupuncture was done following the standards of minimal acupuncture. Needles were inserted superficially, 10 – 20 mm distant to the verum acupoints, outside the meridians, and were not stimulated. (n = 45)	floor distance Complications: minor not serious adverse events occurred in 3 patients in the acupuncture group	treatment. Compared to sham acupuncture plus physiotherapy, acupuncture (plus physiotherapy) reduced only psychological distress. At 9 months, the superiority of acupuncture plus physiotherapy compared to physiotherapy alone became less and acupuncture plus physiotherapy was not different from sham plus physiotherapy.
Meng, 2003*	55 patients with chronic nonspecific LBP (>12 weeks) and older than 60 years Mean age: 71 years; 22 male and 33 female Setting: Private surgeries clinics of the Hospital for Special Surgery at the New York Presbyterian Hospital, New York	1. Acupuncture twice a week for 5 weeks. Between 10 and 14 needles were used per session. Needle retention was 20 minutes. (n = 31) 2. Standard therapy alone: Continued use of primary physician for 5 week intervention period: NSAIDs, aspirin, nonnarcotic analgesic, continue back exercise (physical therapy) or home exercise regimen allowed. Prohibited: narcotics, muscle relaxants, TENS, epidural steroid injections, and trigger point injections (n = 24)	1. Back specific functional status: Roland Disability Questionnaire 2. Pain intensity (VAS, 0 – 10 mm) Complications	Data indicate that acupuncture plus standard therapy does decrease back pain and disability in older patients compared to standard therapy alone in a clinically and statistically significant manner.
Molsberger, 2002*	174 patients with LBP, with average pain score greater than 50 mm (maximum 100 mm) during the last week. Age between 20 and 60 years. 97 males and 89 females.	1. Verum acupuncture plus conventional orthopedic therapy. All patients received 12 acupuncture treatments over 3 weeks, each lasting for 30 minutes (n = 65) 2. Sham acupuncture plus	1. Pain intensity (VAS, 0 – 100 scale) 4. At least 50% reduction in pain intensity 5. Effectiveness of treatment: excellent, good, satisfactory, and failed	Together with conservative orthopedic standard therapy, acupuncture helps to decrease pain intensity directly after treatment and patients rating of the acupuncture treatment is

	Setting: Inpatients in the Hospital, Dusseldorf, Germany	conventional orthopedic therapy. 12 sham acupuncture treatments, 3/week, each lasting 30 minutes. Sham acupuncture was standardized to 10 needles applied superficially (depth of insertion was less than 1 cm) at defined nonacupuncture points of the lumbar region, and 5 needles on either side of the back (n = 61) 3. Conventional orthopedic therapy (n = 60)	6. Schober and finger-to-floor distance 7. Complications	significantly better than that of standard therapy alone. The therapeutic effect lasts for at least three months after the end of treatment.
Pach, 2013	150 patients, 18 years or older, with chronic LBP lasting at least 3 months, average pain intensity of the last 7 days of at least 40 mm on a VAS of 0 – 100 mm Mean age: 57.5 years; 58% female, 42% male Setting: General medical practice; Berlin, Germany	1. Standardized acupuncture (8 points stimulated, 1 – 2 cm depth, de Qi sensation induced) (n = 78) 2 treatments/week; maximum of 15 sessions 2. Individualized acupuncture (points based on symptom diagnosis, 1 – 2 cm depth, de Qi sensation induced) (n = 72) 2 treatments/week; maximum of 15 sessions	1. Low back pain intensity (VAS, 0 – 100 mm) 2. Back function (Hannover Functional Ability Questionnaire) 3. General health related QoL (SF-36) 4. Days absent from work 5. Adverse events	No significant differences between groups were observed in back pain intensity. Individualized acupuncture was not found to be superior to standardized acupuncture for patients suffering from chronic back pain.
Tsukayama, 2002*	20 patients with LBP over 20 years old Mean age: 45 years; 3 males, 16 females Setting: Private clinic Tsukuba, Japan	1. Acupuncture: points selected by tenderness and palpable muscle bands detected on the lower back and the buttock. Four points bilaterally (8 in total). Electrosimulation was applied to the inserted needles. Press tack needles were inserted after electroacupuncture at 4 of the 8 chosen points and left in situ for several days. Twice a week for 2	1. Pain intensity (VAS, 0 – 100 scale) 2. JOA score Complications	The results of the present trial showed a significant between group difference in pain relief in favor of acupuncture.

		weeks. (n = 10) 2. TENS: Applied in the same manner as the acupuncture group. After each session, a poultice containing methyl salicylic acid, methol, and antihistamine was prescribed to be applied at home in between treatments to the low back region. Twice a week for 2 weeks. (n = 10)		
Weiss, 2013	143 patients, 25 - 75 years, with chronic LBP with duration of at least 6 months Mean age: 50.7 years; 67% men, 33% women Setting: Inpatient rehabilitation program at a clinic in Gottingen, Germany	1. Acupuncture (points chosen based on patient diagnosis according to TCM principles + standardized inpatient rehabilitation program) (n = 74) 2 treatments/week for 3 weeks 2. Control (standardized 21-day inpatient rehabilitation program) (n = 69)	1. Quality of life (SF-36) 2. Attitudes toward TCM 3. Pain intensity (0 – 100 scale) 4. Adverse events	Acupuncture was accepted by patients and patients in the acupuncture group had significantly lower pain than the patients in the control group during follow-up.
Yeung, 2003*	52 patients with chronic LBP (>6 months) with or without radiation. Mean age: 53 years; 9 males and 43 females Setting: Outpatient clinic in a hospital in Hong Kong	1. Electroacupuncture: 3/week for 4 weeks, all patients also received exercise therapy, the same as the control group. (n = 26) 2. Standard group exercise program, that consisted of an hourly session each week for 4 consecutive weeks, and comprised of back strengthening and stretching exercising. In addition, patients were advised on spinal anatomy and body mechanics, back care, and postural correction, lifting and ergonomic advice, and behavioral modification, as well as a series of	1. Pain: numerical rating scale for 'average' and for 'worst' pain intensity during the last week (0 – 10 scale) 2. Disability: the Aberdeen LBP scale Complications	Significantly better scores in the NRS and Aberdeen LBP scale were found in the exercise plus electroacupuncture group immediately after treatment, at 1 month follow-up and at 3 months follow-up

		home exercises. (n = 26)		
Yun, 2012	187 patients, 20 – 45 years old, LBP at least 3 months, with average pain severity at least 3 on the 0-10 VAS Mean age: 34 years, 77% males, 23% females Setting: Traditional Chinese Medicine (TCM) Department of Chengdu General Military Hospital; Chengdu, China	1. Hegu acupuncture (8 acupuncture points used for CLBP, 1-3 cm depth) (n = 64) Treatments every other day for 3 weeks, then 2 treatments/week for 4 weeks 2. Standardized acupuncture (8 acupuncture points used for CLBP, 1-3 cm depth) (n = 60) Treatments every other day for 3 weeks, then 2 treatments/week for 4 weeks 3. Usual care (no study-related care; usual care recommended by physician) (n = 63)	1. Pain intensity (VAS, 0 – 10 mm) 2. Physical health (SF-36) 3. Mental health (SF-36) 4. Disability (RMDQ) 5. Medication use	Both types of acupuncture have beneficial and persistent effectiveness for patients with chronic low back pain as compared to usual care. Hegu acupuncture is significantly more effectives than standardized acupuncture, especially in the long term.

*RCT treatment details as described in Furlan et al. 2005

Risk of Bias – Study Level

The results of our risk of bias assessment are shown in Table 16. Twelve RCTs included in this review met at least nine of the methodological criteria, and thus, according to the CBRG's guidelines, were considered high quality studies, and six trials met five to eight of the criteria and were considered medium quality studies. None of the included RCTs were classified as having a high risk of bias. Lack of treatment blinding was a methodological issue in most studies; care providers were not blinded to the interventions in all 18 trials since it was not possible to blind providers on the treatment they were providing study participants. Study participants were not blinded in six trials.

We did not feel comfortable classifying studies as having high study quality if both the study subjects and care providers were not blinded to treatment. Thus, even if a study met nine of more of the CBRG's risk of bias methodological criteria, if both the study participants and care providers were not blinded to treatment, we classified the study as medium quality. In total, of our 18 included studies, we classified eight as having high study quality and ten as medium quality studies. Also, while no study had a fatal flaw, several studies had methodological limitations that were particularly noteworthy. For example, in the RCT by Grant et al., significant differences in pain intensity at baseline existed between the acupuncture and TENS groups, with those in the acupuncture group having higher initial levels of pain intensity. In the Cherkin et al. study, patients in the usual care group were twice as likely as those in the acupuncture or sham acupuncture groups to report a physician visit or to have visited a CAM medicine provider during the study period, and Kerr et al. reported that co-interventions might have influenced their results.

Table 16. Methodological Risk of Bias Quality Assessment of Included Trials													
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**Risk of Bias and Summary Scores**
Brinkhaus, 2006	Y	Y	Y	N	DK	Y	Y	Y	Y	Y	Y	Y	**Low: Score - 10.** Care providers were aware of the acupuncture & sham groups.
Ceccherelli, 2002*	Y	DK	DK	N	Y	Y	Y	Y	DK	DK	Y	Y	**Medium: Score - 7.** Care providers were not blinded.
Cherkin, 2001*	Y	DK	N	N	Y	Y	Y	Y	Y	Y	Y	Y	**Medium: Score - 9.** Patients and care providers were not blinded.
Cherkin, 2009	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	**Low: Score - 11.** Patients in the "usual care" group were twice as likely as those receiving real or simulated acupuncture to report a physician of physical therapist visit or to have visited a CAM medicine provider.
Cho, 2013	Y	Y	Y	N	DK	Y	Y	Y	Y	Y	Y	Y	**Low: Score - 10.** Care providers were aware of the acupuncture & sham groups.
Grant, 1999*	Y	Y	N	N	Y	Y	Y	N	Y	DK	Y	N	**Medium: Score - 7.** Baseline differences in main outcome measures between acupuncture and TENs group. VAS (range 0-200) at baseline in acupuncture group = 140 and in the TENS group = 101.
Haake, 2007	Y	Y	Y	N	DK	Y	Y	Y	N	Y	Y	Y	**Low: Score - 9.** Care providers were aware of the acupuncture & sham groups. Some patients were given 5 additional treatments if they experienced a 10 – 50% reduction in pain intensity.
Inoue, 2009	Y	Y	DK	N	DK	Y	Y	Y	Y	Y	Y	Y	**Medium: Score - 9.** Care providers were aware of the acupuncture & sham groups.
Kennedy, 2008	Y	Y	Y	N	DK	Y	Y	Y	N	Y	Y	Y	**Low: Score - 9.** Care providers were aware of

													the acupuncture & sham groups. Placebo group had higher VAS pain scores & RMDQ scores than acupuncture group. Thus supporting use of ANOVA analysis.
Kerr, 2003*	Y	DK	Y	N	Y	N	Y	DK	DK	DK	Y	N	**Medium: Score - 5.** Cointerventions may have influenced the results. Patients followed: 76% in the short and 66.7% in the intermediate follow-ups.
Leibing, 2002*	Y	Y	Y	N	Y	N	Y	Y	Y	DK	Y	DK	**Medium: Score - 8.** Dropout rate: 24% in the short-term and 37% in the long-term follow-ups.
Meng, 2003*	Y	Y	N	N	N	Y	Y	Y	Y	DK	Y	Y	**Medium: Score - 8.** Patients, care providers, and outcome assessors were not blinded.
Molsberger, 2002*	Y	Y	Y	N	Y	Y	Y	Y	DK	Y	Y	Y	**Low: Score - 10.** Drop-out rate at 3 months was 34%. Blinding was between verum and sham acupuncture, but not between verum and nothing.
Pach, 2013	Y	Y	N	N	DK	Y	Y	Y	Y	Y	Y	Y	**Medium: Score - 9.** Sustained blinding failed when tests – The standardized group guessed the right treatment more often than can be expected by chance. Care providers were aware of the acupuncture & sham groups.
Tsukayama, 2002*	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	**Low: Score - 10.** Outcomes assessor was blinded but patients were not. So it is possible that the blindness was broken, especially because the outcomes are subjective.
Weiss, 2013	Y	Y	DK	N	DK	Y	Y	Y	Y	Y	Y	Y	**Medium: Score - 9.** Care providers were aware of the acupuncture & sham groups.
Yeung, 2003*	DK	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	**Medium: Score - 8.** Outcomes assessor was

													blinded, patient was not. So it is possible blindness was broken, especially because the outcomes are subjective. One of the few studies that adjusted for confounders in the analysis.
Yun, 2012	Y	Y	Y	N	DK	Y	Y	Y	Y	Y	Y	Y	**Low: Score - 10.** Care providers were aware of the acupuncture & sham groups.
Total Yes	17	15	9	0	8	16	18	16	13	12	18	15	
Total No	0	0	6	18	2	2	0	1	2	1	0	2	
Total Don't Know	1	3	3	0	8	0	0	1	3	5	0	1	
* Methodological quality assessment scores reported in Furlan et al. 2005 Review													

Efficacy and Strength of Evidence of Acupuncture for Chronic LBP

This section reports the analytic results of our 18 included trials. Table 17 outlines the treatment groups and follow-up time periods being compared to determine the efficacy of acupuncture for chronic LBP. Meta-analysis results are depicted in Figures 2 – 9 and strength of evidence grading is shown in Table 18.

Table 17. RCT Treatment Arms & Follow-up Time Period Details: Acupuncture versus Comparison Groups

Study	Acupuncture treatment	Control/comparison treatment	Follow-up time periods available
1.1 Acupuncture versus no treatment			
Brinkhaus, 2006	**Acupuncture:** 6 – 10 standardized points based on patient diagnosis and according to TCM until de Qi sensation produced; 2 sessions/week for first 4 weeks, then 1 session/week for next 4 weeks	**No Treatment:** Waiting list control	Immediately post-treatment (<1 week) Intermediate follow-up (3 months to 9 months) Long-term follow-up (>9 months)
Cherkin, 2009	**Acupuncture:** 1. Individualized acupuncture (points chosen based on patients diagnosis, treatments averaged 10.8 needles); 2	**No Treatment:** No study related care - routine care recommended by physician	Immediately post-treatment (<1 week) Intermediate follow-up (3 months to 9 months)

	treatments/week for first 3 weeks, then one treatment/week for next 4 weeks 2. Standardized acupuncture (8 acupuncture points stimulated considered effective by LBP experts, de Qi achieved); 2 treatments/week for first 3 weeks, then one treatment/week for next 4 weeks		Long-term follow-up (>9 months)
Meng, 2003	**Acupuncture:** Acupuncture twice a week for 5 weeks. Between 10 and 14 needles were used per session. Needle retention was 20 minutes.	**No Treatment:** Continued usual use of primary physician for 5-week intervention period.	Immediately post-treatment (<1 week) Short term follow-up (1 week to < 3 months)
Yun, 2012	**Acupuncture:** 1. Hegu acupuncture (8 acupuncture points used for CLBP, 1-3 cm depth); Treatments every other day for 3 weeks, then 2 treatments/week for 4 weeks 2. Standardized acupuncture (8 acupuncture points used for CLBP, 1-3 cm depth); Treatments every other day for 3 weeks, then 2 treatments/week for 4 weeks	**No Treatment:** No study-related care; usual care recommended by physician	Immediately post-treatment (<1 week) Long-term follow-up (>9 months)
1.2 Acupuncture versus placebo (sham)			
Brinkhaus, 2006	**Acupuncture:** 6 – 10 standardized points based on patient diagnosis and according to TCM until de Qi sensation produced; 2 sessions/week for first 4 weeks, then 1 session/week for next 4 weeks	**Sham:** Minimal acupuncture (needles were applied superficially in 6-10 non-acupuncture points, needles not applied in lower back); 2 sessions/week for first 4 weeks, then 1 session/week for next 4 weeks	Immediately post-treatment (<1 week) Intermediate follow-up (3 months to 9 months) Long-term follow-up (>9 months)
Ceccherelli, 2002	**Acupuncture:** Deep acupuncture (1.5 cm); total of 8 sessions over 6 weeks	**Sham:** Depth of needle insertion was only 2 mm in the skin; total of 8 sessions over 6 weeks	Immediately post-treatment (<1 week) Short term follow-up (1 week to < 3 months)

Cherkin, 2009	**Acupuncture:** 1. Individualized acupuncture (points chosen based on patients diagnosis, treatments averaged 10.8 needles); 2 treatments/week for first 3 weeks, then one treatment/week for next 4 weeks 2. Standardized acupuncture (8 acupuncture points stimulated considered effective by LBP experts, de Qi achieved); 2 treatments/week for first 3 weeks, then one treatment/week for next 4 weeks	**Sham:** Needles applied superficially at 8 acupuncture points used in standardized treatment; 2 treatments/week for first 3 weeks, then one treatment/week for next 4 weeks	Immediately post-treatment (<1 week) Intermediate follow-up (3 months to 9 months) Long-term follow-up (>9 months)
Cho, 2013	**Acupuncture:** Perpendicular insertion of needles, points chosen from 3 groups of meridian patterns, 5 – 20 mm depth, until de Qi sensation induced; 2 treatments/week for 6 weeks	**Sham:** Semi-blunt needle without penetration; 8 non-acupuncture points; 2 treatments/week for 6 weeks	Immediately post-treatment (<1 week) Short term follow-up (1 week to < 3 months) Intermediate follow-up (3 months to 9 months)
Haake, 2007	**Acupuncture:** Verum points, 5-40 mm depth insertion, induction of de Qi); 2 treatments/week for 5 weeks, 5 additional treatments for patients who experienced a 10-50% reduction in pain intensity	**Sham:** Needles applied superficially, avoiding verum points & meridians; 2 treatments/week for 5 weeks, 5 additional treatments for patients who experienced a 10-50% reduction in pain intensity	Immediately post-treatment (<1 week) Short term follow-up (1 week to < 3 months) Intermediate follow-up (3 months to 9 months)
Kennedy, 2008	**Acupuncture:** Verum acupuncture unilateral or bilateral points chosen, until induction of de Qi; 3 – 12 treatments over a 4 – 6 week period	**Sham:** Non-penetrating needling; 3 – 12 treatments over a 4 – 6 week period	Immediately post-treatment (<1 week) Short term follow-up (1 week to < 3 months)
Kerr, 2003	**Acupuncture:** Standardized set of verum acupuncture acupoints; 6 sessions over 6 weeks	**Placebo TENS:** a nonfunctioning TENS machine was attached to 4 electrodes placed over the lumbar spine and the unit was placed so as to make it difficult to interfere with the apparatus; 6 sessions over 6 weeks	Immediately post-treatment (<1 week)

1.3 Acupuncture + other treatment versus other treatment			
Leibing, 2002	**Acupuncture + Physiotherapy:** 20 sessions of combined traditional body and ear acupuncture plus active physiotherapy over 12 weeks	**Physiotherapy:** Active physiotherapy over 12 weeks	Immediately post-treatment (<1 week) Intermediate follow-up (3 months to 9 months)
Molsberger, 2002	**Acupuncture + Conventional orthopedic therapy:** All patients received 12 verum acupuncture treatments over 3 weeks, each lasting for 30 minutes + 12 standardized orthopedic therapy sessions, including physiotherapy, physical exercise, back school, mud packs, and infrared heat therapy	**Conventional orthopedic therapy:** 12 standardized orthopedic therapy sessions, including physiotherapy, physical exercise, back school, mud packs, and infrared heat therapy	Immediately post-treatment (<1 week) Intermediate follow-up (3 months to 9 months)
Weis, 2013	**Acupuncture + Standardized inpatients rehabilitation program:** 6 sessions over 3 weeks of acupuncture (points chosen based on patient diagnosis according to TCM principles + 3 weeks of a standardized inpatient rehabilitation program according to current German guidelines	**Standardized inpatient rehabilitation program:** 3 weeks of a standardized inpatient rehabilitation program according to current German guidelines	Immediately post-treatment (<1 week) Short term follow-up (1 week to < 3 months)
1.4 Acupuncture + other treatment versus placebo (sham) + other treatment			
Leibing, 2002	**Acupuncture + Physiotherapy:** 20 sessions of combined traditional body and ear acupuncture plus active physiotherapy over 12 weeks	**Sham + Physiotherapy:** Sham acupuncture plus active physiotherapy over 12 weeks. Sham acupuncture consisted of 20 sessions (each 30 minutes) of minimal acupuncture by the same physician. Sham acupuncture was done following the standards of minimal acupuncture. Needles were inserted superficially, 10 – 20 mm distant to the verum acupoints, outside the meridians, and were not stimulated.	Immediately post-treatment (<1 week) Intermediate follow-up (3 months to 9 months)
Molsberger, 2002	**Acupuncture + Conventional orthopedic therapy:** All patients received 12 verum acupuncture treatments over 3	**Sham + Conventional orthopedic therapy:** Sham acupuncture plus conventional orthopedic	Immediately post-treatment (<1 week) Intermediate follow-up

	weeks, each lasting for 30 minutes + 12 standardized orthopedic therapy sessions, including physiotherapy, physical exercise, back school, mud packs, and infrared heat therapy.	therapy. 12 sham acupuncture treatments, 3/week, each lasting 30 minutes. Sham acupuncture was standardized to 10 needles applied superficially (depth of insertion was less than 1 cm) at defined non-acupuncture points of the lumbar region, and 5 needles on either side of the back + 12 standardized orthopedic therapy sessions, including physiotherapy, physical exercise, back school, mud packs, and infrared heat therapy.	(3 months to 9 months)
1.5 Acupuncture versus practitioner-based treatment			
Cherkin, 2001	**Acupuncture:** Traditional Chinese Medicine acupuncture (Mean of 12 needles, range 5 – 16, were inserted in each visit); Up to 10 visits over 10 weeks	**Massage:** Up to 10 massage visits over 10 weeks	Immediately post-treatment (<1 week)
Haake, 2007	**Acupuncture:** Verum points, 5-40 mm depth insertion, induction of de Qi); 2 treatments/week for 5 weeks, 5 additional treatments for patients who experienced a 10-50% reduction in pain intensity	**Conventional orthopedic treatment regimen:** Drugs, physical therapy, and exercise regimen recommended by physician; 2 treatments/week for 5 weeks, 5 additional treatments for patients who experience a 10-50% reduction in pain intensity	Immediately post-treatment (<1 week) Short term follow-up (1 week to < 3 months) Intermediate follow-up (3 months to 9 months)
1.6 Acupuncture versus self-care treatment			
Cherkin, 2001	**Acupuncture:** Traditional Chinese Medicine acupuncture (Mean of 12 needles, range 5 – 16, were inserted in each visit); Up to 10 visits over 10 weeks	**Self-care education:** A self-care guidebook and 2 professionally produced videotapes	Immediately post-treatment (<1 week) Intermediate follow-up (3 months to 9 months)
Yeung, 2003	**Electroacupuncture:** 3/week for 4 weeks	**Standard exercise therapy:** Standard group exercise program that consisted of an hourly session each week for 4 consecutive weeks, and	Immediately post-treatment (<1 week) Short term follow-up (1 week to < 3 months)

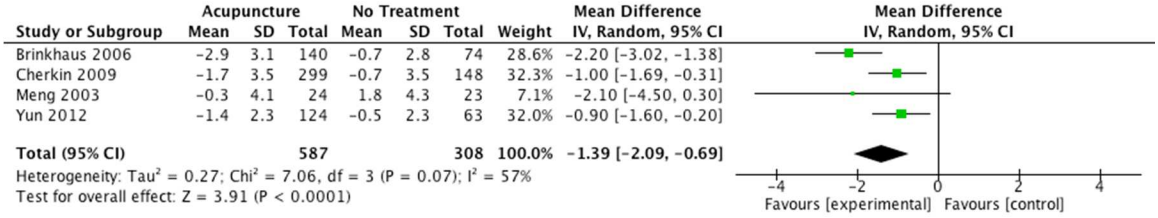
		comprised of back strengthening and stretching exercising. In addition, patients were advised on spinal anatomy and body mechanics, back care, and postural correction, lifting and ergonomic advice, and behavioral modification, as well as a series of home exercises.	
1.7 Acupuncture versus invasive treatment			
Grant, 1999	**Acupuncture:** Two sessions of manual acupuncture weekly for 4 weeks, i.e., 8 sessions total	**TENS:** the patient was given his/her own machine to use at home and instructed to use it during the day as required for up to 30 minutes per session to a maximum of 6 hours per day	Immediately post-treatment (<1 week) Intermediate follow-up (3 months to 9 months)
Inoue, 2009	**Acupuncture:** 10 – 20 mm depth insertion using sparrow technique; 1 treatment/week for 4 weeks	**Anaesthetic injections:** 10 – 20 mm depth insertion of dibucaine hydrochloride/5 ml solution; 1 treatment/week for 4 weeks	Immediately post-treatment (<1 week) Short term follow-up (1 week to < 3 months)
Tsukayama, 2002	**Electroacupuncture:** Points selected by tenderness and palpable muscle bands detected on the lower back and the buttock. Four points bilaterally (8 in total). Electrostimulation was applied to the inserted needles. Press tack needles were inserted after electroacupuncture at 4 of the 8 chosen points and left in situ for several days. Twice a week for 2 weeks.	**TENS:** Applied in the same manner as the acupuncture group. After each session, a poultice containing methyl salicylic acid, menthol, and antihistamine was prescribed to be applied at home in between treatments to the low back region. Twice a week for 2 weeks	Immediately post-treatment (<1 week)
1.8 Individualized acupuncture versus standardized acupuncture			
Cherkin, 2009	**Individualized acupuncture:** Acupuncture points chosen based on patients diagnosis, treatments averaged 10.8 needles; 2 treatments/week for first 3 weeks, then one treatment/week for next 4 weeks	**Standardized acupuncture:** 8 acupuncture points stimulated considered effective by LBP experts, de Qi achieved; 2 treatments/week for first 3 weeks, then one	Immediately post-treatment (<1 week) Intermediate follow-up (3 months to 9 months) Long-term follow-up (>9 months)

		treatment/week for next 4 weeks	
Pach, 2013	**Individualized acupuncture:** Points based on symptom diagnosis, 1 – 2 cm depth, de Qi sensation induced; 2 treatments/week; maximum of 15 sessions	**Standardized acupuncture:** 8 points stimulated, 1 – 2 cm depth, de Qi sensation induced; 2 treatments/week; maximum of 15 sessions	Immediately post-treatment (<1 week) Intermediate follow-up (3 months to 9 months)

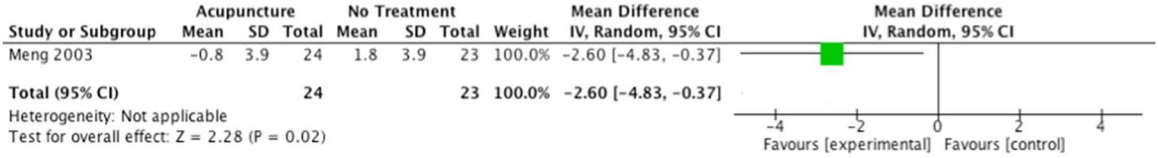
1.1. *Acupuncture versus no treatment.* 3 high quality studies and 1 medium quality study (n = 895) examined the effectiveness of acupuncture compared to no treatment. The meta-analysis results (Figure 2) showed moderate evidence that subjects who received acupuncture had statistically significantly lower pain intensity immediately post-treatment (4 studies, n = 895; pooled [0-10] pain intensity WMD: -1.39, 95% CI: -2.09, -0.69) compared to subjects who received no treatment. Patients who received acupuncture also had significantly lower pain intensity and exceeded the MCID for pain intensity compared to those who received no treatment at short-term follow-up (1 study, n = 47; [0-10] pain intensity WMD: -2.6, 95% CI: -4.83, -0.37), but since only one study with a small sample size observed these differences, there is low evidence to support distinctions between treatment groups at this follow-up. No significant differences in pain intensity were observed between the treatment groups at intermediate or long-term follow-up.

Figure 2. Acupuncture versus No Treatment: Pain Intensity

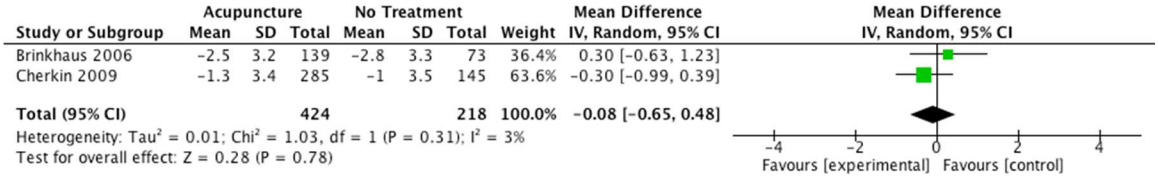
2.1. Immediately post-treatment (<1 week)



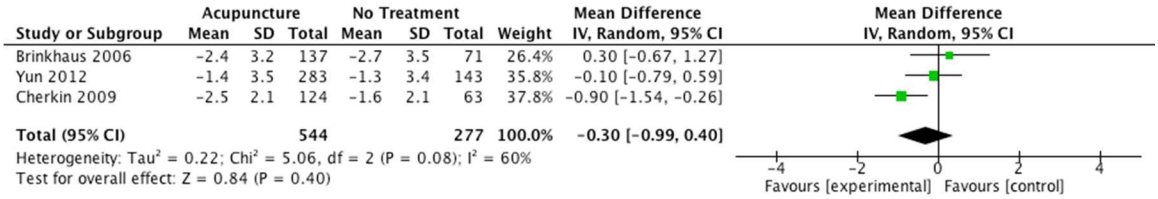
2.2. Short-term follow-up (1 week to <3 months)



2.3. Intermediate follow-up (3 months to 9 months)



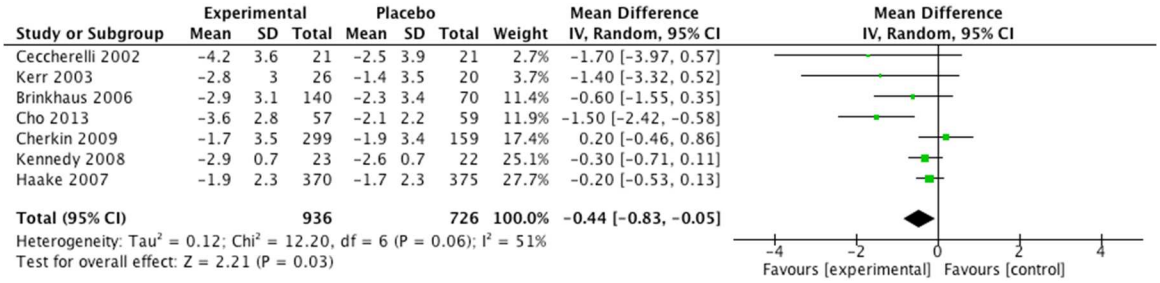
2.4. Long-term follow-up (>9 months)



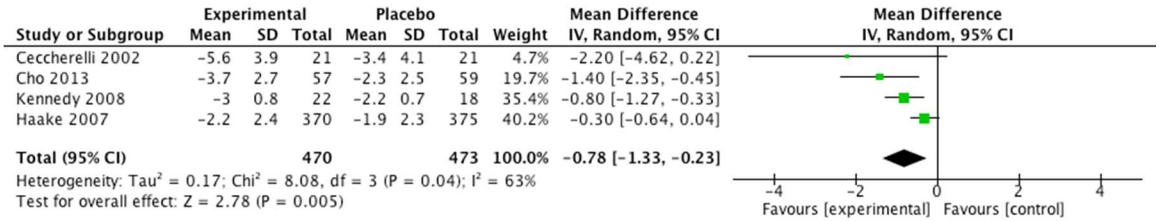
1.2. *Acupuncture versus sham.* 5 high quality and 2 medium quality studies (n = 1,662) investigated acupuncture versus sham acupuncture. A meta-analysis (Figure 3) and strength of evidence assessment (Table 18) showed moderate evidence that acupuncture was significantly better than sham acupuncture in reducing pain immediately following treatment: (7 studies, n = 1,662; pooled [0-10] pain intensity WMD: -0.44, 95% CI: -0.83, -0.05) and at short-term follow-up (4 studies, n = 943; pooled [0-10] pain intensity WMD: -0.78, 95% CI: -1.33, -0.23). The mean pain intensity scores were not significantly different between groups at intermediate and long-term follow-up.

Figure 3. Acupuncture versus Sham: Pain Intensity

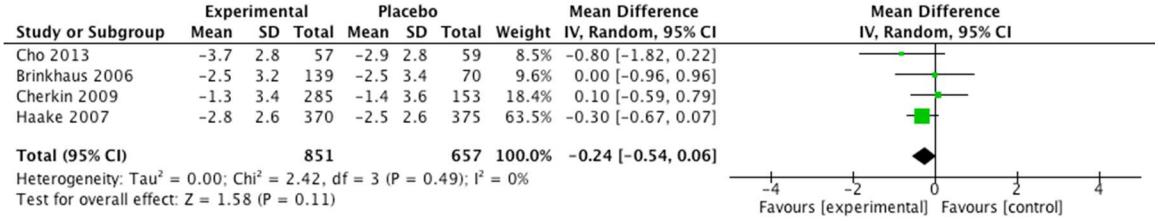
3.1. Immediately post-treatment (<1 week)



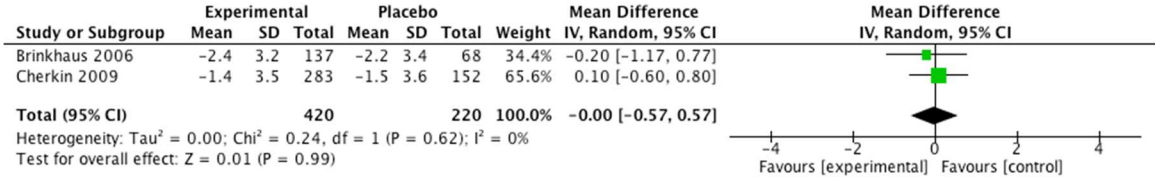
3.2. Short-term follow-up (1 week to <3 months)



3.3. Intermediate follow-up (3 months to 9 months)



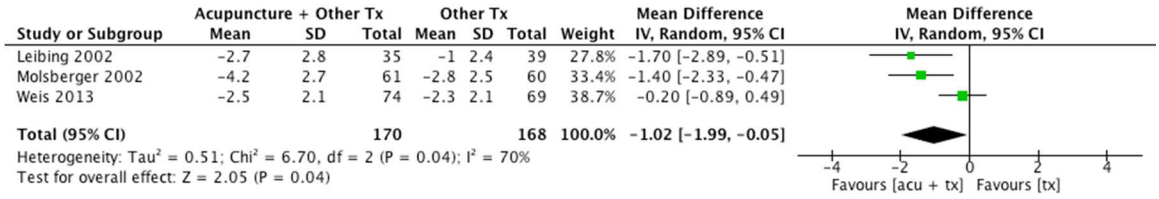
3.4. Long-term follow-up (>9 months)



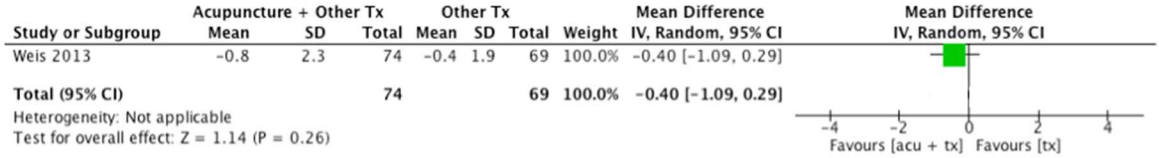
1.3. *Acupuncture + other treatment versus other treatment.* 1 high quality and 2 medium quality studies (n = 338) examined the efficacy of acupuncture in addition to another treatment versus the additional treatment alone. Meta-analysis (Figure 4) and strength of evidence assessment found moderate evidence that acupuncture in conjunction with an additional treatment was significantly better in reducing pain intensity than the additional treatment alone immediately post-treatment (3 studies, n = 338; pooled [0-10] pain intensity WMD: -1.02, 95% CI: -1.99, -0.05) and at intermediate follow-up (2 studies, n = 179; pooled [0-10] pain intensity WMD: -3.21, 95% CI: -3.93, -2.49). In addition, at the intermediate follow-up point, the mean changes in pain intensity in the acupuncture group were greater than the MCID.

Figure 4. Acupuncture + Other Treatment versus Other Treatment: Pain Intensity

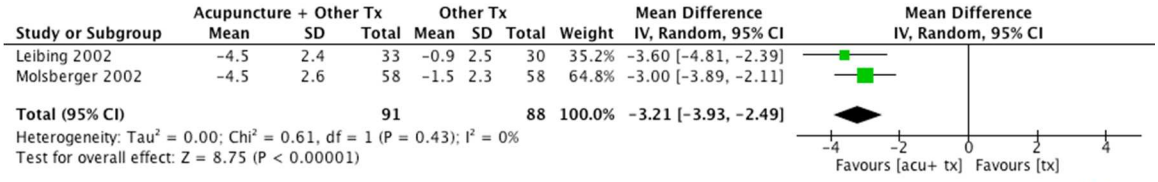
4.1. Immediately post-treatment (<1 week)



4.2. Short-term follow-up (1 week to <3 months)



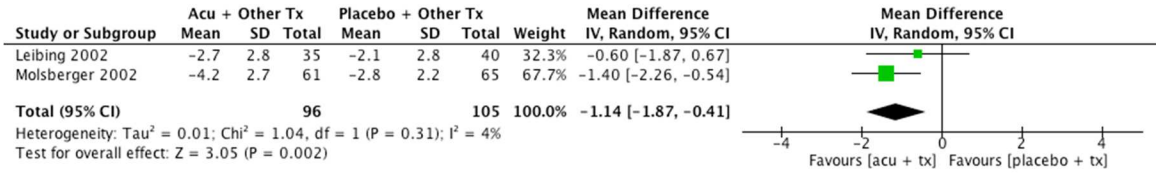
4.3. Intermediate follow-up (3 months to 9 months)



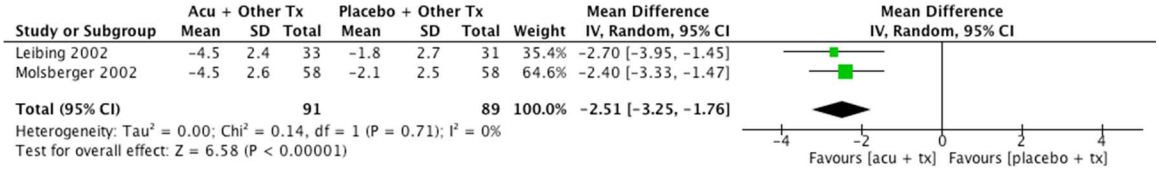
1.4. *Acupuncture + other treatment versus sham + other treatment.* 1 high quality and 1 medium quality trial (n = 201) studied the results of acupuncture and an additional treatment versus sham acupuncture and an additional treatment. Meta-analysis (Figure 5) and strength of evidence results found moderate evidence that acupuncture in addition to a treatment led to significantly lower pain intensity immediately post-treatment (2 studies, n = 201; pooled [0-10] pain intensity WMD: -1.14, 95% CI: -1.87, -0.41) and at intermediate follow-up (2 studies, n = 180; pooled [0-10] pain intensity WMD: -2.51, 95% CI: -3.25, -1.76) as compared to sham acupuncture in addition to a treatment. Mean changes in pain were greater than the MCID at intermediate follow-up.

Figure 5. Acupuncture + Other versus Sham + Other: Pain Intensity

5.1. Immediately post-treatment (<1 week)



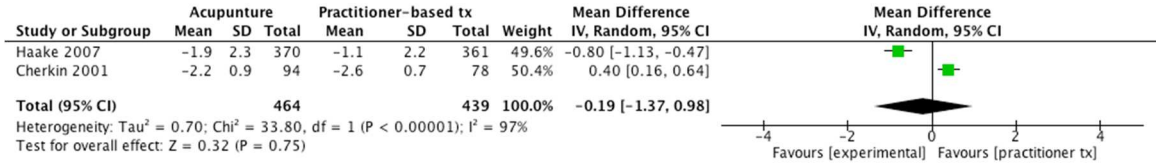
5.2. Intermediate follow-up (3 months to 9 months)



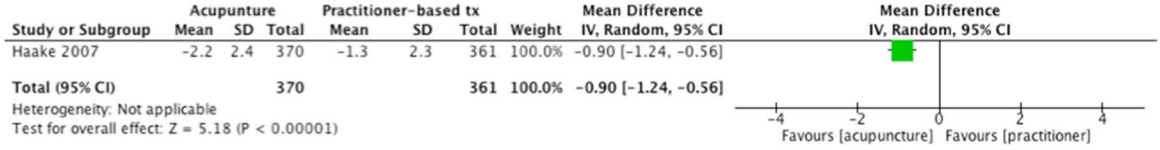
1.5. *Acupuncture versus practitioner-based treatment.* 1 high quality and 1 medium study (n = 903) investigated acupuncture versus a practitioner-based treatment. Figure 6 shows results of this meta-analysis. Acupuncture did not significantly differ from practitioner-based treatment in reducing immediate post-treatment pain, and there was low evidence that acupuncture was significantly better in reducing pain intensity in the short-term (1 study, n = 731; [0-10] pain intensity WMD: -0.90, 95% CI: -1.24, -0.56) and at the intermediate follow-up (1 study, n = 731; [0-10] pain intensity WMD: -1.20, 95% CI: -1.57, -0.83).

Figure 6. Acupuncture versus Practitioner-based Treatment: Pain Intensity

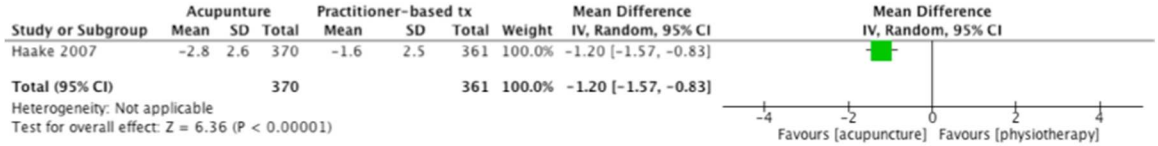
6.1. Immediately post-treatment (<1 week)



6.2. Short-term follow-up (1 week to <3 months)



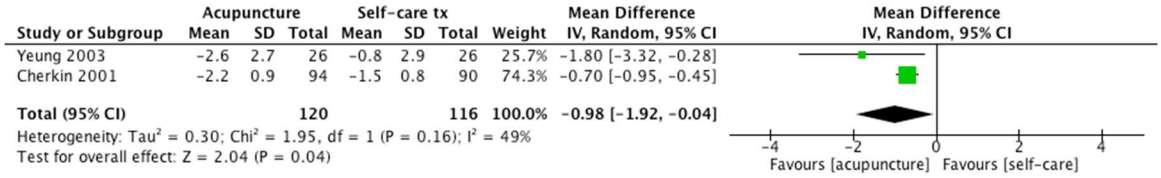
6.3. Intermediate follow-up (3 months to 9 months)



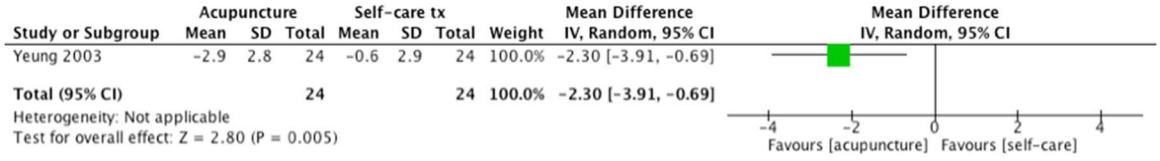
1.6. *Acupuncture versus self-care treatment.* Acupuncture versus self-care treatment was examined in 2 medium quality studies (n = 236) with meta-analysis results depicted in Figure 7. We found low evidence that mean pain intensity scores in the acupuncture group were significantly lower than scores in the self-care treatment group immediately post-treatment (2 studies, n = 236; pooled [0-10] pain intensity WMD: -0.98, 95% CI: -1.92, -0.04). Acupuncture resulted in lower pain scores and exceeded the MCID for pain intensity as compared to self-care treatment at short-term follow-up (1 study, n = 48; [0-10] pain intensity WMD: -2.30, 95% CI: -3.91, -0.69), however this evidence was also graded as low due to a small sample size of the included study.

Figure 7. Acupuncture versus Self-care Treatment: Pain Intensity

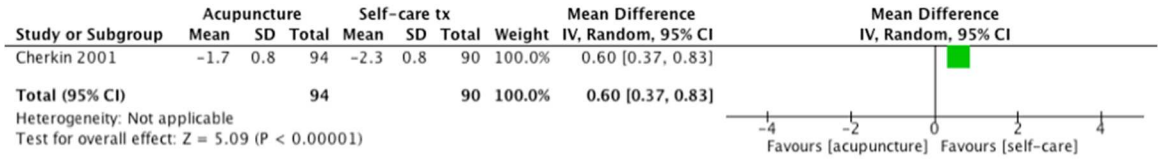
7.1. Immediately post-treatment (<1 week)



7.2. Short-term follow-up (1 week to <3 months)



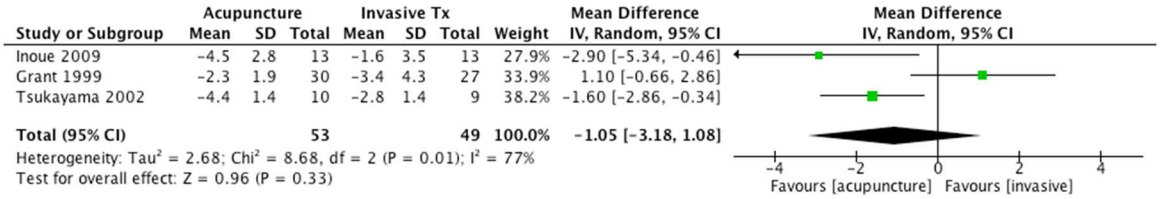
7.3. Intermediate follow-up (3 months to 9 months)



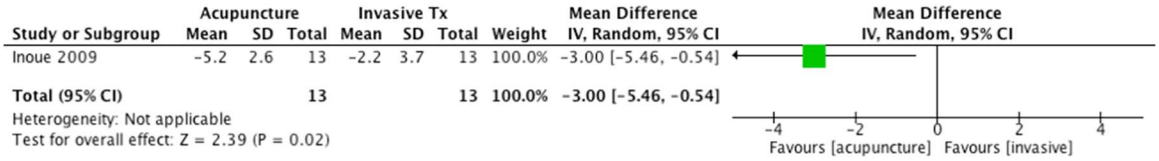
1.7. *Acupuncture versus invasive treatment.* 1 high quality study and 2 medium quality studies (n = 102) compared acupuncture versus invasive treatment. Results of a meta-analysis are shown in Figure 8. Significant differences between groups were only found at the short-term follow-up, with pain intensity significantly lower, and exceeding the MCID, in the acupuncture group as compared to the invasive treatment group, (1 study, n = 26; [0-10] pain intensity WMD: -3.00, 95% CI: -5.46, -0.54). However, we graded the strength of evidence of these results as low due to small sample size of the included study.

Figure 8. Acupuncture versus Invasive Treatment: Pain Intensity

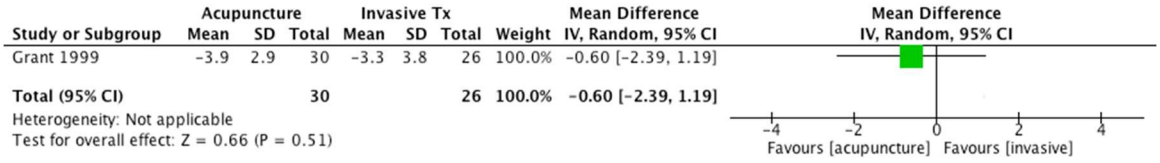
8.1. Immediately post-treatment (<1 week)



8.2. Short-term follow-up (1 week to <3 months)



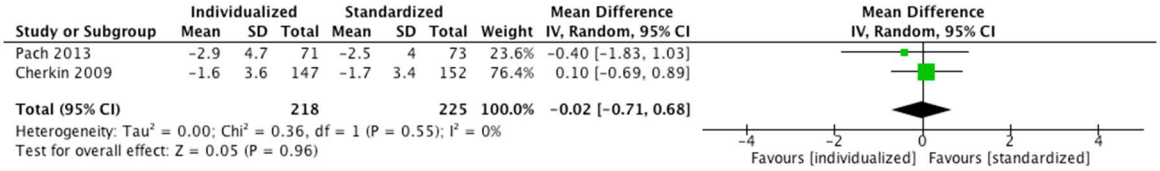
8.3. Intermediate follow-up (3 months to 9 months)



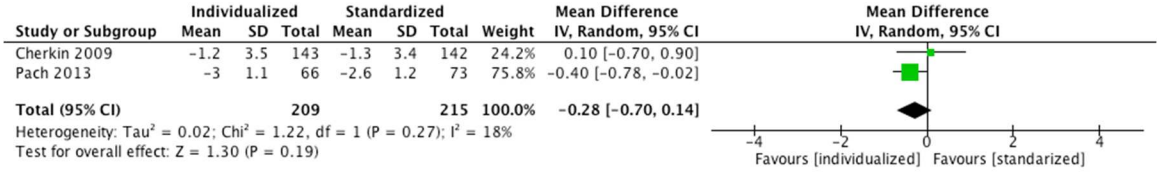
1.8. *Individualized acupuncture versus standardized acupuncture.* The effects of individualized acupuncture versus standardized acupuncture on pain intensity were investigated in 1 high quality and 1 medium quality study (n = 443) and results from a meta-analysis are depicted in Figure 9. Significant differences between individualized acupuncture and standardized acupuncture on pain intensity were not found at any of the follow-up points.

Figure 9. Individualized Acupuncture versus Standardized Acupuncture: Pain Intensity

9.1. Immediately post-treatment (<1 week)



9.2. Intermediate follow-up (3 months to 9 months)



9.3. Long-term follow-up (>9 months)

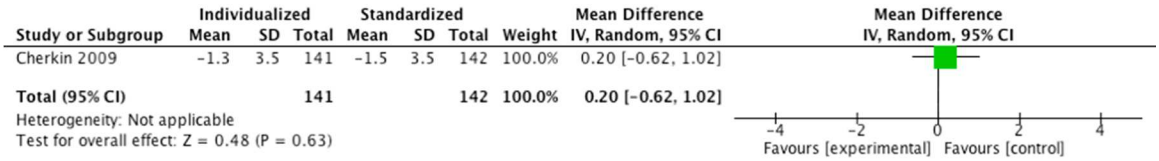


Table 18. Summary of Strength of Evidence for Pain Intensity			
Number of studies, n, ROB of studies	**Length of follow-up**	**GRADE***	**WMD, 95% CI**
Acupuncture versus no treatment			
4 studies, n = 895 3 low, 1 medium	Immediately post-treatment (<1 week)	***Medium*** Limitations of Study: Low Consistency: Consistent Directness: Direct Precision: Imprecise	-1.39 [-2.09, -0.69], favors acupuncture
1 study, n = 47 1 medium	Short-term follow-up (1 week to < 3 months)	***Low*** Limitations of Study: Low Consistency: Unknown (only 1 trial) Directness: Direct Precision: Imprecise	-2.60 [-4.83, -0.37], favors acupuncture
2 studies, n = 642 2 low	Intermediate follow-up (3 months to 9 months)	***Low*** Limitations of Study: Low Consistency: Inconsistent Directness: Direct Precision: Imprecise	-0.08 [-0.65, 0.48]
3 studies, n = 821 3 low	Long-term follow-up (>9 months)	***Low*** Limitations of Study: Low Consistency: Inconsistent Directness: Direct Precision: Imprecise	-0.30 [-0.99, 0.40]
Acupuncture versus sham			
7 studies, n = 1,662 5 low, 2 medium	Immediately post-treatment (<1 week)	***Medium*** Limitations of Study: Low Consistency: Consistent Directness: Direct Precision: Imprecise	-0.44 [-0.83, -0.05], favors acupuncture
4 studies, n = 943 3 low, 1 medium	Short-term follow-up (1 week to < 3 months)	***Medium*** Limitations of Study: Low Consistency: Consistent Directness: Direct Precision: Imprecise	-0.78 [-1.33, -0.23], favors acupuncture
4 studies, n = 1,508 4 low	Intermediate follow-up (3 months to 9 months)	***Low*** Limitations of Study: Low Consistency: Inconsistent Directness: Direct Precision: Imprecise	-0.24 [-0.54, 0.06]
2 studies, n = 640 2 low	Long-term follow-up (>9 months)	***Low*** Limitations of Study: Low Consistency: Inconsistent Directness: Direct Precision: Imprecise	0.00 [-0.57, 0.57]
Acupuncture + other treatment versus other treatment			
3 studies, n = 338 1 low, 2 medium	Immediately post-treatment (<1 week)	***Medium*** Limitations of Study: Low Consistency: Consistent Directness: Direct Precision: Imprecise	-1.02 [-1.99, -0.05], favors acupuncture + other treatment
1 study, n = 143	Short-term follow-up	***Low***	-0.40 [-1.09, 0.29]

1 medium	(1 week to < 3 months)	Limitations of Study: Low Consistency: Unknown (only 1 trial) Directness: Direct Precision: Imprecise	
2 studies, n = 179 1 low, 1 medium	Intermediate follow-up (3 months to 9 months)	***Medium*** Limitations of Study: Low Consistency: Consistent Directness: Direct Precision: Precise	-3.21 [-3.93, -2.49], favors acupuncture
Acupuncture + other treatment versus sham + other treatment			
2 studies, n = 201 1 low, 1 medium	Immediately post-treatment (<1 week)	***Medium*** Limitations of Study: Low Consistency: Consistent Directness: Direct Precision: Imprecise	-1.14 [-1.87, -0.41], favors acupuncture + other treatment
2 studies, n = 180 1 low, 1 medium	Intermediate follow-up (3 months to 9 months)	***Medium*** Limitations of Study: Low Consistency: Consistent Directness: Direct Precision: Precise	-2.51 [-3.25, -1.76], favors acupuncture + other treatment
Acupuncture versus practitioner-based treatment			
2 studies, n = 903 1 low, 1 medium	Immediately post-treatment (<1 week)	***Low*** Limitations of Study: Low Consistency: Inconsistent Directness: Indirect Precision: Imprecise	-0.19 [-1.37, 0.98]
1 study, n = 731 1 low	Short-term follow-up (1 week to < 3 months)	***Low*** Limitations of Study: Low Consistency: Unknown (only 1 trial) Directness: Indirect Precision: Imprecise	-0.90 [-1.24, -0.56], favors acupuncture
1 study, n = 731 1 low	Intermediate follow-up (3 months to 9 months)	***Low*** Limitations of Study: Low Consistency: Unknown (only 1 trial) Directness: Indirect Precision: Imprecise	-1.20 [-1.57, -0.83], favors acupuncture
Acupuncture versus self-care treatment			
2 studies, n = 236 2 medium	Immediately post-treatment (<1 week)	***Low*** Limitations of Study: Low Consistency: Consistent Directness: Indirect Precision: Imprecise	-0.98 [-1.92, -0.04], favors acupuncture
1 study, n = 48 1 medium	Short-term follow-up (1 week to < 3 months)	***Low*** Limitations of Study: Low Consistency: Unknown (only 1 trial) Directness: Indirect Precision: Imprecise	-2.30 [-3.91, -0.69], favors acupuncture
1 study, n = 184	Intermediate follow-up (3 months to 9 months)	***Low*** Limitations of Study: Low Consistency: Unknown	0.60 [0.37, 0.83], favors self-care

1 medium		(only 1 trial) Directness: Direct Precision: Imprecise	
Acupuncture versus invasive treatment			
3 studies, n = 102 1 low, 2 medium	Immediately post-treatment (<1 week)	***Low*** Limitations of Study: Low Consistency: Inconsistent Directness: Indirect Precision: Imprecise	-1.05 [-3.18, 1.08]
1 study, n = 26 1 medium	Short-term follow-up (1 week to < 3 months)	***Low*** Limitations of Study: Low Consistency: Unknown (only 1 trial) Directness: Direct Precision: Imprecise	-3.00 [-5.46, -0.54], favors acupuncture
1 study, n = 56 1 medium	Intermediate follow-up (3 months to 9 months)	***Low*** Limitations of Study: Low Consistency: Unknown (only 1 trial) Directness: Indirect Precision: Imprecise	-0.60 [-2.39, 1.19]
Individualized acupuncture versus standardized acupuncture			
2 studies, n = 443 1 low, 1 medium	Immediately post-treatment (<1 week)	***Low*** Limitations of Study: Low Consistency: Inconsistent Directness: Direct Precision: Imprecise	-0.02 [-0.71, 0.68]
2 studies, n = 424 1 low, 1 medium	Short-term follow-up (1 week to < 3 months)	***Low*** Limitations of Study: Low Consistency: Inconsistent Directness: Direct Precision: Imprecise	-0.28 [-0.70, 0.14]
1 study, n = 283 1 low	Long-term follow-up (>9 months)	***Low*** Limitations of Study: Low Consistency: Unknown (only 1 trial) Directness: Direct Precision: Imprecise	0.20 [-0.62, 1.02]

Adverse Events

Adverse events reported in the included studies were minor and occurred infrequently. Occurrences of adverse events did not appear to differ between acupuncture and sham groups. The Tsukayama et al. (Acupuncture: 30%, TENS: 30%) and Cho et al. (Acupuncture: 15.4%, TENS, 30%) studies reported the highest percentage of adverse events by treatment arms, but both studies reported all adverse events were minimally harmful. Detailed descriptions of each

adverse event reported for these trials included incidents such as temporarily worsening of LBP, pain or bruise at acupunctures site, and minor bothersomeness in foot, leg, or shoulder. Descriptions of adverse events from other trials were similarly minor. For example, Leibing et al. recorded events such as temporary painfulness at acupuncture site and problems with circulation within their acupuncture group. Detailed frequencies of adverse events by treatment arm for each study are shown in Appendix 4.

Discussion

Though we found moderate positive results of acupuncture for pain relief at immediate follow-up (acupuncture versus no treatment, acupuncture versus sham, and acupuncture + other treatment versus sham + other treatment), short-term follow-up (acupuncture versus sham), and at intermediate follow-up (acupuncture + other treatment versus other treatment, acupuncture + other treatment versus sham + other treatment), the magnitude of the effects of acupuncture was generally small and did not reach our MCID threshold in most cases. However, the MCID threshold was exceeded between a few treatment groups. Most notably, patients who received acupuncture had significantly lower pain intensity at short-term follow-up and exceeded the MCID compared to those who received no treatment (WMD: -2.60, 95% CI: -4.83, -0.37) or those who received invasive treatment (WMD: -3.00, 95% CI: -5.46, -0.54). Also, at intermediate follow-up, patients who received acupuncture in addition to another treatment had significantly lower pain outcomes and exceeded the MCID compared to those who received a single other treatment (WMD: -3.21, 95% CI: -3.93, -2.49) or sham in addition to another treatment (WMD: -2.51, 95% CI: -3.25, -1.76). The significant results found between these groups at intermediate follow-up were unexpected and difficult to explain, since significant short-term differences between the same comparison groups were not observed. No differences in pain intensity were found at long-term follow-up for any comparison treatments. Table 19 summarizes our results on

the effectiveness of acupuncture versus comparator treatments.

Table 19. Summary of effectiveness of acupuncture versus comparator treatments

	Immediately post-treatment (< 1 week)	Short-term (1 week to <3 months)	Intermediate (3 months to 9 months)	Long-term (>9 months)
1.1. Acupuncture versus no treatment	+**	+*	⊘*	⊘*
1.2. Acupuncture versus placebo (sham)	+**	+**	⊘*	⊘*
1.3. Acupuncture + other treatment versus other treatment	+**	⊘*	+**	NA
1.4. Acupuncture + other treatment versus placebo (sham) + other treatment	+**	NA	+**	NA
1.5. Acupuncture versus practitioner-based treatment	⊘*	+*	+*	NA
1.6. Acupuncture versus self-care treatment	+*	+*	-*	NA
1.7. Acupuncture versus invasive treatment	⊘*	+*	⊘*	NA
1.8. Individualized acupuncture versus standardized acupuncture	⊘*	⊘*	⊘*	NA
+ = favors acupuncture, - = favors comparator treatment, ⊘= favors neither, ** = medium strength of evidence, * = low strength of evidence				

Previous systematic reviews that have investigated the effectiveness of acupuncture on chronic LBP have included a number of limitations. For example, a review published by Furlan et al. in 2012 focused on a mixed patient population consisting of adults with neck pain in addition to chronic and acute LBP, instead of solely focusing on the adult chronic LBP population. (Furlan

et al., 2012). Another review by Furlan et al., which is the most comprehensive, most recently published systematic literature review examining acupuncture in a chronic LBP population, reported results that were difficult to interpret and not according to guidelines recommended by the Cochrane Collaboration. Also, many studies included in the review were of weak quality, with low Risk of Bias scores. (Furlan et al., 2005) This study adds to the literature by following a detailed framework for conducting a systematic literature review recommended by the Cochrane Collaboration, focusing solely on a population of adults with chronic LBP, and including only randomized controlled trials. In addition, we updated the 2005 Furlan et al. review by including relevant studies published from March 2003 to February 2014.

Overall, the assessment of acupuncture for back pain is difficult, because there are many acupuncture techniques and practices (e.g., points used, number of points stimulated, depth of needle insertion) and back pain is a broad health complaint, with a number of underlying causes and mechanisms. Also, the trials included in this study were heterogeneous in terms of study population, pain intensity outcomes collected, follow-up points collected, and types of acupuncture treatment used. In addition, a major methodological concern when investigating the efficacy of acupuncture on a health condition is the use of sham, or superficial needling, as a control group. (Lund et al., 2006) It has been suggested that sham acupuncture is not an appropriate control comparison since even superficial needling of the skin can alleviate pain through processes such as stimulating mechanoreceptors and the noxious inhibitory control. (Lund et al., 2006) One potential approach to minimize the effect on pain alleviation from sham acupuncture is to needle non-acupuncture points. The ideal study investigating the effectiveness of acupuncture on a condition should include both a sham-control, in which needling is done at non-acupuncture points and does not penetrate skin (such as by using non-penetrating placebo needles), and comparison groups are investigated in parallel. (Ernst et al., 1998) Of those studies included in our review that included sham acupuncture, most stimulated non-acupuncture points

and included comparison treatment arms in addition to acupuncture treatment. However, the sham acupuncture technique in most of our included trials included needling penetration of the skin.

We specified in our inclusion criteria that all studies be RCTs. Thus, our included studies were of relatively high study quality. Our Risk of Bias methodological ratings (Table 16) show that of the 18 studies we examined, twelve were of high study quality and six were of medium study quality. However, we were not comfortable with classifying studies as high quality when both the care providers and study subjects were not blinded to treatment details. Thus, after accounting for the studies in which providers and subjects were not blinded, we determined eight studies were of high quality, and twelve were of medium study quality. Overall, our meta-analysis results are based on studies of scientific rigor, which lends weight to our findings. However, due to the variety in types of treatment types and the follow-up points included in each study, it was difficult to conduct meta-analysis with only 18 trials, and difficult to reach conclusions on most treatments. We suggest that future trials be randomized, fully blinded, utilize Tradition Chinese Medicine (TCM) recommended acupuncture points, collect widely accepted outcome measures, such as pain intensity measured using a VAS, and should test acupuncture on a homogenous subtype of non-complicated chronic LBP.

Also, though our search strategy was comprehensive, it is possible some trials were not located. In addition, due to restricted study resources, we were limited to studies published in English and were not able in include the many trials published in other languages. Also, we were not able to include a number of trials because authors did not report pain outcomes or did not report pain outcome results in an interpretable way. We suggest that future trials report pain outcomes at all follow-up points and more specifically, report the means with standard deviations for continuous measures of pain intensity. An additional limitation in many trials was inadequate patient follow-up. We suggest future trials have short-term follow up (<3 months), intermediate follow-up (3 – 9 months) and long-term follow-up (>9 months) and report outcomes at all follow-

up periods. Future research should also focus on areas where there are few trials, such as 1. acupuncture + other treatment versus other treatment, 2. acupuncture + sham versus sham + other treatment, 3. acupuncture versus other treatments (e.g. practitioner-based treatments, self-care treatments), and 4. individualized acupuncture versus standardized acupuncture. Also, future studies should have larger sample sizes based on power calculations, since a number of trials included very few subjects. We also suggest that future trials report the proportion of patients who met a MCID threshold, to better understand clinically important differences that occurred between study groups.

Generally, acupuncture appears to be associated with reductions in pain intensity in adults with chronic LBP, although the magnitude of observed pain intensity changes were small. The MCID threshold was not reached for most analyses between acupuncture and comparator groups. Significant results occurred primarily immediately post-treatment or at short-term follow-up, and no differences between comparison groups were observed in the long-term. Further studies, with larger samples and longer follow-up, are required to conclude with higher strength of evidence that acupuncture is an effective treatment for adults with chronic LBP.

Conclusion

Overall, we included 18 trials with 3,669 patients. We found moderate evidence that acupuncture may be more effective than no treatment or sham treatment in the short-term (<3 months) in reducing pain intensity. We also found moderate evidence that acupuncture in addition to a treatment may be more effective than sham in addition to a treatment in the short-term and at intermediate follow-up (3 – 9 months), as well as compared to a treatment alone at an intermediate follow-up. However, we found low evidence of the effectiveness of acupuncture on reducing pain as compared to no treatment or sham at intermediate or long-term follow-up. We

also found minimal evidence of the effectiveness of acupuncture as compared to practitioner-based treatments (massage, conventional orthopedic treatment regimen), self-care treatments (self-care education, exercise therapy), or invasive treatments (TENS, anaestheetic injections). No differences were observed in treatment effect between standardized and individualized acupuncture treatment at any follow-up point. Also, no differences between acupuncture and a comparison group were found at any long-term follow-up. This data suggests that acupuncture may be a beneficial addition treatment in addition to other treatments for chronic LBP, though the pain relief effects were not observed for longer-term follow-ups.

CHAPTER 4: ACUPUNCTURE TREATMENT IN ADDITION TO USUAL CARE ON CHRONIC LBP (LBP): A COST-EFFECTIVENESS ANALYSIS

Background

Low back pain (LBP) is a widespread problem, placing an enormous burden on society and health care systems around the world. In the US, LBP results in over $90 billion a year in costs related to health care utilization, and over $16 billion annually in lost productivity due to job-related disability and missed workdays. (Deyo et al., 2006; Ricci et al., 2007) Approximately 80% of adults in the US will experience an episode of back pain during their lifetime, and over 8% suffer from chronic LBP, defined as LBP lasting longer than 12 weeks. (Carey et al., 2009) In the US, chronic LBP is a leading reason for physician visits, hospitalizations, and utilization of other health care services. Commonly utilized conventional medical treatments for chronic LBP include spinal/back surgery, medications, and physical therapy. (Luo et al., 2004) However, patients are increasingly turning to complementary and alternative medicine (CAM) - defined by the National Center for Complementary and Integrative Health (NCCIH) as "a group of diverse medical and healthcare systems, practices, and products that are not presently considered to be a part of conventional medicine" - to find relief from their pain, partially due to dissatisfaction with the efficacy and reliability of conventional medical treatments. (Sherman et al., 2004)

The use of many CAM therapies has increased within the US back pain population, with acupuncture among the CAM therapies receiving particular attention. (McFadden et al., 2010) A number of randomized controlled trials (RCTs) have found acupuncture to be an effective treatment for chronic LBP. (Brinkhaus et al., 2006; Cho et al., 2013; Cherkin et al., 2009) Also, several health organizations have recommended acupuncture as an effective treatment for chronic LBP including the World Health Organization (WHO), American College of Physicians (ACP), and American Pain Society (APS). In addition, studies from England, Germany, and China have

found acupuncture to be a cost-effective treatment for chronic LBP. (Ratcliffe et al., 2006; Witt et al., 2006; Kim et al., 2012) However, a cost-effectiveness analysis examining acupuncture treatment for chronic LBP has not been completed for a US population.

Decision-analytic modeling provides a framework to structure and evaluate evidence on economic and clinical outcomes. Findings from this type of model can help decision makers to make informed decisions on a variety of public policy issues, including how to best allocate resources for health-care and clinical practices. (Weinstein et al., 2003) Markov models are particularly suited to modeling the progression of chronic disease or conditions. (Detsky et al., 1997) Using a Markov decision analytic model to examine acupuncture treatment as compared to other treatment alternatives among US adults with chronic LBP may be an important step to better understand the resources and potential benefits associated with acupuncture treatment within this population.

Decision Analytic Model

Evaluating the Cost-Effectiveness of Acupuncture on Chronic LBP Relief

In this chapter, we developed a decision-analytic Markov model to compare the costs and benefits over a two-year time horizon of receiving acupuncture treatment versus not receiving acupuncture treatment for a hypothetical cohort of 50-year old persons suffering from chronic LBP: 1) acupuncture in addition to usual care versus 2) usual care alone. Benefit was measured by LBP relief and associated quality-of-life (QoL) weights, and costs included back-pain related costs and acupuncture treatment costs, minus the costs averted due to LBP relief. In the model we divided chronic LBP into distinct states representing a range of pain levels, and assigned transitions probabilities for movement between these states over a discrete time period known as a 'Markov cycle.' We used a cycle length of three months to reflect the typical follow-up periods in the RCTs evaluating acupuncture. By attaching estimates of resource use and health outcome

consequences to the states and transitions in the model, and then running the model over a number of cycles, it was possible to estimate the cost and effectiveness outcomes at two years associated with chronic LBP relief as a result of the healthcare interventions considered. The methods to complete the cost-effectiveness analysis are detailed in this chapter, as well as our results and a discussion of the significance of our findings.

Data Sources

We identified eight high-quality RCTs to inform the effectiveness of acupuncture based on a thorough search of the literature published January 1980 to February 2014. The inclusion criteria we specified included the following:

1. Population: Adults, 18 years or older, with nonspecific chronic LBP
2. Intervention: RCTs investigating acupuncture treatment
3. Control: Sham acupuncture or usual/conventional care comparator group
4. Outcome: Pain intensity

In chapter three, we rated the study quality of the eight RCTs according to guidelines published by the Cochrane Back Review Group (CBRG) and chose the five RCTs of the highest study quality to inform the parameters of our model. (Furlan et al., 2009) Table 20 lists the CBRG criteria we used to score study quality and Table 21 shows details of the five chosen RCTs. Additional study characteristics are detailed in Appendix 5.

Table 20. Operationalization of CBRG Study Quality (Criteria for a Judgment of "Yes" for Rating Study Quality) (Furlan et al., 2009)

A	Was the method of randomization adequate?
B	Was the treatment allocation concealed?
C	Was the patient blinded to the intervention?
D	Was the care provider blinded to the intervention?
E	Was the outcome assessor blinded to the intervention?
F	Was the drop-out rate described and acceptable?
G	Were all randomized participants analyzed in the group to which they were allocated?
H	Were the groups similar at baseline regarding the most important prognostic indicators?
I	Were co-interventions avoided or similar?
J	Was the compliance acceptable in all groups?
K	Was the timing of the outcome assessment similar in all groups?
L	Are reports of the study free of suggestion of selective outcome reporting?

Study	Study Subjects	Ns of Treatment Arms	Study Quality Based on CBRG Guidelines ***Scores out of a possible 12 points, with higher scores indicating better study quality**
Brinkhaus, 2006	***Inclusion:*** Aged 40 to 75 years; average pain intensity of 40 or more on a 100 mm visual analogue scale on the previous 7 days; had a clinical diagnosis of chronic LBP with a disease diagnosis of more than 6 months; only use of oral non-steroidal anti-inflammatory drugs for pain treatment ***Exclusion:*** Protrusion or prolapse of 1 or more intervertebral discs with concurrent neurological symptoms; radicular pain; prior vertebral column surgery; infectious spondylopathy; low back pain caused by inflammatory, malignant, or autoimmune disease; congenital deformation of the spine; compression fracture caused by osteoporosis; spondylolysis; any acupuncture treatment during the past 12 months	Acupuncture: N = 147 Minimal acupuncture: N = 75 Waiting list control: N = 79	**Score: 10.** Care providers were aware of the acupuncture & sham groups.
Cherkin, 2009	***Inclusion:*** Patients aged 18 to 70 years who were receiving care for a back problem from an integrated health care delivery system; had uncomplicated chronic low back pain within the prior 3 to 12 months ***Exclusion:*** Specific causes of back pain (e.g., cancer, fractures, spinal stenosis, infections); complicated back problems (e.g., sciatica, prior back surgery); possible contraindications for acupuncture (e.g., coagulation disorders, cardiac pacemakers, pregnancy, seizure disorder); conditions making treatment difficult (e.g, paralysis, psychoses); conditions that might confound	Acupuncture: N = 305 Simulated acupuncture: N = 162 Usual care: N = 161	**Score: 11.** Patients in the "usual care" group were twice as likely as those receiving real or simulated acupuncture to report a physician of physical therapist visit or to have visited a CAM medicine provider.

	treatment effects or interpretation of results (e.g., severe fibromyalgia, rheumatoid arthritis, concurrent care from other providers); less than 3 months of back pain; previous acupuncture treatment for any condition		
Cho, 2013	***Inclusion:*** Patients aged 18 to 65 years who had nonspecific chronic LBP lasting for at least the last 3 months; 10-cm VAS for bothersomeness of LBP exceeding 5, and nonspecific, uncomplicated LBP that was intact on neurological examination. ***Exclusion:*** Sciatic pain (i.e., if a patient reported typical radiating pain in the leg as well as one or more neurological indications of nerve root tension or neurological deficit); pain mainly below the knee; serious spinal disorders including malignancy, vertebral fracture, spinal infection, inflammatory spondylitis and cauda equine compression; history of previous spinal surgery or scheduled surgery to address a chronic disease that could interfere with treatment effects (e.g., cardiovascular disease, diabetic neuropathy, fibromyalgia, rheumatoid arthritis, dementia, and epilepsy); acupuncture treatment of LBP during the previous month; conditions that could compromise the safety of acupuncture (e.g., clotting disorders, taking anticoagulant agent, pregnancy, and seizure disorders); severe psychiatric or psychological disorder; and history of use of corticosteroids, narcotics, muscle relaxants, or herbal medicine to treat LBP	Individualized acupuncture: N = 65 Sham acupuncture: N = 65	**Score: 10.** Care providers were aware of the acupuncture & sham groups.
Haake, 2007	***Inclusion:*** Clinical diagnosis of chronic LBP for 6 months or longer; CPGS grade I; HFAQ less than 70%; therapy-free for at least 7 days; at least 18 years old ***Exclusion:*** Treatment with needle acupuncture for low back pain at any time in the past; treatment with needle	Verum acupuncture: N = 387 Sham acupuncture: N = 387 Conventional therapy: N =	**Score: 9.** Care providers were aware of the acupuncture & sham groups. Some patients were given 5 additional

	acupuncture for any other indication within the last year History of spinal fracture (e.g., osteoporosis or trauma) or disc or spinal surgery; infections or tumors of the spine; systemic bone or joint disorders (e.g., rheumatoid arthritis); scoliosis or kyphosis; sciatica or chronic pain from other disease; hemorrhagic disorders or anticoagulant therapy; skin disease in the area of acupuncture; abuse of drugs or pain medication; pregnancy; epilepsy; patient included in any other studies	388	treatments if they experienced a 10 – 50% reduction in pain intensity.
Molsberger, 2002	***Inclusion:*** LBP between the 12th rib and the gluteal fold; pain for 6 weeks or longer; with an average pain score of 50 mm or more on a 100 mm VAS during the last week, age between 20 and 60 years ***Exclusion:*** Sciatica or other neurological disorders; history of disc or spine surgery; systemic bone and joint disorders (e.g. rheumatoid arthritis); previous treatment with acupuncture; overt psychiatric illness; pregnancy; dependent on regular intake of analgesics; incapacity for work longer than 6 months preceding the trial and currently awaiting decision on an application for pension or disability benefits	Acupuncture + conventional therapy: N = 61 Sham acupuncture + conventional therapy: N = 65 Conventional therapy: N = 60	**Score: 10.** Drop-out rate at 3 months was 34%. Blinding was between verum and sham acupuncture, but not between verum and nothing.

Table 21. RCT Details

Treatment Details from RCTs

Based on the treatment strategies examined in the RCTs, we compared acupuncture with usual care. Details about the treatments administered to patients in the RCTs are summarized in Table 22.

Table 22. Treatments Details from RCTs

Study	Study Arms	Treatment details
Brinkhaus, 2006	1. Acupuncture: N = 147 2. Minimal acupuncture: N = 75 3. Waiting list control: N = 79	1. Acupuncture (standardized points based on patient diagnosis and according to TCM until de Qi sensation produced) (n = 147) 2 sessions/week for first 4 weeks, then 1 session/week for next 4 weeks 2. Minimal acupuncture (needles were applied superficially in 6-10 non-acupuncture points, needles not applied in lower back) (n = 75) 2 sessions/week for first 4 weeks, then 1 session/week for next 4 weeks 3. Waiting list/usual care control (n = 79) *Patients were allowed to treat LBP only with oral non-steroidal anti-inflammatory drugs in all treatment arms.
Cherkin, 2009	1. Acupuncture: N = 305 2. Simulated acupuncture: N = 162 3. Usual care: N = 161	1. Individualized acupuncture (points chosen based on patients diagnosis, treatments averaged 10.8 needles) or standardized acupuncture (8 acupuncture points stimulated considered effective by LBP experts, de Qi achieved) (n = 305) 2 treatments/week for first 3 weeks, then one treatment/week for

		next 4 weeks 2. Simulated acupuncture (needles applied superficially at 8 acupuncture points used in standardized treatment) (n = 162) 2 treatments/week for first 3 weeks, then one treatment/week for next 4 weeks 3. Usual care (No study related care - routine care recommended by physician; mostly medications, primary care, physical therapy visits) (n = 161)
Cho, 2013	1. Individualized acupuncture: N = 65. 2. Sham acupuncture: N = 65	1. Acupuncture (perpendicular insertion, points chosen from3 groups of meridian patterns, 5 – 20 mm depth, until de Qi sensation induced) (n = 65) 2 treatments/week for 6 weeks 2. Sham acupuncture (semi-blunt needle without penetration; 8 non-acupuncture points) (n = 65) 2 treatments/week for 6 weeks *Participants were notified they would be dropped from the study if they received any other additional therapy, such as analgesics or physical treatments before primary end point of 8 weeks
Haake, 2007	1. Verum acupuncture: N = 387 2. Sham acupuncture: N = 387 3. Conventional therapy: N = 388	1. Verum acupuncture (verum points, 5-40 mm depth insertion, induction of de Qi) (n = 387) 2 treatments/week for 5 weeks, 5 additional treatments for patients who experience a 10-50% reduction in pain intensity 2. Sham acupuncture (needles applied superficially, avoiding verum points & meridians)

		(n = 387) 2 treatments/week for 5 weeks, 5 additional treatments for patients who experience a 10-50% reduction in pain intensity 3. *Conventional therapy (drugs, physical therapy, and exercise) (n = 388)* *2 treatments/week for 5 weeks, 5 additional treatments for patients who experience a 10-50% reduction in pain intensity (*Information not used for model estimation)* *Use of any other medications besides non-steroidal anti-inflammatory drugs were prohibited
Molsberger, 2002	1. Acupuncture: N = 61 2. Sham acupuncture: N = 65 3. Conventional orthopedic therapy: N = 60	1. Verum acupuncture plus conventional orthopedic therapy. All patients received 12 acupuncture treatments over 3 weeks, each lasting for 30 minutes 2. Sham acupuncture plus conventional orthopedic therapy. 12 sham acupuncture treatments, 3/week, each lasting 30 minutes. Sham acupuncture was standardized to 10 needles applied superficially (depth of insertion was less than 1 cm) at defined non-acupuncture points of the lumbar region, and 5 needles on either side of the back 3. Conventional orthopedic therapy treatment. On a standardized, daily basis patients received physiotherapy, physical exercise, back school, mud packs, infrared heat therapy. On demand they received 50 mg diclofenac up to three times a day. *Injections or cortisone application of any kind were not allowed

RCTs by Brinkhaus et al., Cherkin et al., and Molsberger et al. included three treatment arms: 1) acupuncture + usual care, 2) sham acupuncture + usual care, 3) and usual care alone. The RCT by Cho et al., included 1) acupuncture and 2) sham acupuncture arms, but did not include a usual care treatment. The trial conducted by Haake et al. included 1) acupuncture, 2) sham, and 3) usual care treatment arms. However, patients in the acupuncture and sham treatment groups in this study did not receive the specific treatment regimen that patients underwent in the usual care arm (2 treatments/week of drugs, physical therapy, and exercise). Therefore, participants in the usual care arm in this trial may have had a treatment effect from receiving usual care, and the treatment effect could not have occurred in participants assigned to the acupuncture or sham treatment groups. Thus, results from the usual care group in the Haake et al. trial were not used in the model estimation.

Considering information from the trials, the treatments included in the decision tree included:

i. Acupuncture in addition to usual care,

ii. Usual care.

Assumptions about each approach included in the model were based on the treatment details from the RCTs. Since the majority of trials included 1) acupuncture treatment, in addition to both 2) non-placebo adjusted acupuncture + usual care and 3) usual care alone, we compared acupuncture treatment to placebo-adjusted usual care (labeled as sham acupuncture + usual care in the RCTs) and also compared acupuncture to usual care alone (labeled as usual care or conventional therapy in the RCTs). The treatment specifics assumed for our model are based on details specified in the RCTs and are follows:

i. Acupuncture + usual care: Patients received two acupuncture treatments a week for six weeks, totaling 12 treatments. The length of each acupuncture session was thirty minutes.

ii. Usual care

a. Placebo-adjusted usual care: Sham acupuncture + Usual care: Patients received two sessions of sham acupuncture a week for six weeks, totaling 12 sessions. The length of each sham acupuncture session was thirty minutes.

b. Usual care alone (not placebo-adjusted): Patients received no specifically outlined care – just the care, if any, they and their physicians chose (such as physical therapy, physician visits, exercise, and continued use of medications).

For example, patients randomized to an acupuncture or sham acupuncture group received on average, 11.7 acupuncture treatments over 6 weeks, ranging from 10 treatments (Cherkin, 2009) to 12.5 treatments (Haake et al., 2007) over 3 (Molsberger et al., 2002) to 8 weeks (Brinkhaus et al., 2006). Definitions for acupuncture-related terms are given in Table 23 to provide additional clarification on treatments that were provided to study subjects in these trials.

Table 23. Acupuncture-Related Terms

Term	**Definition and Relevance**
Acupuncture	A healing technique that involves the insertion of needles into the body to promote health. It can be traced back at least 1500 years as part of the healing system in China.
Sham acupuncture	Any intervention designed to make patients believe they are receiving acupuncture. Usually this involves inserting needles superficially and/or at inappropriate sites, and not stimulating them, known as "penetrating" sham. Blunt devices are occasionally used to apply pressure, without penetration.
Styles of acupuncture used in RCTs	
Chinese acupuncture (Carlsson, 2001) Verum (real) acupuncture (Molsberger,	Needles inserted into traditional meridian points, usually with the intention of influencing energy flow in the meridian. Additional tender points

2002) Hegu acupuncture (Yun, 2012) Traditional acupuncture (Leibing, 2002)	may also be used.
Standardized acupuncture (Yun, 2012 & Cherkin 2009)	Acupuncture prescription considered effective by experts for chronic LBP. Includes 8 acupoints (Du 3, Bladder, 23-bilateral, low back ashi point, Bladder-40 bilateral, and Kidney 3-bilateral) on the lower back and leg commonly used for chronic LBP.
Individualized acupuncture (Cherkin, 2009)	Acupuncture treatment prescribed by the Diagnostician for each patient at the beginning of each visit. Treatments averaged 10.8 needles and included any acupoints that could be needled with patient lying prone.

Markov States

In order to construct a Markov model of disease progression, the disease must be defined in terms of different states. The states for this analysis were based on levels of back pain and were chosen because they represented clinically and economically important events in the progression of lower back pain. (Briggs et al., 1998) After reviewing the included trials, outcomes collected for the trials were extracted. As defined in our inclusion criteria, all studies collected pain outcomes. Three of the five studies collected pain intensity outcomes on a visual analogue scale (VAS), while Haake et al. collected pain intensity using the Chronic Pain Grade Scale (CPGS), and Cherkin et al. used a NPS (Numerical Pain Scale) to measure pain level. Details on the pain outcomes collected in each study are described in Table 24.

Table 24. Pain Outcomes Reported in Included Studies

Study	Pain Measurement Reported		Scale
Brinkhaus, 2006	VAS	Pain intensity over the past 7 days on a 0 – 100 mm scale (0, no bothersomeness; 100, worst imaginable bothersomeness)	0 - 100
Cherkin, 2009	NRS: Back pain intensity	Pain severity over the past 7 days on a 0 (pain not at all bothersome) to 10 (pain worst imaginable bothersome) scale	0 -10
Cho, 2013	VAS	Pain severity over past 7 days on a 0 – 10 mm scale (0, absence of bothersomeness; 10, worst imaginable bothersomeness)	0 - 10
Haake, 2007	NRS of back pain-related questions from CPGS *Does not include CPGS disability related questions	The final pain intensity score, which ranges from 0 –100, is calculated as the mean intensity ratings for three reported scores: current, worst, and average back pain over the past 3 months (0, no pain; 100; worst pain possible)	0 - 100
Molsberger, 2002	VAS	Pain intensity using a 100 mm VAS with 0 representing "no pain at all" and 100 representing "most intense pain imaginable." Study did not specify over what time period patients were rating their back pain.	0 - 100

Studies have found the NPS on a 0 – 10 scale (with 0 representing no pain and 10 representing unbearable pain) to be highly correlated (R = .75 - .91) to the 100 mm VAS (0 indicating no pain and 100 indicating worst imaginable pain) in patients with chronic pain conditions. (Hawker, 2011 & Downie 1978) Since Brinkhaus et al., Cho et al., and Molsberger et al. used the VAS to collect pain outcomes and both Cherkin et al. and Haake et al. used versions

of a NRS to measure pain (Cherkin et al. measured pain intensity using a 0 – 10 NRS scale and Haake et al. averaged results from three pain-related NRS questions to calculate a final pain score on a 0 – 100 scale), the comparison of pain severity outcomes from the five trials appeared to be reasonable.

We specified ten pain states based on pain intensity levels that spanned a scale of 0 (no pain) to 100 (most intense pain imaginable). The pain states included were: i) 0 - 10 pain intensity, ii) 11 - 20 pain intensity, iii) 21 - 30 pain intensity, iv) 31 - 40 pain intensity, v) 41 – 50 pain intensity, vi) 51 – 60 pain intensity, vii) 61 – 70 pain intensity, viii) 71 – 80 pain intensity, ix) 81 – 90 pain intensity, and x) 91 – 100 pain intensity. We also included a dead state for persons who died during the two years due to age-related causes. We chose to include ten pain states in our model, instead of a smaller number of pain states, since a study by Todd et al. found that the minimally clinically important change in pain severity with a 100 mm VAS was approximately 13 mm (Todd et al., 1996). We wanted to ensure that we would be able to observe any movements in the cohort that could indicate minimally clinical important changes in pain severity occurring. In addition, a study by Jensen et al. recommended the inclusion of at least ten pain states to ensure sufficient levels of discrimination for chronic pain patients to designate their pain intensity. (Jensen et al., 1994)

The states were mutually exclusive since a patient could not live in more than one state at a time. At the end of each cycle, an individual in a pain state could remain in the same pain state, move to another pain state (improve or decline), or die. The cohort transitioned through the different health states every three months (i.e., cycle length) based on estimated transition probabilities consistent with RCT target data. The transition matrix for the model is shown in Table 25. A depiction of our model structure is shown in Figure 10.

Table 25. Transition Matrix

	Pain Level 1 (0-10)	**Pain Level 2 (11-20)**	**Pain Level 3 (21-30)**	**Pain Level 4 (31-40)**	**Pain Level 5 (41-50)**	**Pain Level 6 (51-60)**	**Pain Level 7 (61-70)**	**Pain Level 8 (71-80)**	**Pain Level 9 (81-90)**	**Pain Level 10 (91-100)**	**Dead**
Pain Level 1 (0-10)	tp1T1	tp1T2	tp1T3	tp1T4	tp1T5	tp1T6	tp1T7	tp1T8	tp1T9	tp1T10	Mp
Pain Level 2 (11-20)	tp2T1	tp2T2	tp2T3	tp2T4	tp2T5	tp2T6	tp2T7	tp2T8	tp2T9	tp2T10	Mp
Pain Level 3 (21-30)	tp3T1	tp3T2	tp3T3	tp3T4	tp3T5	tp3T6	tp3T7	tp3T8	tp3T9	tp3T10	Mp
Pain Level 4 (31-40)	tp4T1	tp4T2	tp4T3	tp4T4	tp4T5	tp4T6	tp4T7	tp4T8	tp4T9	tp4T10	Mp
Pain Level 5 (41-50)	tp5T1	tp5T2	tp5T3	tp5T4	tp5T5	tp5T6	tp5T7	tp5T8	tp5T9	tp5T10	Mp
Pain Level 6 (51-60)	tp6T1	tp6T2	tp6T3	tp6T4	tp6T5	tp6T6	tp6T7	tp6T8	tp6T9	tp6T10	Mp
Pain Level 7 (61-70)	tp7T1	tp7T2	tp7T3	tp7T4	tp7T5	tp7T6	tp7T7	tp7T8	tp7T9	tp7T10	Mp
Pain Level 8 (71-80)	tp8T1	tp8T2	tp8T3	tp8T4	tp8T5	tp8T6	tp8T7	tp8T8	tp8T9	tp8T10	Mp
Pain Level 9 (81-90)	tp9T1	tp9T2	tp9T3	tp9T4	tp9T5	tp9T6	tp9T7	tp9T8	tp9T9	tp9T10	Mp
Pain Level 10 (91-100)	tp10T1	tp10T2	tp10T3	tp10T4	tp10T5	tp10T6	tp10T7	tp10T8	tp10T9	tp10T10	Mp
Dead	0	0	0	0	0	0	0	0	0	0	1

tp: Transition probability; Mp (mortality probability): United States Life Tables

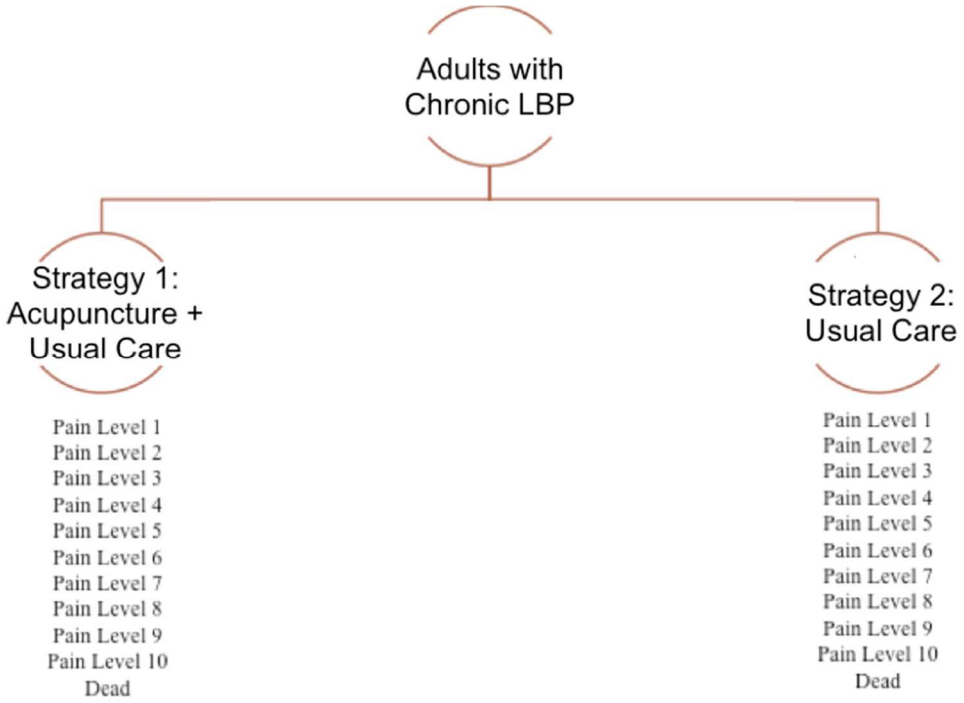


Figure 10. Depiction of model structure

Model Estimation

Pain Intensity Targets Over Time from RCTs

The model was developed over two-year period, consisting of eight three-month cycles. The information used to create the transition matrices for the first year of the model was based on information found in RCTs. Table 26 shows the pain intensity outcomes over time reported by the trials. We chose values for the mean pain and standard deviation of the population during each time period that fit within the range of reported outcomes. Figures 11 – 13 graphically depict the reported RCT outcomes.

Study	Study Arms	Baseline	2 – 3 months following baseline	5 - 6 months following baseline	8 - 9 months following baseline	12 - 13 months following baseline
		(**mean**/SD)	(**mean**/SD)	(**mean**/SD)	(**mean**/SD)	(**mean**/SD)
Brinkhaus, 2006	1. Acupuncture: N = 147 2. Minimal acupuncture: N = 75 3. Waiting list control: N = 79	**63**/13 **67**/16 **66**/14	**35**/29 **44**/30 **59**/25	**38**/30 **42**/30		**39**/29 **45**/30
Cherkin, 2009	1. Acupuncture: N = 305 2. Simulated acupuncture: N = 162 3. Usual care: N = 161	**50**/24 **49**/24 **54**/24	**34**/27 **32**/25 **47**/26	**37**/25 **35**/27 **44**/26		**35**/26 **34**/27 **41**/26
Cho, 2013	1. Individualized acupuncture: N = 65. 2. Sham acupuncture: N = 65	**65**/14 **64**/12	**30**/24 **41**/19	**28**/23 **41**/22	**28**/24 **35**/25	
Haake, 2007	1. Verum acupuncture: N = 387 2. Sham acupuncture: N = 387 3. Conventional therapy: N = 388	**68**/14 **68**/13 **68**/15	**45**/19 **49**/20 **55**/18	**40**/23 **43**/23 **52**/21		
Molsberger, 2002	1. Acupuncture: N = 61 2. Sham acupuncture: N = 65 3. Conventional orthopedic therapy: N = 60	**68**/17 **64**/11 **67**/14	**23**/20 **43**/23 **52**/19			

Table 26. Pain intensity outcomes over time from RCTS

Figure 11. Acupuncture + Usual Care

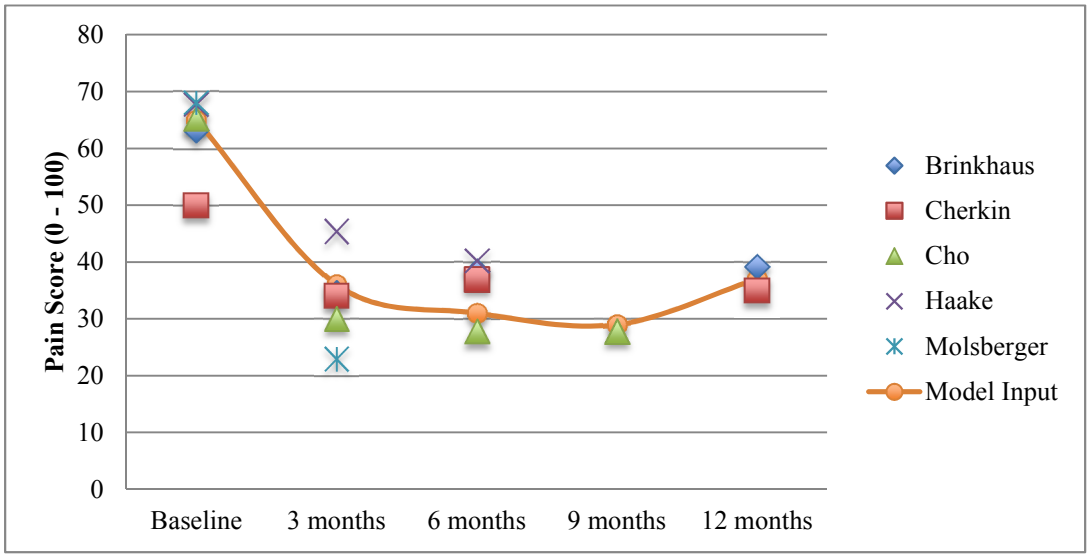


Figure 12. Placebo-adjusted usual care (Sham + Usual Care)

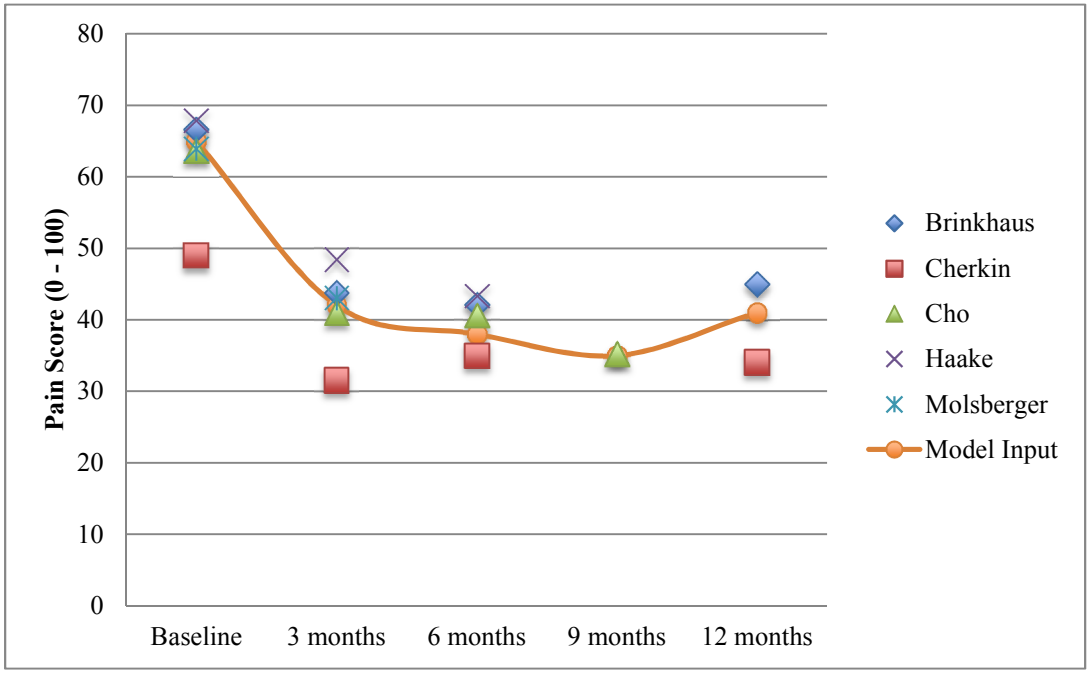
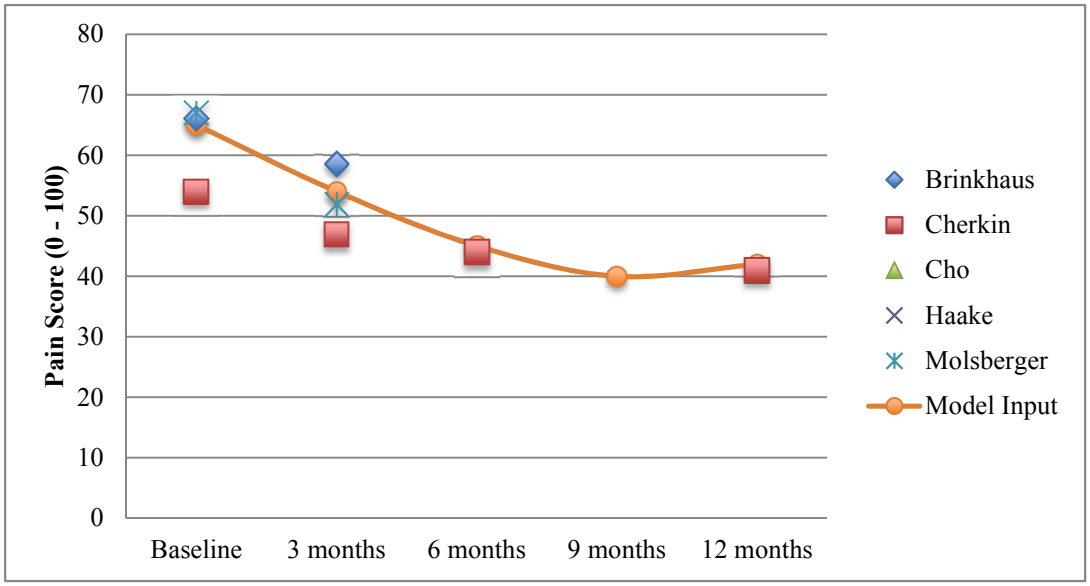


Figure 13. Usual Care

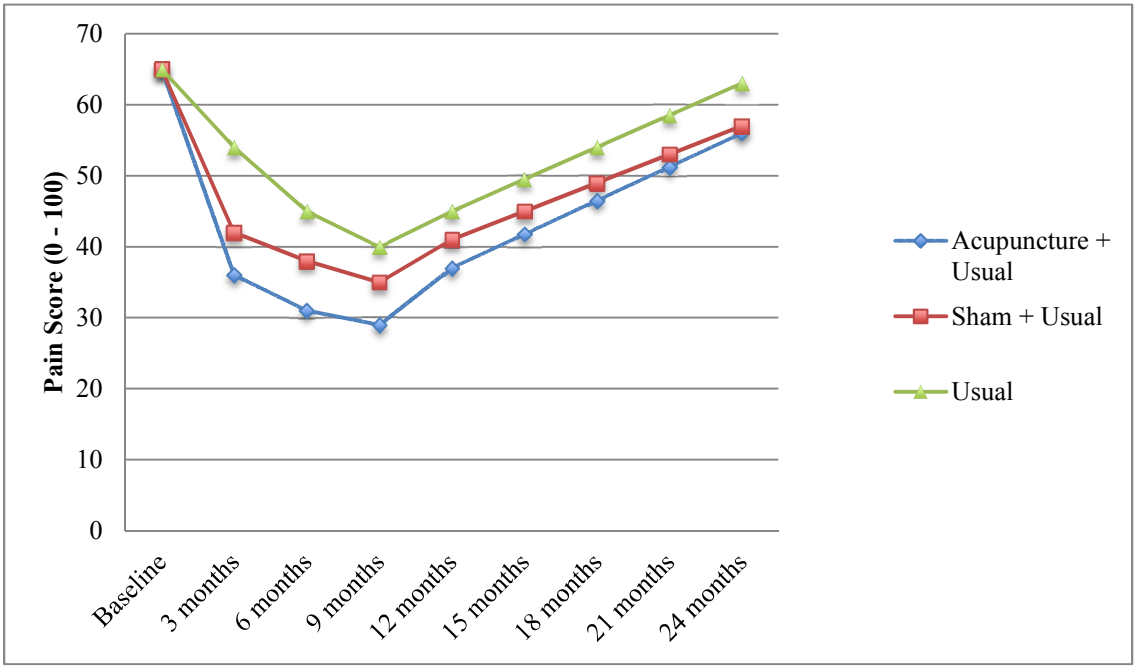


The RCTs we examined did not follow-up with patients past 12 months. Therefore, we used an article by Thomas et al., which reported longer-term clinical benefits of offering acupuncture versus usual care, to extrapolate pain intensity results over the second year. (Thomas et al., 2006) At two years, the study reported patients in the acupuncture and sham acupuncture groups were at 85% of their original pain level, and patients in the usual care group reached 96% of their original pain level. We assumed that the cohort progressed linearly over the last four periods of the analysis, from 12 months to the endpoints at 24 months. The target pain distributions over time determined from the literature are listed in Table 27 and graphically depicted in Figure 14.

Table 27. Target Distributions

	Acupuncture (mean/SD)	Sham (mean/SD)	Usual (mean/SD)
Baseline	**65**/14	**65**/14	**65**/14
3 months	**36**/15	**42**/16	**54**/17
6 months	**31**/17	**38**/18	**45**/20
9 months	**29**/20	**35**/20	**40**/23
12 months	**37**/21	**41**/22	**45**/24
15 months	**41.75**/23	**45**/23	**49.5**/25
18 months	**46.5**/25	**49**/25	**54**/26
21 months	**51.25**/26	**53**/27	**58.5**/27
24 months	**56**/27	**57**/28	**63**/28

Figure 14. Pain Severity Model Inputs over 24 months



Transition Matrices Calculation

To calculate the transition matrices, we utilized linear programming optimization available in MATLAB's optimization toolbox. (MATLAB, 2014) Within the optimization toolbox, we used the linprog command to define target parameter values, based on the target population mean and standard deviations over time, and constraints for each of the transition matrices to be estimated. Matrices of best fit were then generated that closely replicated the defined target values. As an optimization constraint, we specified that patients could not make movements greater than four pain states in either direction to more closely model realistic back pain progression within this population.

During the transition matrix optimization process using MATLAB, we excluded the dead state. We determined sixteen 10 x 10 transition matrices, representative of movements of the population within the ten pain states. Sixteen transition matrices were generated in total, because four distinct transition matrices were calculated for each treatment arm for the first four cycles of the model, and one transition matrix for each treatment arm was calculated for movements during the second year of the model. Appendices 6, 7, and 8 show the calculated transition matrices that fit our pain intensity changes over time for 1) acupuncture + usual care, 2) sham + usual care, and 3) usual care. After optimization of the matrices was completed, the mortality probabilities for transitioning to the dead state were determined using the United States Life Tables.

Transition Matrices Verification

Goodness-of-Fit (GOF) Metric

In order to better understand the ability of our calculated transition matrices to replicate the target data, we used a quantitative goodness-of-fit (GOF) metric. The GOF metric used was a mean squared error (MSE). If $\hat{Y}$ is a vector of n predictions determined from the model, and Y is the vector of the true values of the targets, then the estimated MSE of the predictor is:

$$\mathrm{MSE} = \frac{1}{n}\sum_{i=1}^{n}(\hat{Y}_i - Y_i)^2.$$

Formula 1.

Our acceptance criteria was a MSE ≤ .00156. Since the distribution of our population over time among 10 health states was being compared between the predicted and target data, this resulted in a MSE = $(\frac{1}{10})\sum_1^{10}(\hat{y}i - yi)^2$. If each value in the predicted population distribution vector was within .0125 of the target vector, the MSE ≤ .00156. We calculated the MSE of model fit for each of the sixteen transition matrices, resulting in sixteen MSE values. Appendix 9 shows the predicted and target population distribution vectors over time for each treatment arm, and Appendix 10 shows the MSE results. All resultant MSE met our defined acceptance criteria.

Transitions to Dead State

In addition to the ten pain states in our model, we also included a dead state. We incorporated age-specific mortality rates for 50-year old persons. (National Center for Health Statistics and US Census Bureau, 2009).

Costs

In order to determine the back-pain related costs/cycle for the various levels of pain included in our model, we referred to a study by Engel et al. in which they determined back-pain related costs per year for five levels of pain included in the Von Korff CPGS. The five levels of pain ranged from 0 (pain free) to IV (high disability and severely limiting pain). We adjusted the results from this study by taking into the account the effect of inflation from 1996 to 2014. Table 28 shows the costs per model cycle by Von Korff CPGS levels, and Table 29 shows an approximate breakdown of the services and other items comprising the back-pain related costs estimated by Engel et al. (Engel et al., 1996)

Table 28. Back-pain related costs (Engel et al., 1996)

Chronic Pain Grade (Von Korff)	1996 Back-pain related costs/year	2014 Back pain related costs/year (1996 costs adjusted for inflation)	Costs per 3 month cycle
0	$0	$0	$0
I	$249	$375	$94
II	$413	$622	$156
III	$601	$905	$226
IV	$1164	$1,752	$438

Table 29. Breakdown of items included in back-pain related costs (Engel et al., 1996; Dagenais et al., 2008)

Non-physician services (28%)	PT (17%), chiropractic manipulation (5%), mental health services (1%), other services (5%)
Hospital costs (39%)	Inpatient (17%), outpatient (8%), diagnostic imaging (7%), surgery (5%), ED services (2%)
Outpatient physician services (20%)	Primary care (13%), specialists (7%)
Medications (13%)	

Next, we mapped the costs/cycle per Von Korff pain level to the 0 – 100 pain scale applicable to health states included in our model. Pain measured using a 0 – 100 mm VAS has been shown to be highly correlated (R = 0.71– 0.78) with a five-point verbal descriptive scale ("none," "mild," "moderate," "severe," and "very severe"), when the following cut points were used: no pain (0 – 4 mm), mild pain (5– 44 mm), moderate pain (45–74 mm), severe pain (75– 85 mm) and very severe pain (86 mm – 100 mm) (Hawker et al., 2011; Downie et al., 1978). This five-point verbal description is similar to the five levels of the Von Korff CPGS, so we linked the

mean VAS values of each of the five levels of the descriptive scale to the 2014 back-pain related costs/cycle for each Von Korff CPGS level. We show this relationship mapping in Table 30.

Table 30. Relating Von Korff CPGS back-pain related costs/cycle to VAS (0 – 100 mm) values

Von Korff CPGS	Description of Von Korff CPGS	Back-pain related costs/cycle	Mean VAS (0 – 100 mm) on 5-point descriptive scale	Description of pain on 5-point scale
I	Pain free	$0	2	None
II	Low disability – low intensity	$94	25	Mild
III	Low disability-moderately limiting	$156	60	Moderate
IV	High disability – moderately limiting	$226	80	Severe
V	High disability – severely limiting	$438	93	Very severe

Then, using a regression line of best fit derived from the costs/cycle and corresponding mean VAS values, shown in Figure 15, we calculated the cost of back pain per cycle using the mean value of each pain level included in our model. The costs/cycle by pain level is shown in Table 31. Since the pain outcomes incorporated in our model were based on the VAS or NRS, which is strongly correlated with VAS results, we felt it suitable to calculate costs/cycle based on corresponding VAS pain levels.

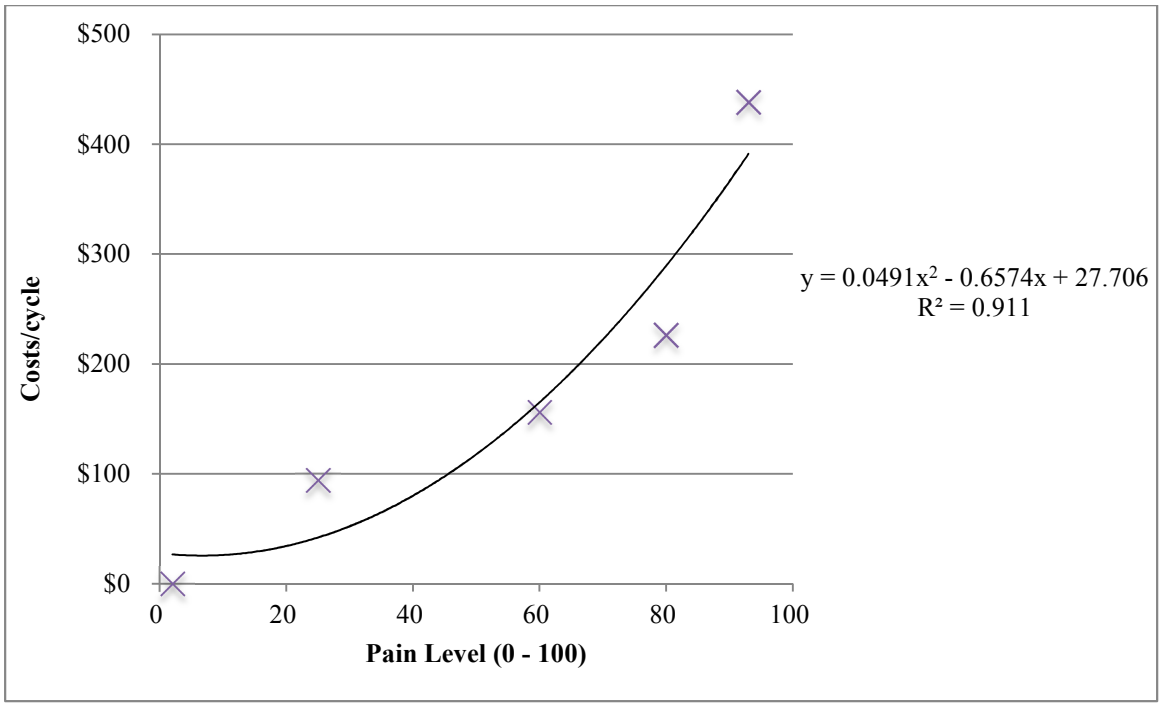


Figure 15. $/Pain Level

Table 31. Costs/per pain level

Pain Level	Cost per cycle
0 – 10 (x = 5)	$26
11 – 20 (x = 15)	$29
21 – 30 (x = 25)	$42
31 – 40 (x = 35)	$65
41 – 50 (x = 45)	$98
51 – 60 (x = 55)	$140
61 – 70 (x = 65)	$192
71 – 80 (x = 75)	$255
81- 90 (x = 85)	$327
91 – 100 (x = 95)	$408

In addition to measuring back-pain related costs, we included $900 for costs of acupuncture during the initial cycle (12 sessions for $75/session). Costs per session of acupuncture typically range from $50 to $100 in the United States (Sierpina et al., 2005).

Health-Related Quality of Life (QoL)

To determine the QoL utilities associated with our back pain states, we used utilities determined by the Health Utilities Index Mark 3 (HUI: 3) multi-attribute utility function. (Feeny et al., 2002) Table 32 shows the utility values assigned for levels of eight health attributes, including pain.

Table 32. HUI: 3 multi–attribute utility function on a dead-perfect health scale

Vision		Hearing		Speech		Ambulation		Dexterity		Emotion		Cognition*		Pain	
x_1	b_1	x_2	b_2	x_3	b_3	x_4	b_4	x_5	b_5	x_6	b_6	x_7	b_7	x_8	b_8
1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00	1	1.00
2	0.98	2	0.95	2	0.94	2	0.93	2	0.95	2	0.95	2	0.92	2	0.96
3	0.89	3	0.89	3	0.89	3	0.86	3	0.88	3	0.85	3	0.95	3	0.90
4	0.84	4	0.80	4	0.81	4	0.73	4	0.76	4	0.64	4	0.83	4	0.77
5	0.75	5	0.74	5	0.68	5	0.65	5	0.65	5	0.46	5	0.60	5	0.55
6	0.61	6	0.61	6	n/a	6	0.58	6	0.56	6	n/a	6	0.42	6	n/a

Formula (Dead-Perfect Health Scale)

$$u^* = 1.371\ (b_1{*}b_2{*}b_3{*}b_4{*}b_5{*}b_6{*}b_7{*}b_8) - 0.371$$

where u* is the utility of a chronic health state† on the utility scale where dead‡ has a utility of 0.00, and healthy† has a utility of 1.00.

Using information from the HUI: 3, we were able to assign utilities for pain levels 1 (free of pain) to 5 (severe pain) by using the utility values provided in Table 32 and incorporating those values into the HUI: 3 multi-attribute utility formula. In order to calculate conservative QoL utility estimates, we assumed utility values of 1.00 for all other health attributes included in the utility formula.

Formula 2. $u^* = 1.371\ (b_1{*}b_2{*}b_3{*}b_4{*}b_5{*}b_6{*}b_7{*}b_8) - 0.371$

Details of pain levels, descriptions of pain, and utilities for each pain level determined from the HUI: 3 are shown in Table 33.

Table 33. HUI 3 utilities (u*) by pain level

HUI: 3 Pain Levels	HUI: 3 Description of Pain	u*
1	Free of pain	1.00
2	Mild to moderate pain that prevents no activities	0.96
3	Moderate pain that disrupts a few activities	0.90
4	Moderate to severe pain that prevents some activities	0.77
5	Severe pain that prevents most activities	0.55

Next, similar to our methods when determining costs/cycle, we mapped the HUI levels of pain to the 0 – 100 pain scale included in our model. As mentioned previously, pain collected on a 0 – 100 mm VAS has been found to be highly correlated (R = 0.71– 0.78) with a five-point verbal descriptive scale ("none," "mild," "moderate," "severe," and "very severe"), for the following VAS cut points: no pain (0 – 4 mm), mild pain (5– 44 mm), moderate pain (45–74 mm), severe pain (75– 85 mm) and very severe pain (86 mm – 100 mm) (Hawker, 2011 & Downie, 1978). The HUI descriptions of the five levels of pain are similar to the five-point descriptive scale applied to the VAS. Thus, we associated the HUI "free of pain" description with "no pain" on the VAS scale (0 – 4 mm), "mild to moderate pain that disrupts no activities" on the HUI scale with "mild pain" on the VAS scale (5 – 44 mm), "moderate pain that disrupts a few activities" on the HUI scale to "moderate" pain on the VAS scale (45 – 74 mm), "moderate to severe pain that prevents some activities" on the HUI scale with "severe" on the VAS scale (75 – 85 mm), and "severe pain that prevents most activities" on the HUI scale with "very severe" on the VAS scale (86 – 100 mm). We show this association between HUI pain levels, utilities, and VAS pain levels in Table 34.

Table 34. Mapping HUI: 3 back pain levels to VAS (0 – 100 mm)

HUI: 3 Pain Levels	HUI: 3 Description of Pain	u* using HUI: 3	VAS range; Mean VAS (0 – 100 mm) on descriptive scale	Description of pain on verbal description scale
1	Free of pain	1.00	2	None
2	Mild to moderate pain that prevents no activities	0.95	25	Mild
3	Moderate pain that disrupts a few activities	0.86	60	Moderate
4	Moderate to severe pain that prevents some activities	0.68	80	Severe
5	Severe pain that prevents most activities	0.38	93	Very severe

Then, using a linear regression line of best fit derived from the HUI: 3 QoL utilities and matching mean VAS values (depicted in Figure 16), we estimated the QoL utilities from 0 (dead) to 1 (perfect health) of each pain level included in our model. The QoL utilities by pain level are shown in Table 35.

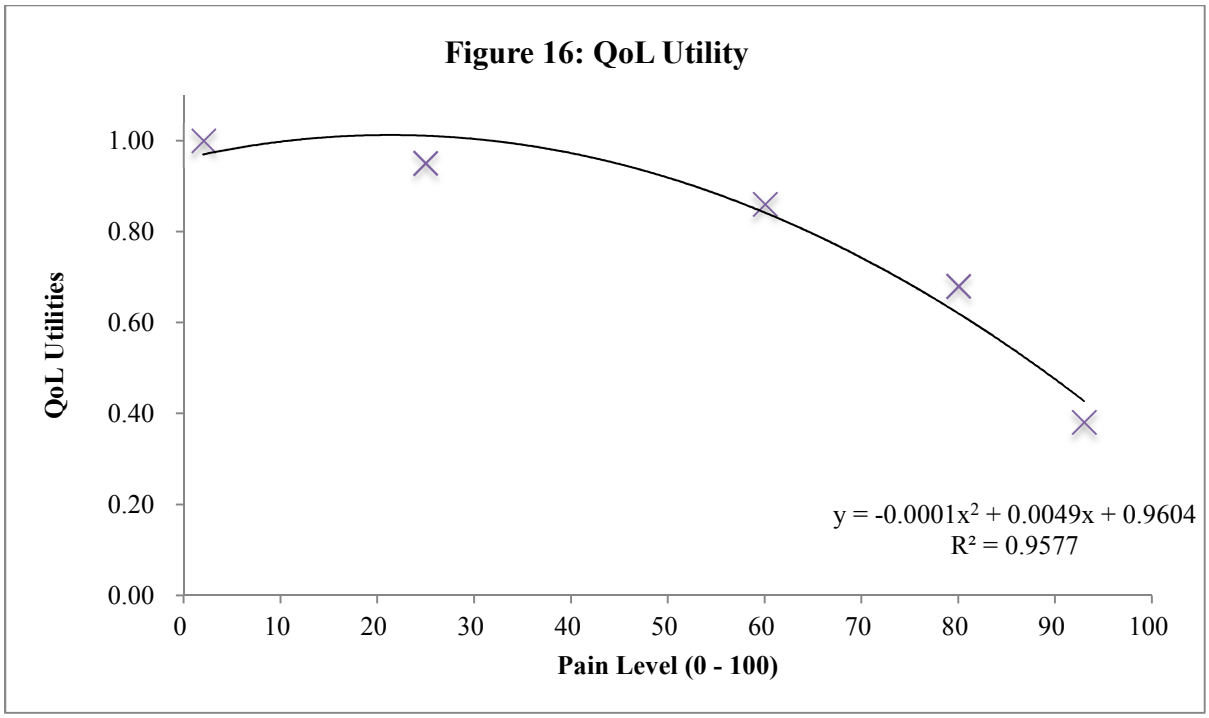


Figure 16. QoL Utility

Table 35. QoL utilities/per pain level

Pain Level	Cost per cycle
0 – 10 (x = 5)	1.00
11 – 20 (x = 15)	1.00
21 – 30 (x = 25)	1.00
31 – 40 (x = 35)	1.00
41 – 50 (x = 45)	0.98
51 – 60 (x = 55)	0.93
61 – 70 (x = 65)	0.86
71 – 80 (x = 75)	0.77
81- 90 (x = 85)	0.65
91 – 100 (x = 95)	0.52

Though our calculated QoL utilities may seem low for individuals in the 81 – 90 and 91 – 100 pain states, a small proportion of individuals in our model exist in those states. At baseline, 10.5% of our cohort was in the 81 – 90 pain state and 3.7% was the 91 – 100 state. At one year, 1.0% of the population was in the 81 – 90 pain level and 0.2% in the 91 – 100 pain level, and at the end of the two years, 8.1% of the cohort was in the 81 – 90 pain state and 5.0% in the 91 – 100 state.

Analysis

Cost-Effectiveness Analysis

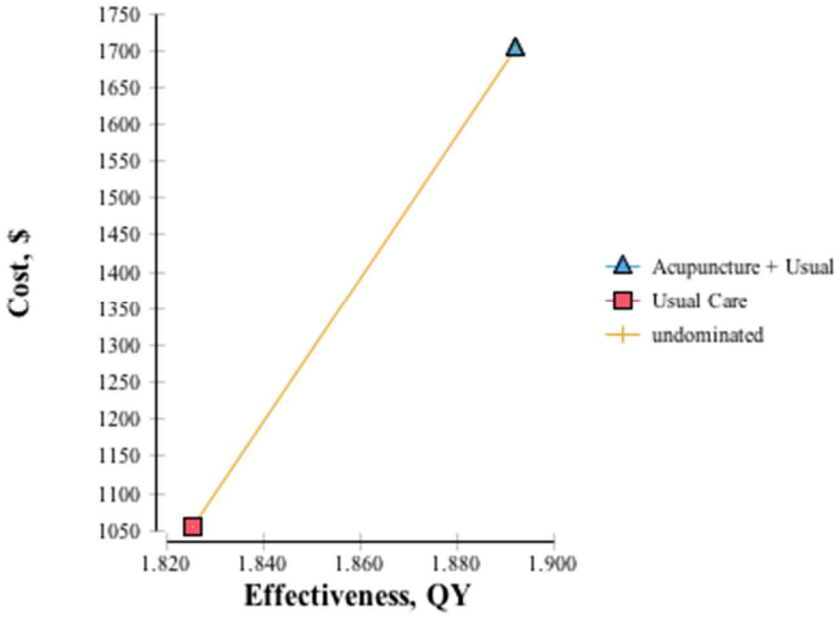
The outputs from the model were costs and quality-adjusted life years over a two-year period. Incremental analyses were performed by rank ordering 1) acupuncture + usual care and 2) usual care by increasing effectiveness. We also compared 1) acupuncture + usual care with 2) placebo-adjusted usual care. Then, the incremental cost-effectiveness ratios (ICER) were calculated between the strategies (additional cost divided by additional benefit). Costs and life years were discounted at an annual rate of 3%. All analyses were performed by TreeAge Pro 2014. (TreeAge Software, 2014)

Results

For our cohort of 50-year old US adults with chronic LBP, non-placebo adjusted usual care resulted in a discounted gain of 1.83 QALY and a cost of $1,055 over two years while placebo-adjusted usual care resulted in 1.87 QALY and cost $915. Acupuncture in addition to usual care resulted in a discounted gain of 1.89 QALY and a cost of $1,702 over two years. The ICER, derived from the non-placebo adjusted usual care versus acupuncture treatment results was $9,679 per QALY, and the ICER comparing placebo-adjusted usual care with acupuncture resulted in an ICER of $29,323/QALY. In the United States, an ICER threshold below

$100,000/QALY is typically accepted in the medical literature. (Shiroiwa et al., 2010) Therefore, both the ICER comparing acupuncture to non-placebo adjusted usual care and the ICER comparing acupuncture to placebo-adjusted usual care treatments are significantly less than the accepted threshold. For our sensitivity analyses, we focused on acupuncture compared with placebo-adjusted usual care since the non-placebo adjusted usual care strategy was more expensive and less effective than the placebo-adjusted usual care strategy in all analyses. The base-case cost-effectiveness results comparing acupuncture with non-placebo-adjusted usual care are shown in Figure 17 and listed in Table 36, while the results comparing acupuncture with placebo-adjusted usual care are depicted in Table 37 and shown in Figure 18.

Figure 17. Base-case cost-effectiveness analysis: Acupuncture versus non-placebo adjusted usual care



Strategy	Cost ($)	Incremental Cost ($)	Effectiveness (QALY)	Incremental Effectiveness (QALY)	ICER ($/ICER)
Usual Care	1055		1.83		
Acupuncture + Usual Care	1702	648	1.89	0.07	9678.54

Table 36. Base-case cost-effectiveness results: Acupuncture versus non-placebo adjusted usual care

Table 37. Base-case cost-effectiveness analysis: Acupuncture versus placebo-adjusted usual care

Strategy	Cost ($)	Incremental Cost ($)	Effectiveness (QALY)	Incremental Effectiveness (QALY)	ICER ($/ICER)
Placebo-adjusted Usual Care	915		1.87		
Acupuncture + Usual Care	1702	787	1.89	0.03	29322.88

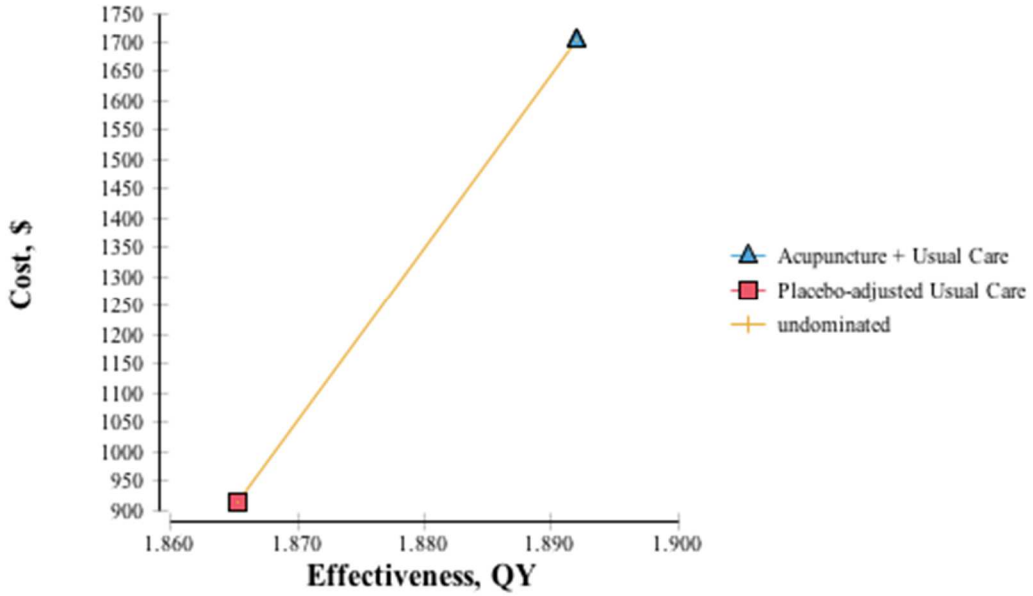


Figure 18. Base-case cost-effectiveness results: Acupuncture versus placebo-adjusted usual care

Sensitivity Analysis

One-way sensitivity analyses were performed on back-pain related costs, acupuncture costs, QoL utilities, and pain intensity changes over time in the model in order to evaluate the effect of changing baseline estimates within clinically reasonable ranges on our results. All sensitivity analyses compared acupuncture with placebo-adjusted usual care, since the ICERs between these two strategies were larger for all analyses as compared to the resultant ICERs of acupuncture versus non-placebo-adjusted usual care.

Back-pain Related Costs – Linear Relationship Between VAS verbal description & Von Korff Mapping

In our base-case analysis, we used a quadratic line of best fit between back-pain related costs/cycle and corresponding VAS pain levels. For our one-way structural sensitivity analysis for back-pain related costs, we used back-pain related costs derived from a linear regression line of best fit based on the costs/cycle and related mean VAS values we previously determined. The back-pain related costs/cycle by pain level found from the linear regression is depicted in Figure 19 and Table 38.

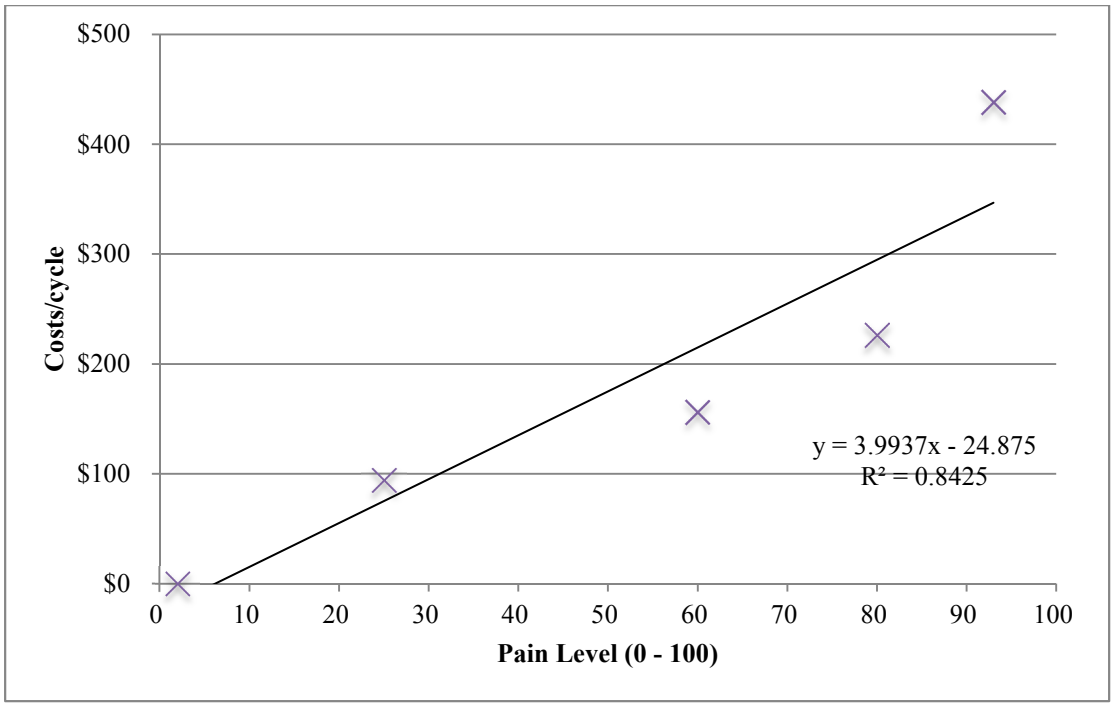


Figure 19. $/Pain Level

Table 38. Costs/per pain level

Pain Level	Cost per cycle
0 – 10 (x = 5)	$0
11 – 20 (x = 15)	$35
21 – 30 (x = 25)	$75
31 – 40 (x = 35)	$115
41 – 50 (x = 45)	$155
51 – 60 (x = 55)	$195
61 – 70 (x = 65)	$235
71 – 80 (x = 75)	$275
81- 90 (x = 85)	$315
91 – 100 (x = 95)	$355

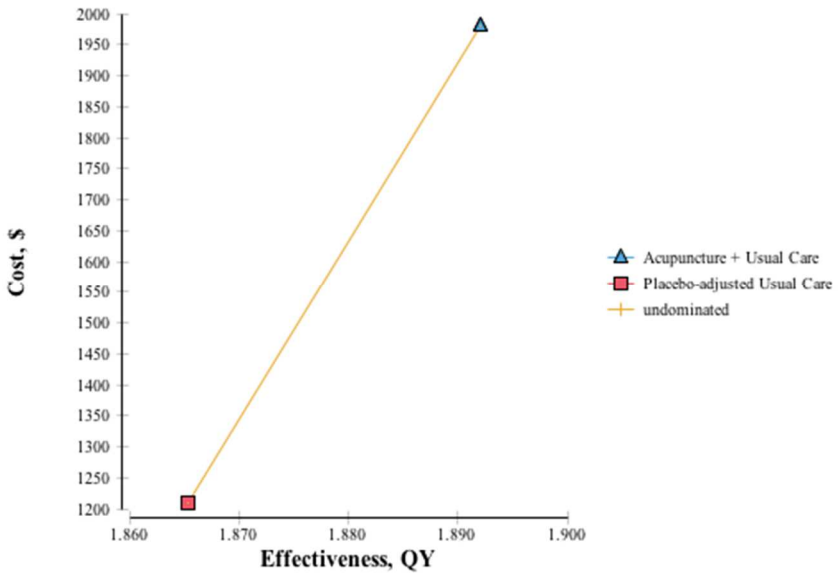


Figure 20. Cost-effectiveness results based on back-pain related costs from a linear regression

Strategy	Cost ($)	Incremental Cost ($)	Effectiveness (QALY)	Incremental Effectiveness (QALY)	ICER ($/ICER)
Placebo-adjusted Usual Care	1209		1.87		
Acupuncture + Usual Care	1980	771	1.89	0.03	28728.78

Table 39. Cost-effectiveness results based on back-pain related costs from a linear regression

Results from using these back-pain related costs did not vary considerably from our base-case results and are depicted in Figure 20 and Table 39. Discounted costs for placebo-adjusted usual care was $1,209 for an effectiveness of 1.87 QALY over two years, and acupuncture in addition to usual care cost $1,980 for an effectiveness of 1.89 QALY, resulting in an ICER of $28,729/QALY between the two strategies - an almost identical figure as compared to our base-case analysis.

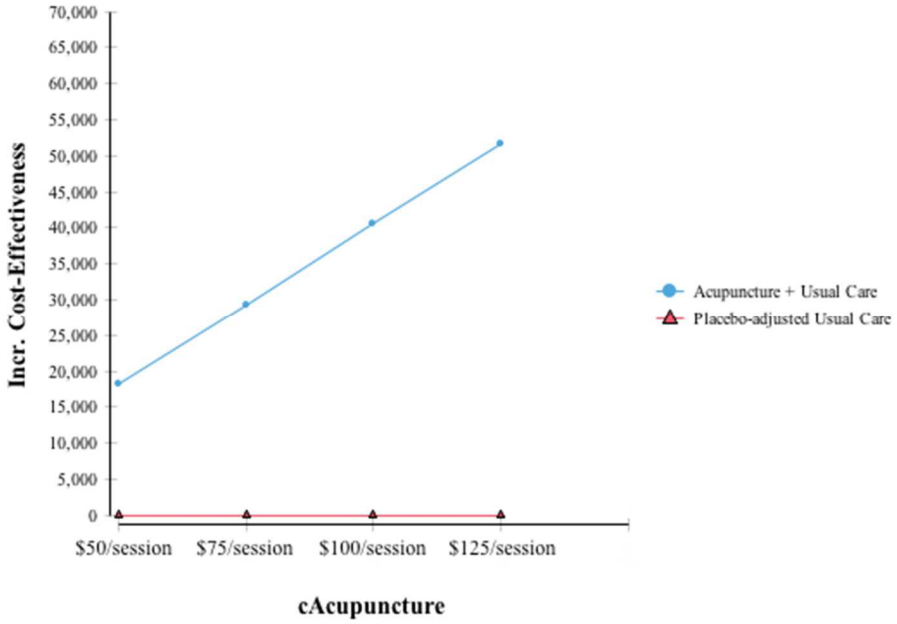
Acupuncture Costs

In our base case analysis, we assumed the cost of an acupuncture session to be $75 ($900 for 12 sessions). However, in our sensitivity analysis we varied the costs per session from a lower threshold of $50 per session (or $600 for 12 sessions) to $100 per acupunctures session ($1200 for 12 sessions) based on a study by Sierpina et al. which found that acupuncture costs per session in the United States ranged from $50 to $100. (Sierpina et al., 2005) Table 40 shows results of a one-way sensitivity analysis if acupuncture costs were varied from $50/session to $100/session, and acupuncture in addition to usual care was found to be a cost-effective strategy as compared to placebo-adjusted usual care, with ICERs between the two treatments equal not exceeding the threshold of $100,000/QALY in both scenarios. We found that the ICER comparing acupuncture in addition to usual care with placebo-adjusted usual care exceeded the $100,000/QALY ICER threshold when the costs per acupuncture session were $225. Sensitivity analysis results are depicted in Figure 21.

VARIABLE	Strategy	Cost ($)	Incremental Cost ($)	Effectiveness (QALY)	Incremental Effectiveness (QALY)	ICER ($/ICER)
$50/session	**Placebo-adjusted Usual Care**	915.30		1.87		
	Acupuncture + Usual Care	1402.33	487.03	1.89	0.03	18145.57
$75/session	**Placebo-adjusted Usual Care**	915.30		1.87		
	Acupuncture + Usual Care	1702.33	787.03	1.89	0.03	29322.88
$100/session	**Placebo-adjusted Usual Care**	915.30		1.87		
	Acupuncture + Usual Care	2002.33	1087.03	1.89	0.03	40500.19
$125/session	**Placebo-adjusted Usual Care**	915.30		1.87		
	Acupuncture + Usual Care	2302.33	1387.03	1.89	0.03	51677.51

Table 40. Cost-effectiveness results from one-way sensitivity analysis of acupuncture costs

Figure 21. ICERs when acupuncture costs vary from $50/session - $125/session



QoL Utilities

In a structural sensitivity analysis, we varied QoL utilities from our base case analysis, by using a linear regression line of best fit instead of a quadratic regression line of best fit between HUI: 3 utilities and VAS descriptive pain levels to calculate QoL for the pain levels in our model. The linear regression line of best fit we calculated is depicted in Figure 22 and the final QoL utilities per pain level used in this sensitivity analysis are listed in Table 41. Cost-effectiveness results from varying QoL utilities did not vary significantly from our base-case results, with a resultant ICER of $17,319/QALY between acupuncture and placebo-adjusted usual care. Results are listed in Table 42.

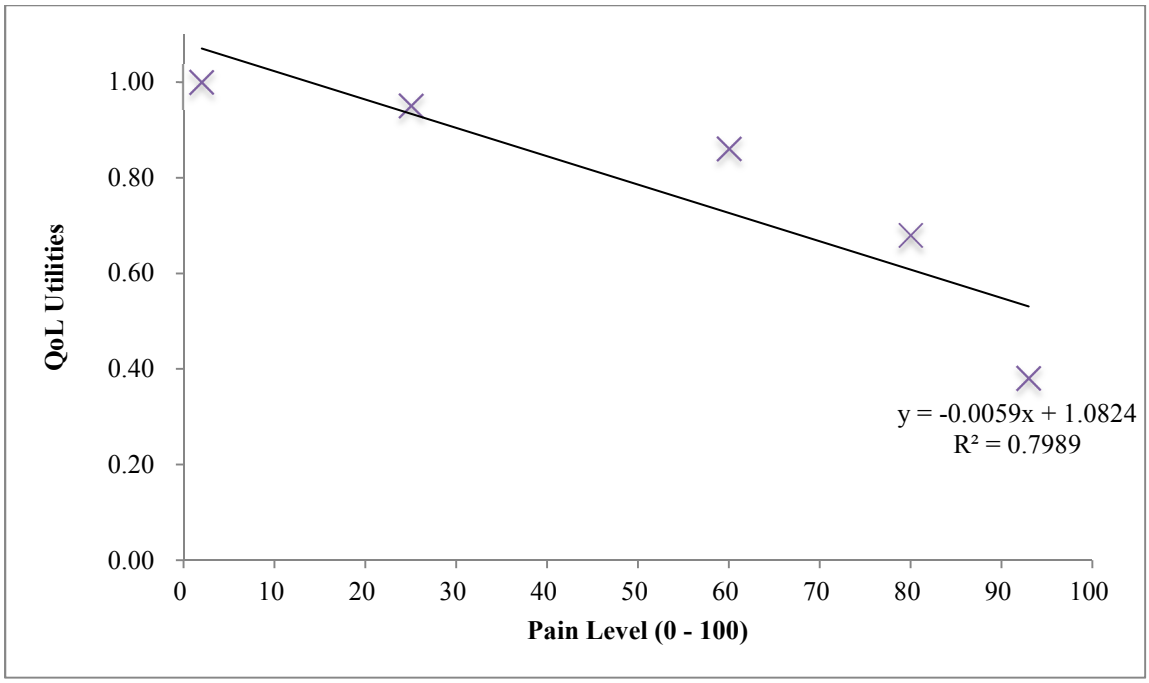


Figure 22. QoL Utility

Table 41. QoL utilities/per pain level

Pain Level	Cost per cycle
0 – 10 (x = 5)	1.00
11 – 20 (x = 15)	0.99
21 – 30 (x = 25)	0.93
31 – 40 (x = 35)	0.88
41 – 50 (x = 45)	0.82
51 – 60 (x = 55)	0.76
61 – 70 (x = 65)	0.70
71 – 80 (x = 75)	0.64
81- 90 (x = 85)	0.58
91 – 100 (x = 95)	0.52

Strategy	Cost ($)	Incremental Cost ($)	Effectiveness (QALY)	Incremental Effectiveness (QALY)	ICER ($/ICER)
Placebo-adjusted Usual Care	915		1.63		
Acupuncture + Usual Care	1702	787	1.68	0.05	17419.10

Table 42. Cost-effectiveness results from using QoL values based on a linear regression

Pain Intensity over Time – Quadratic changes from 12 – 24 months

In a structural sensitivity analysis, we varied the last 12 months of our pain severity model inputs. We varied the progression of pain severity over the last 12 months from a linear relationship to a curved, exponentially increasing progression to our end-points. These pain severity model inputs are listed in Table 43 and depicted in Figure 23. Appendices 11, 12, and 13 show the calculated transition matrices to fit these pain intensity changes over time. Cost-effectiveness results from this structural sensitivity analysis are depicted in Figure 24 and Table 44 and do not differ significantly from our base case analysis. In this analysis, the ICER comparison acupuncture in addition to usual care versus placebo-adjusted usual care is $32,632/QALY, which is significantly below the ICER threshold of $100,000/QALY.

Table 43. Target Distributions

	Acupuncture (mean/SD)	**Placebo-adjusted Usual Care (mean/SD)**	**Usual Care (mean/SD)**
Baseline	**65**/14	**65**/14	**65**/14
3 months	**36**/15	**42**/16	**54**/17
6 months	**31**/17	**38**/18	**45**/20
9 months	**29**/20	**35**/20	**40**/23
12 months	**37**/21	**41**/22	**45**/24
15 months	**44**/23	**46**/23	**50**/25
18 months	**50**/25	**52**/25	**57**/26
21 months	**55**/26	**56**/27	**63**/27
24 months	**56**/27	**57**/28	**63**/28

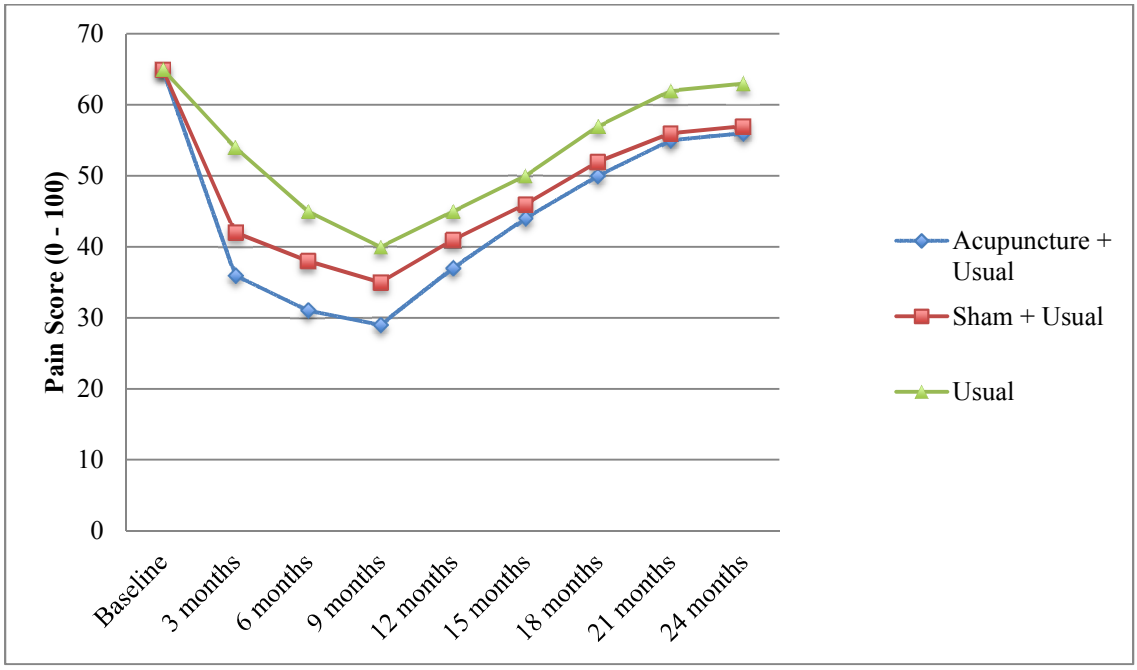


Figure 23. Pain Severity Model Inputs over 24 Months

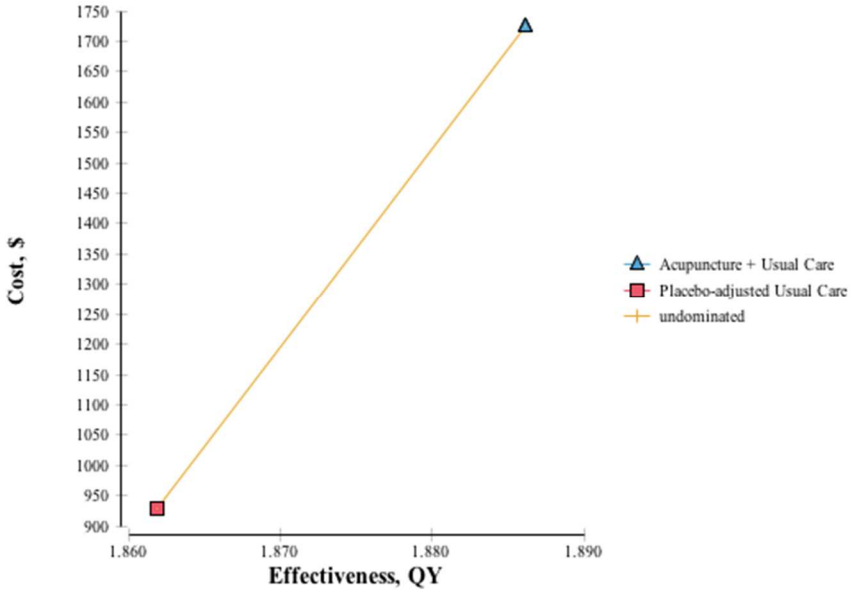


Figure 24. Cost-effectiveness results from varying target pain severity inputs from 12- 24 months

Strategy	Cost ($)	Incremental Cost ($)	Effectiveness (QALY)	Incremental Effectiveness (QALY)	ICER ($/ICER)
Placebo-adjusted Usual Care	928		1.86		
Acupuncture + Usual Care	1724	796	1.89	0.02	32632.41

Table 44. Cost-effectiveness results from varying target pain severity inputs from 12–24 months

Discussion

According to our analysis, acupuncture (in addition to usual care) cost $787 more than placebo-adjusted usual care and resulted in 0.03 additional quality-adjusted years. The added benefit of 0.03 quality-adjusted years, or 10 quality-adjusted days, reflects the improved symptom relief afforded by acupuncture treatment. The incremental cost-effectiveness ratio of acupuncture compared to placebo-adjusted usual care was $29,323 per quality-adjusted life year, which is significantly below our $100,000/QALY ICER threshold commonly accepted within the medical literature. (Shiroiwa et al., 2010)

The analysis was not sensitive to changes in model parameters. The incremental cost-effectiveness ratio of acupuncture compared to placebo-adjusted usual care did not vary considerably (ranged from $17,419/QALY to $32,632/QALY) when varying back-pain related costs, quality-of-life utilities, or the pattern of pain intensity changes over time (from 12 to 24 months). The analysis was most sensitive to the cost of acupuncture per session. In our one-way sensitivity analysis, we varied the costs of acupuncture per session from $50 to $100, the average range of acupuncture costs per session in the United States. (Sierpina et al., 2005) This resulted in the incremental cost-effective ratios of acupuncture (in addition to usual care) versus placebo-adjusted usual care to range from $18,146/QALY to $40,500/QALY. We found that the ICER between the two strategies exceeded the $100,000/QALY ICER threshold when the cost per acupuncture session exceeded $225.

In this analysis, sham acupuncture was included as a placebo control. In the past few decades, a number of trials have investigated the efficacy of acupuncture as a treatment for chronic LBP, and most of these trials have included a sham or 'placebo' acupuncture arm as a control procedure. These control procedures often involve minimal or superficial needling of the skin and/or needling of non-acupuncture points. However a widespread concern in acupuncture research is that no satisfactory placebo for acupuncture has been developed, which may make it difficult to differentiate the therapeutic effects of the treatment setting from the effects of acupuncture treatment. (Streitberger et al., 1998) Sham acupuncture is often viewed as insufficient as a control procedure, because studies have found that even superficial needling of the skin at non-acupuncture points produces physiological effects due to mechanisms such as the activation of ergo-receptors, which triggers pain-suppressing systems in the spinal cord, and deactivation of limbic structures, which are involved in minimizing the sensory component of pain. Therefore, many do not regard sham or 'placebo' acupuncture as a control procedure. (Lund, 2006) We included placebo-adjusted usual care, or sham acupuncture in addition to usual care in our model due to the lack of a better control alternative, although in the future, the development of a better acupuncture control may give us a better indication of the placebo effect occurring when receiving acupuncture treatment. For example, Streitberger et al. developed placebo needles, which they claim could be used to closely simulate an acupuncture procedure without penetrating the skin. They found that experimental volunteers could not distinguish between the acupuncture and placebo treatment. (Streitberger et al., 1998)

We used information from the literature to establish model parameters. However, a number of limitations existed in the RCTs we used to determine our model inputs. For example, many RCTs collected outcomes from patients for less than one year. The time horizon of the model was over two years, and the effectiveness of acupuncture on chronic LBP over the second

year after treatment had to be estimated from the very limited literature that collected outcomes from patients for over one year. In addition, many trials did not use acupuncture procedures that an experienced acupuncturist normally would use. Instead, many trials used fixed acupuncture points rather than points tailored to each patient's presentation. Since many trials used standardized acupuncture points instead of tailoring the acupuncture treatment to an individual's specific symptoms, it is possible that the observed pain outcomes were different than what would actually occur outside a trial setting. Also, we pooled information from trials that were different in many ways, such as having varied patient populations, pain intensity outcomes, follow-up points, and types of acupuncture and usual care treatments. In addition, in clinical settings, patients often receive repeat courses of acupuncture, while in these trials, patients only received one course of acupuncture, which varied from ten sessions to twelve sessions.

Overall, our analysis supports the recommendation of acupuncture (in addition to usual care) as a cost-effective treatment option for fifty-year old US adults with chronic LBP as compared to usual care. As back-pain related medical costs continue to rise in the US, it is important for decision-makers to determine where to allocate scarce monetary and healthcare resources for patients suffering from chronic LBP. Our results indicate that acupuncture in addition to usual care is a cost-effective strategy as compared to usual care alone. Incorporating acupuncture as part of multidisciplinary approach for pain management in adults with chronic LBP appears to be a cost-effective strategy.

Conclusions

Acupuncture in addition to usual care is a cost-effective treatment option for fifty-year US adults with chronic LBP as compared to usual care alone. Findings were insensitive to changes in model parameters, but somewhat sensitive to changes in acupuncture costs. Better data

collection in future acupuncture RCTs should be done, such as longer RCT follow-up of patients, in order to determine more accurate model parameters. This cost-effectiveness analysis is important to provide decision-makers with evidence to support the recommendation of acupuncture as a viable, cost-effective treatment strategy for adults with chronic LBP.

CHAPTER 5: IMPLICATIONS

Low back pain (LBP) is a widespread, costly problem in the United States. According to studies, over 80% of adults experience back pain at some points in their lives, and about 8% experience chronic LBP, or when LBP persists for at least three months. (Deyo et al., 2006) In 2005, back-pain related health expenditures in the United States were estimated to be over $86 billion, a 65% increase from 1997. (Deyo, et al. 2006) Overall, a small group of people is burdened with the majority of LBP related costs, with about 5% of individuals suffering from LBP in the United States accounting for 75% of the LBP associated costs. (Chou et al., 2007) Also, chronic LBP causes enormous losses in productivity, resulting in approximately 83 million lost days of work a year in the United States. (Stewart et al., 2003) As health care costs and losses in productivity related to chronic LBP continue to rise rapidly, it is important to allocate limited healthcare resources toward therapies that offer the most benefit for people suffering from chronic LBP.

Through our analysis of the 2012 NHIS, we found that a large proportion of the LBP population – 40% - used a CAM therapy in the past year, with higher use reported among adults with limiting LBP. Results showed that the majority of the LBP population used CAM specifically to treat their LBP and that most survey respondents who used CAM perceived a great deal of benefit. Compared to past analyses of CAM use within the US adult LBP population, our results are indicative of CAM therapies becoming an increasingly important component of care for people with LBP. (Kanodia et al., 2010) However, though the perceived benefit of CAM therapies, such as acupuncture, among adults with LBP who used CAM modalities to treat their back pain was high, our results showed that within the LBP population, the overall prevalence of acupuncture use was very low, with less than 3% of adults with LBP utilizing acupuncture.

The low prevalence of acupuncture use within the population may be due to the lack of knowledge surrounding acupuncture as a therapy for LBP. A study by Pearson et al. found that among the reasons for not using acupuncture, unawareness or unfamiliarity with the treatment ranked at the top, above safety concerns, effectiveness, or healthcare providers' negative opinions about the treatment. The authors of the study reported that most adults who received acupuncture treatments were informed about the modality by their conventional medical providers, such as their medical doctors. (Pearson et al., 2007) Thus, increased communication about acupuncture, and other CAM modalities, as a potential treatment for LBP between health providers and their LBP patients may be useful. Also, implementing information about the use of CAM into the curriculum of health professionals, especially conventional health providers, may help health professionals become more familiar with CAM treatment. These actions could lead to increased awareness and more accurate information about CAM treatment options being relayed to adults with LBP. (Pearson et al., 2007)

Additionally, Pearson et al. found that previous acupuncture users considered cost to be a deterrent of acupuncture use. With the average cost per acupuncture visit in the United States ranging from $50 to $100, the out-of-pocket cost per acupuncture visit is usually more than the copay for a conventional doctor's visit, and is often a barrier to receive acupuncture treatment. (Sierpina et al., 2005) One possible solution to this obstacle is for acupuncture providers to establish multi-bed acupuncture clinics. Increasingly, multi-bed acupuncture clinics are being offered in the UK, Japan, and Germany. These establishments provide acupuncture at a lower cost than the average acupuncture services, often ranging from $20 - $40 per treatment. By offering lower cost treatments at high-volume, multi-bed acupuncture clinics, it may be possible to reach a wider number of people who may not be able to afford the usual course of acupuncture treatments. (Kanodia et al., 2010)

Currently, acupuncture services are not covered by many insurers in the United States. (Kanodia et al., 2010). Since acupuncture users have reported that the price of acupuncture treatments is a reason for their discontinued use, if acupuncture was covered by health insurance, then a higher prevalence of acupuncture use among adults with LBP could occur. (Pearson et al., 2007) In the United Kingdom (UK), the National Institute for Health and Care Excellence (NICE) has recommended that acupuncture be used in conjunction with usual care for adults with LBP due to their cost-effectiveness findings. Though acupuncture services are not always covered by the National Health Service (NHS), there are plans in the works to increase NHS coverage of acupuncture in the future, partially due to RCT and cost-effectiveness findings comparing acupuncture to other treatments within UK LBP populations. (Chou et al., 2007) We believe that results found from our systematic literature review completed in Chapter 3 and cost-effectiveness analysis completed in Chapter 4, provide important findings that acupuncture in addition to usual care is a cost-effective treatment choice for the US LBP population when compared to usual care alone.

Results from our cost-effectiveness analysis could be used to provide US decision-makers with evidence to support the recommendation of acupuncture as a viable, cost-effective treatment strategy for US adults with chronic LBP. Proving that acupuncture has real, measurable benefits is necessary in order to increase its role in the US health care system as is being done in other countries. (Chou et al, 2007) As LBP related health care costs continue to rise in the US, federal policy makers have focused attention on cost-effectiveness analyses of various alternative therapies and providers in order to determine how to most effectively manage LBP in the face of a finite healthcare budget. Thus, while higher-quality prospective trials are needed to more accurately estimate the cost-effectiveness of acupuncture for adults with LBP in the US, our analysis is an important step in demonstrating that acupuncture may be a cost-effective option to

treat LBP as the US healthcare system is struggling with rising costs and a shortage of primary care providers. (Kanodia et al., 2010)

Overall, findings from our analyses may be helpful in facilitating future practice, policy, and research recommendations involving the benefit of CAM, and more specifically, acupuncture, on treating chronic LBP in the United States. Already, the use of many CAM therapies for treating chronic LBP have been recommended by organizations such as the World Health Organization (WHO), the American College of Physicians (ACP), and the American Pain Society (APS). (Chou et al., 2007) As healthcare reform proceeds in a direction favoring lower-cost approaches, further integration of acupuncture practitioners into healthcare systems and increased communication about acupuncture between providers and patients may be beneficial. Our analyses helps add to the evidence indicating the importance of acupuncture for treating chronic LBP, and can be used to help policymakers, health practitioners, and patients to make informed decisions on allocating scarce healthcare resources on acupuncture treatments for adults with chronic LBP population.

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Appendices

Appendix 1. Database Search Strategies

1.1 Medline Search Strategy

#	Searches	Results	Search Type
1	low back pain.mp.	1625	Advanced
2	low$2 back pain.mp.	1736	Advanced
3	backache.mp.	125	Advanced
4	lumbago.mp.	41	Advanced
5	sciatica.mp.	208	Advanced
6	(lumbar adj2 pain).mp.	174	Advanced
7	(lumbosacral adj2 pain).mp.	24	Advanced
8	1 or 2 or 3 or 4 or 5 or 6 or 7	2169	Advanced
9	acupuncture.mp.	1321	Advanced
10	electroacupuncture.mp.	249	Advanced
11	acupressure.mp.	80	Advanced
12	(acupuncture adj1 therapy).mp.	60	Advanced
13	needling.mp.	219	Advanced
14	dry needl$.mp.	31	Advanced
15	9 or 10 or 11 or 12 or 13 or 14	1583	Advanced
16	randomized controlled trial.mp.	4362	Advanced
17	controlled clinical trial.mp.	789	Advanced
18	(controlled adj1 clinical adj1 trial$).mp.	1464	Advanced
19	(random$4 adj2 allocat$).mp.	1467	Advanced
20	(controlled adj1 clinical adj1 stud$3).mp.	160	Advanced
21	rct$.mp.	2856	Advanced
22	16 or 17 or 18 or 19 or 20 or 21	9446	Advanced
23	8 and 15 and 22	16	Advanced
24	limit 23 to (english language and yr="2003 - 2013")	16	Advanced

1.2 Embase Search Strategy

#	Searches	Results	Search Type
1	exp low back pain/	35092	Advanced
2	low$2 back pain.mp.	40518	Advanced
3	exp backache/	66729	Advanced
4	backache.mp.	33764	Advanced
5	(lumbar adj2 pain).mp.	2763	Advanced
6	(lumbosacral adj2 pain).mp.	355	Advanced
7	lumbago.mp.	1552	Advanced
8	exp sciatica/	198	Advanced
9	sciatica.mp.	4490	Advanced
10	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9	75108	Advanced
11	exp acupuncture/	32360	Advanced
12	exp acupuncture analgesia/	1321	Advanced
13	acupuncture.mp.	32147	Advanced
14	(acupuncture adj1 therapy).mp.	3344	Advanced
15	needling.mp.	2064	Advanced
16	dry needl$.mp.	229	Advanced
17	acupuncture needle/	153	Advanced
18	11 or 12 or 13 or 14 or 15 or 16 or 17	34658	Advanced
19	randomized controlled trial/	366947	Advanced
20	exp controlled clinical trial/	502219	Advanced
21	(controlled adj1 clinical adj1 trial$).mp.	424358	Advanced
22	(random$4 adj2 allocat$).mp.	25481	Advanced
23	(controlled adj1 clinical adj1 stud$3).mp.	3793	Advanced
24	rct$.mp.	26531	Advanced
25	19 or 20 or 21 or 22 or 23 or 24	546622	Advanced
26	10 and 18 and 25	391	Advanced
27	limit 26 to (english language and yr="2003 - 2013")	267	Advanced

1.3. Cochrane Central Register of Controlled Trials Search Strategy

Search Name: acupuncture for low back pain

Date Run: 14/03/14 21:26:10.957

Description:

ID	Search	Hits
#1	"low back pain" or "lumbago" or "sciatica" or "lumbar pain" or "lumbosacral pain"	4149
#2	"acupuncture" or "acupuncture therapy" or "dry needling" or "acupuncture needle" or "acupuncture analgesia"	7535
#3	#1 and #2 from 2003 to 2014	233

All Results (233)

Cochrane Reviews (61)
- All
- Review
- Protocol

Other Reviews (25)
Trials (125)
Methods Studies (3)
Technology Assessments (9)
Economic Evaluations (9)
Cochrane Groups (1)

Appendix 2. Criteria for Judgment of "Yes" for the Sources of Risk of Bias (Furlan, 2009)

1	A random (unpredictable) assignment sequence. Examples of adequate methods are coin toss (for studies with 2 groups), rolling a dice (for studies with 2 or more groups), drawing of balls of different colors, drawing of ballots with the study group labels from a dark bag, computer-generated random sequence, pre-ordered sealed envelops, sequentially-ordered vials, telephone call to a central office, and pre-ordered list of treatment assignments Examples of inadequate methods are: alternation, birth date, social insurance/ security number, date in which they are invited to participate in the study, and hospital registration number.
2	Assignment generated by an independent person not responsible for determining the eligibility of the patients. This person has no information about the persons included in the trial and has no influence on the assignment sequence or on the decision about eligibility of the patient.
3	This item should be scored "yes" if the index and control groups are indistinguishable for the patients or if the success of blinding was tested among the patients and it was successful.
4	This item should be scored "yes" if the index and control groups are indistinguishable for the care providers or if the success of blinding was tested among the care providers and it was successful.
5	Adequacy of blinding should be assessed for the primary outcomes. This item should be scored "yes" if the success of blinding was tested among the outcome assessors and it was successful or: –for patient-reported outcomes in which the patient is the outcome assessor (*e.g.*, pain, disability): the blinding procedure is adequate for outcome assessors if participant blinding is scored "yes" –for outcome criteria assessed during scheduled visit and that supposes a contact between participants and outcome assessors (*e.g.*, clinical examination): the blinding procedure is adequate if patients are blinded, and the treatment or adverse effects of the treatment cannot be noticed during clinical examination –for outcome criteria that do not suppose a contact with participants (*e.g.*, radiography, magnetic resonance imaging): the blinding procedure is adequate if the treatment or adverse effects of the treatment cannot be noticed when assessing the main outcome –for outcome criteria that are clinical or therapeutic events that will be determined by the interaction between patients and care providers (*e.g.*, co-interventions, hospitalization length, treatment failure), in which the care provider is the outcome assessor: the blinding procedure is adequate for outcome assessors if item "4" (caregivers) is scored "yes" –for outcome criteria that are assessed from data of the medical forms: the blinding procedure is adequate if the treatment or adverse effects of the treatment cannot be noticed on the extracted data
6	The number of participants who were included in the study but did not complete the observation period or were not included in the analysis must be described and reasons given. If the percentage of withdrawals and drop-outs does not exceed 20% for short-term follow-up and 30% for long-term follow-up and does not lead to substantial bias a "yes" is scored. (N.B. these percentages are arbitrary, not supported by literature).
7	All randomized patients are reported/analyzed in the group they were allocated to by randomization for the most important moments of effect measurement (minus missing values) irrespective of non-compliance and co-interventions.
8	In order to receive a "yes", the review author determines if all the results from all pre-specified outcomes have been adequately reported in the published report of the trial. This information is either obtained by comparing the protocol and the report, or in the absence of the protocol, assessing that the published report includes enough information to make this judgment.
9	In order to receive a "yes", groups have to be similar at baseline regarding demographic factors, duration and severity of complaints, percentage of patients with neurological symptoms, and value of main outcome measure(s).
10	This item should be scored "yes" if there were no co-interventions or they were similar between the index and control groups.
11	The reviewer determines if the compliance with the interventions is acceptable, based on the reported intensity, duration, number and frequency of sessions for both the index intervention and control intervention(s). For example, physiotherapy treatment is usually administered over several sessions; therefore it is necessary to assess how many sessions each patient attended. For single-session interventions (e.g., surgery), this item is irrelevant.
12	Timing of outcome assessment should be identical for all intervention groups and for all important outcome assessments.

Appendix 3. Required domains and their definitions

Domain	Definition and elements	Score and application
Risk of bias	Risk of bias is the degree to which the included studies for a given outcome or comparison have a high likelihood of adequate protection against bias (i.e., good internal validity), assessed through two main elements: • Study design (e.g., RCTs or observational studies) • Aggregate quality of the studies under consideration. Information for this determination comes from the rating of quality (good/fair/poor) done for individual studies	Use one of the three levels of aggregate risk of bias: • Low risk of bias • Medium risk of bias • High risk of bias
Consistency	The principal definition of consistency is the degree to which reported effect sizes from included studies appear to have the same direction of effect. This can be assessed through two main elements: • Effect sizes have the same sign (that is, are on the same side of "no effect") • The range of effect sizes is narrow	Use one of the three levels of consistency: • Consistent (i.e., no inconsistency) • Inconsistent • Unknown or not applicable (e.g., single study) As noted in the text, single-study evidence bases (even mega trials) cannot be judged with respect to consistency. In that instance, use "Consistency unknown (single study)"
Directness	The rating of directness relates to whether the evidence links the interventions directly to health outcomes. For a comparison of two treatments, directness implies that head-to-head trials measure the most important health or ultimate outcomes. Two types of indirectness, which can coexist, may be of concern. Evidence is indirect if: • It uses intermediate or surrogate outcomes instead of ultimate health outcomes. In this case, one body of evidence links the intervention to intermediate outcomes and another body of evidence links the intermediate to most important (health or ultimate) outcomes • It uses two or more bodies of evidence to compare interventions A and B—e.g., studies of A vs. placebo and B vs. placebo, or studies of A vs. C and B vs. C but not A vs. B. Indirectness always implies that more than one body of evidence is required to link interventions to the most important health outcomes Directness may be contingent on the outcomes of interest. EPC authors are expected to make clear the outcomes involved when assessing this domain	Score dichotomously as one of two levels directness: • Direct • Indirect If indirect, specify which of the two types of indirectness accounts for the rating (or both, if that is the case)—namely, use of intermediate/surrogate outcomes rather than health outcomes, and use of indirect comparisons. Comment on the potential weaknesses caused by, or inherent in, the indirect analysis. The EPC should note if both direct and indirect evidence was available, particularly when indirect evidence supports a small body of direct evidence
Precision	Precision is the degree of certainty surrounding an effect estimate with respect to a given outcome (i.e., for each outcome separately) If a meta-analysis was performed, this will be the confidence interval around the summary effect size	Score dichotomously as one of two levels of precision: • Precise • Imprecise A precise estimate is an estimate that would allow a clinically useful conclusion. An imprecise estimate is one for which the confidence interval is wide enough to include clinically distinct conclusions. For example, results may be statistically compatible with both clinically important superiority and inferiority (i.e., the direction of effect is unknown), a circumstance that will preclude a valid conclusion

Appendix 4. Adverse Events

Study	% Adverse Events by Treatment Arm
Brinkhaus, 2006	Acupuncture: 9.5% Minimal Acupuncture: 5.3% Waiting List Control: 6.3%
Ceccherelli, 2002	Not reported
Cherkin, 2001	Not reported
Cherkin, 2009	Individualized acupuncture: 3.8% Standardized acupuncture: 3.8% Simulated acupuncture: 0% Usual care: 0%
Cho, 2013	Acupuncture: 15.4% Sham acupuncture: 26.2%
Grant, 1999	Acupuncture: 9.4% TENS: 10.7%
Haake, 2007	Not reported
Inoue, 2009	Acupuncture: 0% Anesthetic injection group: 0%
Kennedy, 2007	Not reported
Kerr, 2003	Acupuncture: 7.7% Placebo TENS: 6.7%
Leibing, 2002	Acupuncture + physiotherapy: 7.5% Sham acupuncture: 0% Physiotherapy: 0%
Meng, 2003	Not reported
Molsberger, 2002	Not reported
Pach, 2013	Standardized acupuncture: 0% Individualized acupuncture: 0%
Tsukayama, 2002	Electroacupuncture: 30% TENS: 30%
Weiss, 2013	Acupuncture + rehabilitation: 0% Rehabilitation: 0%
Yeung, 2003	Not reported
Yun, 2012	Not reported

Appendix 5. Study characteristics

Study	Participants and Settings	Interventions	Outcomes
Brinkhaus, 2006	298 patients 40 – 75 years old with chronic LBP (disease duration of more than 6 months), average pain intensity of 40 mm+ on 100 mm VAS. Mean age: 59 years; 68% female, 32% male Setting: 30 outpatient centers in Germany	4. Acupuncture (standardized points based on patient diagnosis and according to TCM until de Qi sensation produced) (n = 147) 2 sessions/week for first 4 weeks, then 1 session/week for next 4 weeks 5. Minimal acupuncture (needles were applied superficially in 6-10 non-acupuncture points, needles not applied in lower back) (n = 75) 2 sessions/week for first 4 weeks, then 1 session/week for next 4 weeks 6. Waiting list control (n = 79)	7. Back pain intensity (Visual Analogue Scale: VAS) 8. Back function (Hannover Functional Ability Questionnaire: HFAQ) 9. Pain Disability Index 10. Emotion aspects of pain 11. Depression scale (Allgemeine Depressionsskala) 12. Quality of life (SF-36)
Cherkin, 2009	638 patients 18 – 70 years with uncomplicated chronic LBP within the past 3 – 12 months, severity rating of at least 3 on 0 - 10 back bothersomeness scale Mean age: 47 years; 62% female, 38% men Setting: 2 research clinics in Western Washington and Northern California.	4. Individualized acupuncture (points chosen based on patients diagnosis, treatments averaged 10.8 needles) (n = 157) 2 treatments/week for first 3 weeks, then one treatment/week for next 4 weeks 5. Standardized acupuncture (8 acupuncture points stimulated considered effective by LBP experts, de Qi achieved) (n = 158) 2 treatments/week for first 3 weeks, then one treatment/week for next 4 weeks 6. Simulated acupuncture (needles applied superficially at 8 acupuncture points used in standardized treatment) (n = 162)	7. Disability (Roland Morris Disability Questionnaire: RMDQ) 8. Back pain intensity (0-10 scale) 9. Physical health (SF-36) 10. Mental health (SF-36) 11. Number of days spend in bed 12. Number of days lost from work or school

		2 treatments/week for first 3 weeks, then one treatment/week for next 4 weeks 7. Usual care (No study related care - routine care recommended by physician) (n = 161)	
Cho, 2013	130 patients, 18 – 65 years, with nonspecific chronic LBP and pain level of at least 5 on the 0-10 VAS scale. Mean age: 42 years; 84.5% female, 14.5% male Setting: 3 hospitals; Seoul, Korea	3. Acupuncture (perpendicular insertion, points chosen from3 groups of meridian patterns, 5 – 20 mm depth, until de Qi sensation induced) (n = 65) 2 treatments/week for 6 weeks 4. Sham acupuncture (semi-blunt needle without penetration; 8 non-acupuncture points) (n = 65) 2 treatments/week for 6 weeks	7. Pain bothersomeness (VAS) 8. Pain intensity (VAS) 9. Disability (Oswestry Disability Index: ODI) 10. Quality of life (SF-36) 11. Depression (Beck Depression Inventory: BDI) 12. Expectation
Haake, 2007	1162 patients, 18 – 86 years old, with chronic LBP lasting at least 6 months; Von Korff Chronic Pain Grade score of grade 1 or higher and a Hannover Functional Ability Questionnaire score of less than 70% Mean age: 50 years, 40% men, 60% women Setting: 340 outpatient practices; Germany	4. Verum acupuncture (verum points, 5-40 mm depth insertion, induction of de Qi) (n = 387) 2 treatments/week for 5 weeks, 5 additional treatments for patients who experience a 10-50% reduction in pain intensity 5. Sham acupuncture (needles applied superficially, avoiding verum points & meridians) (n = 387) 2 treatments/week for 5 weeks, 5 additional treatments for patients who experience a 10-50% reduction in pain intensity 6. Conventional therapy (drugs, physical therapy, and exercise) (n = 388) 2 treatments/week for 5 weeks, 5 additional treatments for patients who experience a 10-50%	7. Pain intensity (Chronic Pain Grade Scale) 8. Back-specific functional status (HFAQ) 9. Quality of life (SF-12) 10. Assessment of therapy effectiveness (1-6 scale) 11. Medication use 12. Adverse events

		reduction in pain intensity	
Molsberger, 2002	186 patients with LBP, with average pain score greater than 50 mm (maximum 100 mm) during the last week. Age between 20 and 60 years. 97 males and 89 females. Setting: Inpatients in the Hospital, Dusseldorf, Germany	4. Verum acupuncture plus conventional orthopedic therapy. All patients received 12 acupuncture treatments over 3 weeks, each lasting for 30 minutes 5. Sham acupuncture plus conventional orthopedic therapy. 12 sham acupuncture treatments, 3/week, each lasting 30 minutes. Sham acupuncture was standardized to 10 needles applied superficially (depth of insertion was less than 1 cm) at defined nonacupuncture points of the lumbar region, and 5 needles on either side of the back	6. Pain intensity (VAS) 7. At least 50% reduction in pain intensity 8. Effectiveness of treatment: excellent, good, satisfactory, and failed 9. Schober and finger-to-floor distance 10. Complications

Appendix 6. Acupuncture + Usual Care Transition Matrices

A_1: Baseline to 3 months & 3 months to 6 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.149548788	0.168843447	0.178255937	0.177708534	0.169480596	0.156162697	0	0	0	0
Pain Level 2	0.108332278	0.157557206	0.186602257	0.185068685	0.15939254	0.122675104	0.080371931	0	0	0
Pain Level 3	0.075769101	0.159236427	0.22129278	0.219378382	0.163929881	0.095033005	0.045241652	0.020118772	0	0
Pain Level 4	0.061935933	0.158922209	0.243580172	0.244556254	0.168065556	0.078785466	0.028845747	0.010849091	0.004459571	0
Pain Level 5	0.072754404	0.155723512	0.238329392	0.249427049	0.174623869	0.076966035	0.022754442	0.006491548	0.001902527	0.001027222
Pain Level 6	0.106862279	0.148471795	0.214833481	0.24102708	0.181329459	0.081593626	0.02033237	0.004384367	0.001046903	1.19E-04
Pain Level 7	0	0.168718764	0.226893541	0.262781662	0.209417952	0.100940771	0.025516607	0.004790674	0.000910569	2.95E-05
Pain Level 8	0	0	0.264530554	0.293461142	0.245880925	0.13921441	0.049124231	0.006755054	0.001015173	1.85E-05
Pain Level 9	0	0	0	0.342366163	0.313745293	0.222655493	0.095184899	0.023685975	0.002340836	2.13E-05
Pain Level 10	0	0	0	0	0.348737863	0.320119051	0.237184105	0.086361311	0.007555889	4.18E-05

A_2: 6 months to 9 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.145384194	0.173415005	0.19097051	0.188672938	0.167140871	0.134416481	0	0	0	0
Pain Level 2	0.11572479	0.169024916	0.205087385	0.200291702	0.156553834	0.097802529	0.055514845	0	0	0

Pain Level 3	0.10139534	0.174411922	0.226276622	0.219301136	0.156889515	0.078920194	0.032495923	0.010309348	0	0
Pain Level 4	0.100972838	0.174321025	0.226266593	0.219290614	0.156786872	0.078415554	0.031856849	0.010009028	0.002080627	0
Pain Level 5	0.10995498	0.166632183	0.205344053	0.200185791	0.153334447	0.091301854	0.048432984	0.020266693	0.003375718	0.001171298
Pain Level 6	0.118131214	0.153532025	0.176495019	0.17346468	0.145277531	0.105114503	0.072198383	0.04210023	0.013553692	0.000132722
Pain Level 7	0	0.156503818	0.16622625	0.164980375	0.152816784	0.131761732	0.106871974	0.07444318	0.036712082	0.009683805
Pain Level 8	0	0	0.159203682	0.158892906	0.155882833	0.150540328	0.142241903	0.123056466	0.08047617	0.029705713
Pain Level 9	0	0	0	0.15653857	0.156027013	0.155139281	0.153692979	0.149379486	0.133981499	0.095241172
Pain Level 10	0	0	0	0	0.169767132	0.169648545	0.16944321	0.168753267	0.165892539	0.156495307

A_3: 9 months to 12 months

	Pain Level 1	**Pain Level 2**	**Pain Level 3**	**Pain Level 4**	**Pain Level 5**	**Pain Level 6**	**Pain Level 7**	**Pain Level 8**	**Pain Level 9**	**Pain Level 10**
Pain Level 1	0.296114057	0.333213658	0.202251798	0.101772127	0.047480973	0.019167387	0	0	0	0
Pain Level 2	0.108096761	0.295686408	0.368344618	0.15264263	0.053080765	0.016596404	0.005552415	0	0	0
Pain Level 3	0.037513352	0.092798555	0.303527334	0.433951072	0.100025381	0.02425482	0.006176124	0.001753363	0	0

Pain Level 4	0.016097715	0.03267087	0.071380411	0.282633498	0.532483132	0.048586467	0.013328148	0.001808108	0.001011651	0
Pain Level 5	0.010332366	0.015644372	0.026794088	0.049124777	0.216990232	0.654697518	0.020513187	0.004690236	0.001021224	0.000192001
Pain Level 6	0.007841183	0.00988699	0.013247874	0.022095046	0.044196341	0.139943456	0.75283984	0.008019643	0.001436699	0.000492929
Pain Level 7	0	0.008842492	0.010414995	0.014076655	0.022028196	0.035421836	0.074559717	0.832742016	0.000954657	0.000959437
Pain Level 8	0	0	0.011157275	0.012832087	0.015404502	0.018152549	0.021169377	0.047131689	0.865386153	0.008766368
Pain Level 9	0	0	0	0.016424518	0.017295132	0.018381185	0.018462765	0.002166663	0.126113497	0.801156241
Pain Level 10	0	0	0	0	0.032830497	0.033756008	0.034242894	0.044587686	0.158097772	0.696485142

A_4: 12 months to 15 months, 15 to 18 months, 18 to 21 months, 21 to 24 months

	Pain Level 1	**Pain Level 2**	**Pain Level 3**	**Pain Level 4**	**Pain Level 5**	**Pain Level 6**	**Pain Level 7**	**Pain Level 8**	**Pain Level 9**	**Pain Level 10**
Pain Level 1	0.153611043	0.236965592	0.257216693	0.187311570	0.107558011	0.057337091	0	0	0	0
Pain Level 2	0.121121452	0.328827206	0.303779496	0.144417486	0.059934331	0.028179610	0.013740419	0	0	0
Pain Level 3	0.096376300	0.188544415	0.364761128	0.229225076	0.075719282	0.028156960	0.011110055	0.006106785	0	0
Pain Level 4	0.045652217	0.030316418	0.111327533	0.454567099	0.269407033	0.060670870	0.017825991	0.006217005	0.004015832	0
Pain Level 5	0.009171145	0.006427501	0.014962606	0.067834659	0.503425381	0.356737430	0.019825627	0.014945556	0.003479077	0.003191017
Pain Level 6	0.006199338	0.005086195	0.007792979	0.019925417	0.025419175	0.404368787	0.493422026	0.020875327	0.012579501	0.004331255
Pain Level 7	0	0.004381616	0.006089743	0.010546970	0.025454414	0.075430286	0.313600749	0.521529120	0.042344423	0.000622680
Pain Level 8	0	0	0.006268029	0.009631334	0.018576368	0.040086075	0.091536448	0.294415365	0.488295334	0.051191046
Pain Level 9	0	0	0	0.013561131	0.020827935	0.032004014	0.051527525	0.092009477	0.298821208	0.491248710

Pain Level 10	0	0	0	0	0.037756044	0.052500982	0.077610791	0.123262119	0.244054024	0.464816040

Appendix 7. Placebo-adjusted Usual Care Transition Matrices

S_1: Baseline to 3 months, 3 months to 6 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.146931856	0.165404411	0.172890017	0.174918981	0.172336859	0.167517875	0	0	0	0
Pain Level 2	0.097662355	0.139106282	0.162249813	0.169006552	0.160496537	0.145011865	0.126466595	0	0	0
Pain Level 3	0.056229303	0.119846352	0.17179624	0.189522562	0.169480008	0.132652204	0.095668264	0.064805067	0	0
Pain Level 4	0.033151759	0.105085171	0.186571946	0.222235022	0.191709157	0.128382269	0.072084782	0.037912781	0.022867112	0
Pain Level 5	0.032751127	0.09477528	0.18505266	0.240801427	0.21681182	0.135733948	0.059885274	0.020949207	0.007209447	0.006029812
Pain Level 6	0.062004416	0.089199631	0.161358983	0.229684094	0.230633214	0.151163707	0.059043241	0.01302497	0.003077379	0.000810365
Pain Level 7	0	0.101331821	0.154006604	0.226149903	0.247438914	0.176963281	0.074798285	0.015706466	0.003108088	0.000496637
Pain Level 8	0	0	0.170946684	0.229315022	0.253469925	0.200697656	0.108724768	0.033328578	0.003054043	4.63E-04
Pain Level 9	0	0	0	0.253215705	0.26426306	0.232518024	0.153148065	0.075959117	0.019431611	0.001464418
Pain Level 10	0	0	0	0	0.276284555	0.267107701	0.238673958	0.162720144	0.055207815	5.83E-06

S_2: 6 months to 9 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.14327371	0.161801541	0.176540059	0.182463665	0.17609911	0.159821914	0	0	0	0
Pain Level 2	0.102555317	0.138709469	0.171708428	0.185481176	0.170695359	0.134626435	0.096223816	0	0	0

Pain Level 3	0.074247391	0.128928683	0.185199608	0.209597588	0.18340392	0.122410273	0.066298832	0.029913705	0	0
Pain Level 4	0.062273895	0.126398031	0.195978482	0.226645876	0.193742883	0.11862562	0.053735347	0.018517471	0.004082393	0
Pain Level 5	0.066333345	0.126948055	0.191314168	0.219460538	0.189276971	0.119711924	0.05797206	0.022169122	0.005149878	0.001663939
Pain Level 6	0.080559601	0.128343021	0.175688124	0.195968178	0.174179727	0.122703916	0.073247194	0.037671987	0.011553738	8.45E-05
Pain Level 7	0	0.138746185	0.167485619	0.179281019	0.166528407	0.13476926	0.100732907	0.069479226	0.036275662	0.006701716
Pain Level 8	0	0	0.165788457	0.170383465	0.165431781	0.152206744	0.134105504	0.109270819	0.072297336	0.030515894
Pain Level 9	0	0	0	0.16913263	0.16780926	0.164251252	0.15891803	0.148619319	0.12201406	0.069255449
Pain Level 10	0	0	0	0	0.176784341	0.176090641	0.17503251	0.172665877	0.164152115	0.135274515

S_3: 9 months to 12 months

	Pain Level 1	**Pain Level 2**	**Pain Level 3**	**Pain Level 4**	**Pain Level 5**	**Pain Level 6**	**Pain Level 7**	**Pain Level 8**	**Pain Level 9**	**Pain Level 10**
Pain Level 1	0.340573637	0.217469218	0.153547684	0.123488344	0.096750145	0.068170972	0	0	0	0
Pain Level 2	0.19710441	0.332262626	0.18510212	0.129082376	0.087548971	0.046639534	0.022259963	0	0	0
Pain Level 3	0.000593899	0.149582173	0.36825764	0.251611964	0.141344871	0.06030512	0.021288755	0.007015579	0	0
Pain Level 4	0.005386713	0.034537212	0.150540638	0.35523741	0.267728009	0.117565972	0.047911048	0.015290165	0.005802832	0
Pain Level 5	0.001738031	0.008137435	0.04777498	0.137110443	0.316792571	0.297912508	0.128458831	0.045752468	0.012085567	0.004237166
Pain Level 6	0.002266488	0.006876311	0.015754566	0.057897732	0.143784848	0.284112364	0.308396331	0.129526669	0.041358869	0.010025821
Pain Level 7	0	0.004548585	0.009753387	0.032034311	0.085894044	0.174155118	0.267578399	0.287676436	0.110115281	0.028244439
Pain Level 8	0	0	0.014606645	0.033701786	0.070237162	0.121961161	0.17031217	0.232600182	0.252391386	0.104189508
Pain Level 9	0	0	0	0.055273411	0.081394042	0.113312095	0.139927567	0.171629979	0.220946558	0.217516348

Pain Level 10	0	0	0	0	0.117605541	0.137839181	0.154297318	0.173166374	0.196073614	0.221017973

S_4: 12 months to 15 months, 15 months to 18 months, 18 months to 21 months, 21 months to 24 months

	Pain Level 1	**Pain Level 2**	**Pain Level 3**	**Pain Level 4**	**Pain Level 5**	**Pain Level 6**	**Pain Level 7**	**Pain Level 8**	**Pain Level 9**	**Pain Level 10**
Pain Level 1	0.123580754	0.157642408	0.171389646	0.215057385	0.196795118	0.135534690	0	0	0	0
Pain Level 2	0.066096926	0.182784478	0.289071393	0.245221349	0.131852102	0.059601402	0.025372349	0	0	0
Pain Level 3	0.041204360	0.173707194	0.367258438	0.261855460	0.098100327	0.035538905	0.014632029	0.007703287	0	0
Pain Level 4	0.047621694	0.118856753	0.170511640	0.361138280	0.210035363	0.061229933	0.018469161	0.008077516	0.004059660	0
Pain Level 5	0.051293317	0.022317346	0.007125660	0.110226722	0.471841770	0.271719029	0.042504475	0.014636172	0.005079103	0.003256407
Pain Level 6	0.024947091	0.006534284	0.007740859	0.014695606	0.064625942	0.460690706	0.388595471	0.015123909	0.013366751	0.003679381
Pain Level 7	0	0.005096435	0.004779812	0.008548277	0.024208439	0.075846904	0.378912055	0.470909341	0.031540248	0.000158488
Pain Level 8	0	0	0.005093577	0.007597011	0.016044996	0.038215207	0.111839911	0.334877350	0.441700400	0.044631549
Pain Level 9	0	0	0	0.009085584	0.016081792	0.026307784	0.051245765	0.111074966	0.338700728	0.447503381
Pain Level 10	0	0	0	0	0.026627437	0.038147596	0.066386339	0.116360225	0.255968350	0.496510052

Appendix 8. Usual Care Transition Matrices

U_1: Baseline to 3 months, 3 months to 6 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.181850191	0.175158314	0.170045755	0.16375551	0.157792572	0.151397658	0	0	0	0
Pain Level 2	0.209584762	0.18293126	0.160350851	0.138615339	0.119868315	0.101827672	0.086821801	0	0	0
Pain Level 3	0.29067585	0.233148215	0.155205354	0.115192704	0.083411154	0.055164369	0.036674571	0.030527783	0	0
Pain Level 4	0.049425007	0.306114341	0.297493326	0.172235672	0.094405156	0.038242629	0.015832605	0.012629614	0.01362165	0
Pain Level 5	0.002460924	0.042511254	0.286965067	0.370240813	0.18236939	0.064589559	0.01879859	0.011231162	0.010238942	0.010594299
Pain Level 6	0.002450956	0.003581507	0.050211894	0.225269619	0.373672409	0.219384174	0.076773331	0.028244609	0.012898589	0.007512911
Pain Level 7	0	0.006397459	0.010689358	0.061418595	0.192364475	0.341278918	0.251285065	0.09668944	0.032252097	0.007624592
Pain Level 8	0	0	0.008847379	0.03593988	0.117297685	0.241265384	0.307215218	0.209121467	0.068666638	1.16E-02
Pain Level 9	0	0	0	0.064145078	0.122965751	0.194781238	0.24258524	0.223632157	0.119562172	0.032328364
Pain Level 10	0	0	0	0	0.162860802	0.188664809	0.200385809	0.192933694	0.162779658	0.092375227

U_2: 6 months to 9 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.153321436	0.161452512	0.169164941	0.174228273	0.173906368	0.167926469	0	0	0	0

Pain Level 2	0.115605579	0.133271087	0.150789652	0.162501354	0.161753843	0.147955205	0.12812328	0	0	0
Pain Level 3	0.084572799	0.114735882	0.146366667	0.167975939	0.166588613	0.141188014	0.105778754	0.072793333	0	0
Pain Level 4	0.065520854	0.106658205	0.151924984	0.183403864	0.181372071	0.1444271	0.094199824	0.050830834	0.021662265	0
Pain Level 5	0.060119088	0.105007922	0.155331955	0.190604129	0.188320905	0.146947067	0.09128672	0.044598455	0.01571936	0.002064399
Pain Level 6	0.06531117	0.106199869	0.151204663	0.182517268	0.180495576	0.143746739	0.093810674	0.050698358	0.021661479	0.004354204
Pain Level 7	0	0.117754775	0.150254302	0.172417198	0.170995571	0.144939905	0.108547033	0.074590093	0.046168449	0.014332674
Pain Level 8	0	0	0.151465762	0.163560271	0.16278898	0.148543595	0.128096657	0.107484643	0.086576278	0.051483813
Pain Level 9	0	0	0	0.162671292	0.162347335	0.156332049	0.147516076	0.138117547	0.127368361	0.10564734
Pain Level 10	0	0	0	0	0.17482013	0.172810373	0.169820461	0.166512815	0.162461108	0.153575113

U_3: 9 months to 12 months

	Pain Level 1	**Pain Level 2**	**Pain Level 3**	**Pain Level 4**	**Pain Level 5**	**Pain Level 6**	**Pain Level 7**	**Pain Level 8**	**Pain Level 9**	**Pain Level 10**
Pain Level 1	0.688003593	0.202721373	0.047184218	0.032050047	0.018265152	0.011775617	0	0	0	0
Pain Level 2	0.019524819	0.63886363	0.25200044	0.052153078	0.020894581	0.010829405	0.005734047	0	0	0
Pain Level 3	0.008651465	0.00878778	0.620609667	0.295697289	0.042502205	0.014320756	0.00595472	0.003476117	0	0
Pain Level 4	0.002410581	0.006267544	0.007550527	0.588558357	0.350153779	0.029077512	0.009717609	0.003709753	0.002554338	0
Pain Level 5	0.001576913	0.003951607	0.006214729	0.011805593	0.548066142	0.400081072	0.015072646	0.0079944	0.002886072	0.002350825
Pain Level 6	0.001161293	0.002037969	0.003348652	0.007111423	0.016519821	0.496732837	0.446638732	0.015547724	0.008917252	0.001984296

Pain Level 7	0	0.002277223	0.00279055	0.004716624	0.011800572	0.039466593	0.461939766	0.4514359	0.0194926	0.006080173
Pain Level 8	0	0	0.002998124	0.004346649	0.008793558	0.020950832	0.056957946	0.460558919	0.434663449	0.010730523
Pain Level 9	0	0	0	0.005609136	0.009966583	0.0181413	0.032833187	0.076406789	0.444163148	0.412879858
Pain Level 10	0	0	0	0	0.014379621	0.021735392	0.034320012	0.064522644	0.21487708	0.65016525

U_4: 12 months to 15 months, 15 months to 18 months, 18 months to 21 months, 21 months to 24 months

	Pain Level 1	**Pain Level 2**	**Pain Level 3**	**Pain Level 4**	**Pain Level 5**	**Pain Level 6**	**Pain Level 7**	**Pain Level 8**	**Pain Level 9**	**Pain Level 10**
Pain Level 1	0.521628853	0.285600112	0.083569063	0.053906142	0.033686005	0.021609824	0	0	0	0
Pain Level 2	0.137048771	0.516449069	0.219931220	0.070301712	0.029358387	0.016748720	0.010162120	0	0	0
Pain Level 3	0.000012315	0.067424961	0.596027134	0.243640807	0.055629388	0.021753547	0.010141263	0.005370585	0	0
Pain Level 4	0.003406802	0.010262275	0.041964424	0.592147684	0.278963723	0.047908031	0.015121756	0.005984919	0.004240387	0
Pain Level 5	0.001506778	0.003898878	0.006888086	0.038086745	0.590348140	0.313880661	0.027643652	0.010716246	0.004057930	0.002972885
Pain Level 6	0.001401626	0.002682134	0.005401718	0.009318006	0.025623502	0.552274953	0.372475901	0.017943164	0.010404774	0.002474223
Pain Level 7	0	0.002228979	0.003199944	0.005908887	0.014034558	0.044710642	0.501962713	0.397668812	0.021554042	0.008731423
Pain Level 8	0	0	0.003557014	0.004780718	0.009324370	0.022437190	0.073822279	0.493424412	0.375508307	0.017145710
Pain Level 9	0	0	0	0.005037983	0.008667829	0.016533213	0.033948992	0.092734826	0.508551105	0.334526052
Pain Level 10	0	0	0	0	0.011353866	0.017769732	0.029066764	0.054853817	0.175909744	0.711046076

Appendix 9. Predicted & Target Population Distribution Vectors

Acupuncture + Conventional Care

	Predicted Vector Pain Level										Target Vector Pain Level									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
3 months	0.0334	0.1017	0.2019	0.2611	0.2221	0.1228	0.0447	0.0106	0.0016	0.0001	0.0418	0.1005	0.2023	0.2618	0.2174	0.1214	0.0432	0.0099	0.0015	0.0002
6 months	0.0768	0.1557	0.2255	0.2333	0.1724	0.0909	0.0342	0.0092	0.0018	0.0002	0.1084	0.1504	0.2177	0.2252	0.1664	0.0878	0.0331	0.0089	0.0017	0.0003
9 months	0.0821	0.1566	0.2203	0.2262	0.1707	0.0968	0.0368	0.0089	0.0015	0.0002	0.1711	0.1553	0.1936	0.1889	0.1443	0.0863	0.0404	0.0148	0.0042	0.0011
12 months	0.1054	0.1676	0.2085	0.2034	0.1558	0.0937	0.0438	0.0162	0.0047	0.0010	0.0993	0.1098	0.1603	0.1874	0.1753	0.1312	0.0787	0.0377	0.0145	0.0058
15 months	0.0628	0.1144	0.1669	0.1949	0.1824	0.1368	0.0824	0.0395	0.0153	0.0047	0.0697	0.0787	0.1230	0.1596	0.1719	0.1538	0.1142	0.0704	0.0360	0.0228
18 months	0.0433	0.0815	0.1274	0.1653	0.1780	0.1592	0.1184	0.0733	0.0375	0.0160	0.0548	0.0603	0.0968	0.1327	0.1554	0.1554	0.1327	0.0968	0.0603	0.0548
21 months	0.0327	0.0622	0.1013	0.1405	0.1653	0.1652	0.1402	0.1006	0.0609	0.0311	0.0417	0.0474	0.0790	0.1139	0.1418	0.1525	0.1418	0.1139	0.0790	0.0891
24 months	0.0258	0.0501	0.0839	0.1215	0.1517	0.1633	0.1515	0.1209	0.0827	0.0485	0.0442	0.0470	0.0766	0.1089	0.1353	0.1468	0.1391	0.1150	0.0831	0.1040

Sham + Conventional Care

	Predicted Vector Pain Level										Target Vector Pain Level									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
3 months	0.0184	0.0617	0.1418	0.2232	0.2425	0.1796	0.0916	0.0322	0.0078	0.0012	0.0228	0.0618	0.1421	0.2236	0.2412	0.1782	0.0902	0.0313	0.0074	0.0013
6 months	0.0432	0.1004	0.1727	0.2198	0.2071	0.1444	0.0744	0.0284	0.0080	0.0017	0.0599	0.0987	0.1697	0.2159	0.2033	0.1417	0.0731	0.0279	0.0079	0.0019
9 months	0.0489	0.1049	0.1724	0.2145	0.2013	0.1440	0.0763	0.0287	0.0075	0.0014	0.1056	0.1210	0.1747	0.1974	0.1747	0.1210	0.0656	0.0278	0.0092	0.0030
12 months	0.0689	0.1264	0.1820	0.2054	0.1819	0.1264	0.0683	0.0288	0.0096	0.0024	0.0794	0.0905	0.1386	0.1733	0.1769	0.1473	0.1002	0.0556	0.0252	0.0130
15 months	0.0502	0.0940	0.1437	0.1795	0.1832	0.1526	0.1038	0.0575	0.0260	0.0096	0.0588	0.0704	0.1142	0.1538	0.1719	0.1596	0.1230	0.0787	0.0418	0.0279
18 months	0.0373	0.0728	0.1180	0.1589	0.1776	0.1649	0.1270	0.0813	0.0431	0.0190	0.0465	0.0538	0.0892	0.1262	0.1525	0.1574	0.1387	0.1044	0.0671	0.0643
21 months	0.0291	0.0564	0.0935	0.1323	0.1599	0.1650	0.1454	0.1094	0.0703	0.0386	0.0442	0.0470	0.0766	0.1089	0.1353	0.1468	0.1391	0.1150	0.0831	0.1040
24 months	0.0271	0.0506	0.0824	0.1172	0.1457	0.1580	0.1496	0.1237	0.0893	0.0563	0.0466	0.0466	0.0743	0.1044	0.1294	0.1414	0.1361	0.1155	0.0864	0.1193

	Conventional Care																			
	Predicted Vector Pain Level										Target Vector Pain Level									
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
3 months	0.0041	0.0179	0.0561	0.1258	0.2025	0.2316	0.1896	0.1112	0.0469	0.0142	0.0048	0.0179	0.0563	0.1261	0.2019	0.2309	0.1888	0.1102	0.0460	0.0171
6 months	0.0281	0.0662	0.1225	0.1771	0.2004	0.1776	0.1232	0.0669	0.0285	0.0095	0.0401	0.0656	0.1210	0.1747	0.1974	0.1747	0.1210	0.0656	0.0278	0.0122
9 months	0.0643	0.1097	0.1554	0.1844	0.1788	0.1420	0.0908	0.0473	0.0203	0.0070	0.0961	0.0962	0.1396	0.1681	0.1681	0.1396	0.0962	0.0551	0.0262	0.0149
12 months	0.0678	0.1070	0.1482	0.1756	0.1753	0.1469	0.0976	0.0517	0.0219	0.0079	0.0724	0.0764	0.1172	0.1515	0.1650	0.1515	0.1172	0.0764	0.0420	0.0304
15 months	0.0509	0.0857	0.1255	0.1589	0.1717	0.1578	0.1205	0.0749	0.0381	0.0160	0.0548	0.0603	0.0968	0.1327	0.1554	0.1554	0.1327	0.0968	0.0603	0.0548
18 months	0.0386	0.0685	0.1053	0.1410	0.1631	0.1624	0.1376	0.0977	0.0576	0.0284	0.0353	0.0420	0.0722	0.1071	0.1373	0.1521	0.1455	0.1204	0.0860	0.1022
21 months	0.0244	0.0476	0.0804	0.1174	0.1487	0.1630	0.1540	0.1253	0.0874	0.0518	0.0271	0.0329	0.0581	0.0896	0.1208	0.1421	0.1460	0.1310	0.1026	0.1499
24 months	0.0175	0.0356	0.0633	0.0981	0.1326	0.1566	0.1613	0.1449	0.1133	0.0769	0.0292	0.0331	0.0570	0.0864	0.1155	0.1361	0.1414	0.1294	0.1044	0.1675

Appendix 10. Transition Matrix Verification

10a. Acupuncture + Usual Care Transition Matrix Verification

Transition Matrix	MSE
A_1	0.00001
A_2	0.00012
A_3	0.00109
A_4	0.00096
A_5	0.00076
A_6	0.00059
A_7	0.00061
A_8	0.00044

10b. Placebo-adjusted Usual Care Transition Matrix Verification

Transition Matrix	MSE
S_1	0.00000
S_2	0.00003
S_3	0.00051
S_4	0.00069
S_5	0.00037
S_6	0.00063
S_7	0.00066
S_8	0.00054

Appendix 10 continued. Transition Matrix Verification

10c. Usual Care Transition Matrix Verification

Transition Matrix	MSE
$\mathbf{U_1}$	0.00000
$\mathbf{U_2}$	0.00002
$\mathbf{U_3}$	0.00020
$\mathbf{U_4}$	0.00045
$\mathbf{U_5}$	0.00051
$\mathbf{U_6}$	0.00106
$\mathbf{U_7}$	0.00126
$\mathbf{U_8}$	0.00100

Appendix 11. Acupuncture + Usual Care Transition Matrices

A_1: Baseline to 3 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.149548788	0.168843447	0.178255937	0.177708534	0.169480596	0.156162697	0	0	0	0
Pain Level 2	0.108332278	0.157557206	0.186602257	0.185068685	0.15939254	0.122675104	0.080371931	0	0	0
Pain Level 3	0.075769101	0.159236427	0.22129278	0.219378382	0.163929881	0.095033005	0.045241652	0.020118772	0	0
Pain Level 4	0.061935933	0.158922209	0.243580172	0.244556254	0.168065556	0.078785466	0.028845747	0.010849091	0.004459571	0
Pain Level 5	0.072754404	0.155723512	0.238329392	0.249427049	0.174623869	0.076966035	0.022754442	0.006491548	0.001902527	0.001027222
Pain Level 6	0.106862279	0.148471795	0.214833481	0.24102708	0.181329459	0.081593626	0.02033237	0.004384367	0.001046903	1.19E-04
Pain Level 7	0	0.168718764	0.226893541	0.262781662	0.209417952	0.100940771	0.025516607	0.004790674	0.000910569	2.95E-05
Pain Level 8	0	0	0.264530554	0.293461142	0.245880925	0.13921441	0.049124231	0.006755054	0.001015173	1.85E-05
Pain Level 9	0	0	0	0.342366163	0.313745293	0.222655493	0.095184899	0.023685975	0.002340836	2.13E-05
Pain Level 10	0	0	0	0	0.348737863	0.320119051	0.237184105	0.086361311	0.007555889	4.18E-05

A_2: 3 months to 6 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.149548788	0.168843447	0.178255937	0.177708534	0.169480596	0.156162697	0	0	0	0
Pain Level 2	0.108332278	0.157557206	0.186602257	0.185068685	0.15939254	0.122675104	0.080371931	0	0	0
Pain Level 3	0.075769101	0.159236427	0.22129278	0.219378382	0.163929881	0.095033005	0.045241652	0.020118772	0	0

Pain Level 4	0.061935933	0.158922209	0.243580172	0.244556254	0.168065556	0.078785466	0.028845747	0.010849091	0.004459571	0
Pain Level 5	0.072754404	0.155723512	0.238329392	0.249427049	0.174623869	0.076966035	0.022754442	0.006491548	0.001902527	0.001027222
Pain Level 6	0.106862279	0.148471795	0.214833481	0.24102708	0.181329459	0.081593626	0.02033237	0.004384367	0.001046903	1.19E-04
Pain Level 7	0	0.168718764	0.226893541	0.262781662	0.209417952	0.100940771	0.025516607	0.004790674	0.000910569	2.95E-05
Pain Level 8	0	0	0.264530554	0.293461142	0.245880925	0.13921441	0.049124231	0.006755054	0.001015173	1.85E-05
Pain Level 9	0	0	0	0.342366163	0.313745293	0.222655493	0.095184899	0.023685975	0.002340836	2.13E-05
Pain Level 10	0	0	0	0	0.348737863	0.320119051	0.237184105	0.086361311	0.007555889	4.18E-05

A_3: 6 months to 9 months

	Pain Level 1	**Pain Level 2**	**Pain Level 3**	**Pain Level 4**	**Pain Level 5**	**Pain Level 6**	**Pain Level 7**	**Pain Level 8**	**Pain Level 9**	**Pain Level 10**
Pain Level 1	0.145384194	0.173415005	0.19097051	0.188672938	0.167140871	0.134416481	0	0	0	0
Pain Level 2	0.11572479	0.169024916	0.205087385	0.200291702	0.156553834	0.097802529	0.055514845	0	0	0
Pain Level 3	0.10139534	0.174411922	0.226276622	0.219301136	0.156889515	0.078920194	0.032495923	0.010309348	0	0
Pain Level 4	0.100972838	0.174321025	0.226266593	0.219290614	0.156786872	0.078415554	0.031856849	0.010009028	0.002080627	0
Pain Level 5	0.10995498	0.166632183	0.205344053	0.200185791	0.153334447	0.091301854	0.048432984	0.020266693	0.003375718	0.001171298
Pain Level 6	0.118131214	0.153532025	0.176495019	0.17346468	0.145277531	0.105114503	0.072198383	0.04210023	0.013553692	0.000132722
Pain Level 7	0	0.156503818	0.16622625	0.164980375	0.152816784	0.131761732	0.106871974	0.07444318	0.036712082	0.009683805
Pain Level 8	0	0	0.159203682	0.158892906	0.155882833	0.150540328	0.142241903	0.123056466	0.08047617	0.029705713
Pain Level 9	0	0	0	0.15653857	0.156027013	0.155139281	0.153692979	0.149379486	0.133981499	0.095241172
Pain Level 10	0	0	0	0	0.169767132	0.169648545	0.16944321	0.168753267	0.165892539	0.156495307

A_4: 9 months to 12 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.296114057	0.333213658	0.202251798	0.101772127	0.047480973	0.019167387	0	0	0	0
Pain Level 2	0.108096761	0.295686408	0.368344618	0.15264263	0.053080765	0.016596404	0.005552415	0	0	0
Pain Level 3	0.037513352	0.092798555	0.303527334	0.433951072	0.100025381	0.02425482	0.006176124	0.001753363	0	0
Pain Level 4	0.016097715	0.03267087	0.071380411	0.282633498	0.532483132	0.048586467	0.013328148	0.001808108	0.001011651	0
Pain Level 5	0.010332366	0.015644372	0.026794088	0.049124777	0.216990232	0.654697518	0.020513187	0.004690236	0.001021224	0.000192001
Pain Level 6	0.007841183	0.00988699	0.013247874	0.022095046	0.044196341	0.139943456	0.75283984	0.008019643	0.001436699	0.000492929
Pain Level 7	0	0.008842492	0.010414995	0.014076655	0.022028196	0.035421836	0.074559717	0.832742016	0.000954657	0.000959437
Pain Level 8	0	0	0.011157275	0.012832087	0.015404502	0.018152549	0.021169377	0.047131689	0.865386153	0.008766368
Pain Level 9	0	0	0	0.016424518	0.017295132	0.018381185	0.018462765	0.002166663	0.126113497	0.801156241
Pain Level 10	0	0	0	0	0.032830497	0.033756008	0.034242894	0.044587686	0.158097772	0.696485142

A_5: 12 months to 15 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.296114057	0.333213658	0.202251798	0.101772127	0.047480973	0.019167387	0	0	0	0
Pain Level 2	0.108096761	0.295686408	0.368344618	0.15264263	0.053080765	0.016596404	0.005552415	0	0	0
Pain Level 3	0.037513352	0.092798555	0.303527334	0.433951072	0.100025381	0.02425482	0.006176124	0.001753363	0	0

Pain Level 4	0.016097715	0.03267087	0.071380411	0.282633498	0.532483132	0.048586467	0.013328148	0.001808108	0.001011651	0
Pain Level 5	0.010332366	0.015644372	0.026794088	0.049124777	0.216990232	0.654697518	0.020513187	0.004690236	0.001021224	0.000192001
Pain Level 6	0.007841183	0.00988699	0.013247874	0.022095046	0.044196341	0.139943456	0.75283984	0.008019643	0.001436699	0.000492929
Pain Level 7	0	0.008842492	0.010414995	0.014076655	0.022028196	0.035421836	0.074559717	0.832742016	0.000954657	0.000959437
Pain Level 8	0	0	0.011157275	0.012832087	0.015404502	0.018152549	0.021169377	0.047131689	0.865386153	0.008766368
Pain Level 9	0	0	0	0.016424518	0.017295132	0.018381185	0.018462765	0.002166663	0.126113497	0.801156241
Pain Level 10	0	0	0	0	0.032830497	0.033756008	0.034242894	0.044587686	0.158097772	0.696485142

A_6: 15 months to 18 months

	Pain Level 1	**Pain Level 2**	**Pain Level 3**	**Pain Level 4**	**Pain Level 5**	**Pain Level 6**	**Pain Level 7**	**Pain Level 8**	**Pain Level 9**	**Pain Level 10**
Pain Level 1	0.195949686	0.236849039	0.207631622	0.159416013	0.117608533	0.082545109	0	0	0	0
Pain Level 2	0.137910943	0.232036629	0.237144669	0.173242886	0.113747296	0.068263343	0.037654234	0	0	0
Pain Level 3	0.062184305	0.144715476	0.258483196	0.245873384	0.155951025	0.081020015	0.037337274	0.014435325	0	0
Pain Level 4	0.018074602	0.052950648	0.150984069	0.29131473	0.262283662	0.136412154	0.05917058	0.019428004	0.009381552	0
Pain Level 5	0.007168839	0.020347918	0.054697766	0.149369801	0.31269934	0.270083938	0.12207368	0.046156655	0.009630133	0.007771929
Pain Level 6	0.004986193	0.008463167	0.020860985	0.05455375	0.129480555	0.314763049	0.315985179	0.112495364	0.035224457	0.003187301
Pain Level 7	0	0.007301912	0.010647917	0.024378903	0.060205218	0.136240971	0.28862515	0.338595362	0.103834246	0.030170321
Pain Level 8	0	0	0.010153696	0.015852062	0.034298584	0.077226333	0.153489525	0.288019347	0.3389367	0.082023753
Pain Level 9	0	0	0	0.016688694	0.030521086	0.057355061	0.097174036	0.162945674	0.304139554	0.331175895
Pain Level 10	0	0	0	0	0.042943462	0.06426844	0.091745093	0.131412161	0.218745919	0.450884925

A_7: 18 months to 21 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.195949686	0.236849039	0.207631622	0.159416013	0.117608533	0.082545109	0	0	0	0
Pain Level 2	0.137910943	0.232036629	0.237144669	0.173242886	0.113747296	0.068263343	0.037654234	0	0	0
Pain Level 3	0.062184305	0.144715476	0.258483196	0.245873384	0.155951025	0.081020015	0.037337274	0.014435325	0	0
Pain Level 4	0.018074602	0.052950648	0.150984069	0.29131473	0.262283662	0.136412154	0.05917058	0.019428004	0.009381552	0
Pain Level 5	0.007168839	0.020347918	0.054697766	0.149369801	0.31269934	0.270083938	0.12207368	0.046156655	0.009630133	0.007771929
Pain Level 6	0.004986193	0.008463167	0.020860985	0.05455375	0.129480555	0.314763049	0.315985179	0.112495364	0.035224457	0.003187301
Pain Level 7	0	0.007301912	0.010647917	0.024378903	0.060205218	0.136240971	0.28862515	0.338595362	0.103834246	0.030170321
Pain Level 8	0	0	0.010153696	0.015852062	0.034298584	0.077226333	0.153489525	0.288019347	0.3389367	0.082023753
Pain Level 9	0	0	0	0.016688694	0.030521086	0.057355061	0.097174036	0.162945674	0.304139554	0.331175895
Pain Level 10	0	0	0	0	0.042943462	0.06426844	0.091745093	0.131412161	0.218745919	0.450884925

A_8: 21 months to 24 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.956896225	0.042674735	3.72828E-05	0.000147622	0.000148862	9.52733E-05	0	0	0	0
Pain Level 2	0.00034772	0.93565339	0.062647033	0.000395073	0.000447155	0.000294619	0.000215011	0	0	0
Pain Level 3	1.29698E-05	0.000756583	0.925484507	0.070312726	0.001786112	0.000798272	0.000487797	0.000361034	0	0
Pain Level 4	2.23E-06	9.6138E-05	0.001249574	0.922225037	0.072181361	0.002217588	0.000980159	0.000586393	0.000461514	0

Pain Level 5	3.52E-10	3.60893E-05	0.000101403	0.001723102	0.921189849	0.072288768	0.002477395	0.001173587	0.000642414	0.000367392
Pain Level 6	1.89E-10	1.39894E-05	7.30768E-05	4.36223E-05	0.002392843	0.922676774	0.069923241	0.003319765	0.00107862	0.000478069
Pain Level 7	0	9.14E-06	5.26375E-05	0.000142923	0.000401117	0.002716784	0.925600446	0.06655439	0.004522469	9.50E-08
Pain Level 8	0	0	4.88457E-05	0.000147781	0.00041967	0.001359328	0.005828334	0.926357995	0.061200937	0.00463711
Pain Level 9	0	0	0	0.000159946	0.000407882	0.00102268	0.002650571	0.013652944	0.929258968	0.052847008
Pain Level 10	0	0	0	0	0.000481949	0.001043071	0.001964664	0.004829879	0.026719911	0.964960526

Appendix 12. Placebo-adjusted Usual Care Transition Matrices

S_1: Baseline to 3 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.146931856	0.165404411	0.172890017	0.174918981	0.172336859	0.167517875	0	0	0	0
Pain Level 2	0.097662355	0.139106282	0.162249813	0.169006552	0.160496537	0.145011865	0.126466595	0	0	0
Pain Level 3	0.056229303	0.119846352	0.17179624	0.189522562	0.169480008	0.132652204	0.095668264	0.064805067	0	0
Pain Level 4	0.033151759	0.105085171	0.186571946	0.222235022	0.191709157	0.128382269	0.072084782	0.037912781	0.022867112	0
Pain Level 5	0.032751127	0.09477528	0.18505266	0.240801427	0.21681182	0.135733948	0.059885274	0.020949207	0.007209447	0.006029812
Pain Level 6	0.062004416	0.089199631	0.161358983	0.229684094	0.230633214	0.151163707	0.059043241	0.01302497	0.003077379	0.000810365
Pain Level 7	0	0.101331821	0.154006604	0.226149903	0.247438914	0.176963281	0.074798285	0.015706466	0.003108088	0.000496637
Pain Level 8	0	0	0.170946684	0.229315022	0.253469925	0.200697656	0.108724768	0.033328578	0.003054043	4.63E-04
Pain Level 9	0	0	0	0.253215705	0.26426306	0.232518024	0.153148065	0.075959117	0.019431611	0.001464418
Pain Level 10	0	0	0	0	0.276284555	0.267107701	0.238673958	0.162720144	0.055207815	5.83E-06

S_2: 3 months to 6 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.146931856	0.165404411	0.172890017	0.174918981	0.172336859	0.167517875	0	0	0	0
Pain Level 2	0.097662355	0.139106282	0.162249813	0.169006552	0.160496537	0.145011865	0.126466595	0	0	0

Pain Level 3	0.056229303	0.119846352	0.17179624	0.189522562	0.169480008	0.132652204	0.095668264	0.064805067	0	0
Pain Level 4	0.033151759	0.105085171	0.186571946	0.222235022	0.191709157	0.128382269	0.072084782	0.037912781	0.022867112	0
Pain Level 5	0.032751127	0.09477528	0.18505266	0.240801427	0.21681182	0.135733948	0.059885274	0.020949207	0.007209447	0.006029812
Pain Level 6	0.062004416	0.089199631	0.161358983	0.229684094	0.230633214	0.151163707	0.059043241	0.01302497	0.003077379	0.000810365
Pain Level 7	0	0.101331821	0.154006604	0.226149903	0.247438914	0.176963281	0.074798285	0.015706466	0.003108088	0.000496637
Pain Level 8	0	0	0.170946684	0.229315022	0.253469925	0.200697656	0.108724768	0.033328578	0.003054043	4.63E-04
Pain Level 9	0	0	0	0.253215705	0.26426306	0.232518024	0.153148065	0.075959117	0.019431611	0.001464418
Pain Level 10	0	0	0	0	0.276284555	0.267107701	0.238673958	0.162720144	0.055207815	5.83E-06

S_3: 6 months to 9 months

	Pain Level 1	**Pain Level 2**	**Pain Level 3**	**Pain Level 4**	**Pain Level 5**	**Pain Level 6**	**Pain Level 7**	**Pain Level 8**	**Pain Level 9**	**Pain Level 10**
Pain Level 1	0.14327371	0.161801541	0.176540059	0.182463665	0.17609911	0.159821914	0	0	0	0
Pain Level 2	0.102555317	0.138709469	0.171708428	0.185481176	0.170695359	0.134626435	0.096223816	0	0	0
Pain Level 3	0.074247391	0.128928683	0.185199608	0.209597588	0.18340392	0.122410273	0.066298832	0.029913705	0	0
Pain Level 4	0.062273895	0.126398031	0.195978482	0.226645876	0.193742883	0.11862562	0.053735347	0.018517471	0.004082393	0
Pain Level 5	0.066333345	0.126948055	0.191314168	0.219460538	0.189276971	0.119711924	0.05797206	0.022169122	0.005149878	0.001663939
Pain Level 6	0.080559601	0.128343021	0.175688124	0.195968178	0.174179727	0.122703916	0.073247194	0.037671987	0.011553738	8.45E-05
Pain Level 7	0	0.138746185	0.167485619	0.179281019	0.166528407	0.13476926	0.100732907	0.069479226	0.036275662	0.006701716
Pain Level 8	0	0	0.165788457	0.170383465	0.165431781	0.152206744	0.134105504	0.109270819	0.072297336	0.030515894
Pain Level 9	0	0	0	0.16913263	0.16780926	0.164251252	0.15891803	0.148619319	0.12201406	0.069255449

Pain Level 10	0	0	0	0	0.176784341	0.176090641	0.17503251	0.172665877	0.164152115	0.135274515

S_4: 9 months to 12 months

	Pain Level 1	**Pain Level 2**	**Pain Level 3**	**Pain Level 4**	**Pain Level 5**	**Pain Level 6**	**Pain Level 7**	**Pain Level 8**	**Pain Level 9**	**Pain Level 10**
Pain Level 1	0.340573637	0.217469218	0.153547684	0.123488344	0.096750145	0.068170972	0	0	0	0
Pain Level 2	0.19710441	0.332262626	0.18510212	0.129082376	0.087548971	0.046639534	0.022259963	0	0	0
Pain Level 3	0.000593899	0.149582173	0.36825764	0.251611964	0.141344871	0.06030512	0.021288755	0.007015579	0	0
Pain Level 4	0.005386713	0.034537212	0.150540638	0.35523741	0.267728009	0.117565972	0.047911048	0.015290165	0.005802832	0
Pain Level 5	0.001738031	0.008137435	0.04777498	0.137110443	0.316792571	0.297912508	0.128458831	0.045752468	0.012085567	0.004237166
Pain Level 6	0.002266488	0.006876311	0.015754566	0.057897732	0.143784848	0.284112364	0.308396331	0.129526669	0.041358869	0.010025821
Pain Level 7	0	0.004548585	0.009753387	0.032034311	0.085894044	0.174155118	0.267578399	0.287676436	0.110115281	0.028244439
Pain Level 8	0	0	0.014606645	0.033701786	0.070237162	0.121961161	0.17031217	0.232600182	0.252391386	0.104189508
Pain Level 9	0	0	0	0.055273411	0.081394042	0.113312095	0.139927567	0.171629979	0.220946558	0.217516348
Pain Level 10	0	0	0	0	0.117605541	0.137839181	0.154297318	0.173166374	0.196073614	0.221017973

S_5: 12 months to 15 months

	Pain Level 1	**Pain Level 2**	**Pain Level 3**	**Pain Level 4**	**Pain Level 5**	**Pain Level 6**	**Pain Level 7**	**Pain Level 8**	**Pain Level 9**	**Pain Level 10**
Pain Level 1	0.340573637	0.217469218	0.153547684	0.123488344	0.096750145	0.068170972	0	0	0	0
Pain Level 2	0.19710441	0.332262626	0.18510212	0.129082376	0.087548971	0.046639534	0.022259963	0	0	0
Pain Level 3	0.000593899	0.149582173	0.36825764	0.251611964	0.141344871	0.06030512	0.021288755	0.007015579	0	0

Pain Level 4	0.005386713	0.034537212	0.150540638	0.35523741	0.267728009	0.117565972	0.047911048	0.015290165	0.005802832	0
Pain Level 5	0.001738031	0.008137435	0.04777498	0.137110443	0.316792571	0.297912508	0.128458831	0.045752468	0.012085567	0.004237166
Pain Level 6	0.002266488	0.006876311	0.015754566	0.057897732	0.143784848	0.284112364	0.308396331	0.129526669	0.041358869	0.010025821
Pain Level 7	0	0.004548585	0.009753387	0.032034311	0.085894044	0.174155118	0.267578399	0.287676436	0.110115281	0.028244439
Pain Level 8	0	0	0.014606645	0.033701786	0.070237162	0.121961161	0.17031217	0.232600182	0.252391386	0.104189508
Pain Level 9	0	0	0	0.055273411	0.081394042	0.113312095	0.139927567	0.171629979	0.220946558	0.217516348
Pain Level 10	0	0	0	0	0.117605541	0.137839181	0.154297318	0.173166374	0.196073614	0.221017973

S_6: 15 months to 18 months

	Pain Level 1	**Pain Level 2**	**Pain Level 3**	**Pain Level 4**	**Pain Level 5**	**Pain Level 6**	**Pain Level 7**	**Pain Level 8**	**Pain Level 9**	**Pain Level 10**
Pain Level 1	0.08951046	0.146940342	0.1776269	0.196847485	0.201487888	0.187586925	0	0	0	0
Pain Level 2	0.029457787	0.103201545	0.157691161	0.194850599	0.203548024	0.175764303	0.135486581	0	0	0
Pain Level 3	0.00905592	0.071059091	0.14409213	0.201057413	0.216707368	0.176806491	0.119060557	0.062161029	0	0
Pain Level 4	0.007274207	0.055716925	0.130096362	0.197815292	0.224595223	0.187605955	0.124220127	0.058662522	0.014013387	0
Pain Level 5	0.019584537	0.052764371	0.104867069	0.163322947	0.202265457	0.193537845	0.148876538	0.084798445	0.024731768	0.005251023
Pain Level 6	0.108429752	0.051466885	0.064541587	0.096201808	0.136578142	0.168913639	0.170242775	0.134638325	0.065179709	0.003807378
Pain Level 7	0	0.065532084	0.044523175	0.052896943	0.082956395	0.141363521	0.191092334	0.204308626	0.163210347	0.054116576
Pain Level 8	0	0	0.034370118	0.031509558	0.048651843	0.103072801	0.168256023	0.2139933	0.222527031	0.177619327
Pain Level 9	0	0	0	0.034374108	0.04664563	0.091258889	0.14873805	0.198128385	0.230286713	0.250568225
Pain Level 10	0	0	0	0	0.071840279	0.108313986	0.151700378	0.189910213	0.220529795	0.25770535

S_7: 18 months to 21 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.08951046	0.146940342	0.1776269	0.196847485	0.201487888	0.187586925	0	0	0	0
Pain Level 2	0.029457787	0.103201545	0.157691161	0.194850599	0.203548024	0.175764303	0.135486581	0	0	0
Pain Level 3	0.00905592	0.071059091	0.14409213	0.201057413	0.216707368	0.176806491	0.119060557	0.062161029	0	0
Pain Level 4	0.007274207	0.055716925	0.130096362	0.197815292	0.224595223	0.187605955	0.124220127	0.058662522	0.014013387	0
Pain Level 5	0.019584537	0.052764371	0.104867069	0.163322947	0.202265457	0.193537845	0.148876538	0.084798445	0.024731768	0.005251023
Pain Level 6	0.108429752	0.051466885	0.064541587	0.096201808	0.136578142	0.168913639	0.170242775	0.134638325	0.065179709	0.003807378
Pain Level 7	0	0.065532084	0.044523175	0.052896943	0.082956395	0.141363521	0.191092334	0.204308626	0.163210347	0.054116576
Pain Level 8	0	0	0.034370118	0.031509558	0.048651843	0.103072801	0.168256023	0.2139933	0.222527031	0.177619327
Pain Level 9	0	0	0	0.034374108	0.04664563	0.091258889	0.14873805	0.198128385	0.230286713	0.250568225
Pain Level 10	0	0	0	0	0.071840279	0.108313986	0.151700378	0.189910213	0.220529795	0.25770535

S_8: 21 months to 24 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.956215095	0.043384996	3.39E-05	0.000114358	0.000150631	0.000101044	0	0	0	0
Pain Level 2	0.000378987	0.9348013	0.063517184	0.000298328	0.000462451	0.000311541	0.000230207	0	0	0
Pain Level 3	1.30E-05	0.000809704	0.924746125	0.070811674	0.001868245	0.000850515	0.000519987	0.000380757	0	0
Pain Level 4	1.73E-06	0.000107642	0.001241784	0.922170236	0.072070633	0.002331101	0.001008132	0.000601033	0.000467707	0

Pain Level 5	4.02E-10	3.84E-05	0.000122993	0.001534276	0.921644181	0.071980076	0.00253153	0.001161561	0.000642859	0.000344171
Pain Level 6	3.38E-10	1.50E-05	8.53E-05	4.53E-05	0.002243014	0.923233558	0.069539048	0.003345433	0.001035526	0.000457835
Pain Level 7	0	1.02E-05	5.79E-05	0.000147158	0.000336426	0.002599605	0.926218227	0.066122515	0.004507834	9.09E-08
Pain Level 8	0	0	5.24E-05	0.000150466	0.000393254	0.001296493	0.00576152	0.927040642	0.06050774	0.004797451
Pain Level 9	0	0	0	0.000161815	0.000387655	0.000974861	0.002536181	0.013691888	0.930869705	0.051377896
Pain Level 10	0	0	0	0	0.000456034	0.000981011	0.00182509	0.004407107	0.02566942	0.966661338

Appendix 13. Usual Care Transition Matrices

U_1: Baseline to 3 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.181850191	0.175158314	0.170045755	0.16375551	0.157792572	0.151397658	0	0	0	0
Pain Level 2	0.209584762	0.18293126	0.160350851	0.138615339	0.119868315	0.101827672	0.086821801	0	0	0
Pain Level 3	0.29067585	0.233148215	0.155205354	0.115192704	0.083411154	0.055164369	0.036674571	0.030527783	0	0
Pain Level 4	0.049425007	0.306114341	0.297493326	0.172235672	0.094405156	0.038242629	0.015832605	0.012629614	0.01362165	0
Pain Level 5	0.002460924	0.042511254	0.286965067	0.370240813	0.18236939	0.064589559	0.01879859	0.011231162	0.010238942	0.010594299
Pain Level 6	0.002450956	0.003581507	0.050211894	0.225269619	0.373672409	0.219384174	0.076773331	0.028244609	0.012898589	0.007512911
Pain Level 7	0	0.006397459	0.010689358	0.061418595	0.192364475	0.341278918	0.251285065	0.09668944	0.032252097	0.007624592
Pain Level 8	0	0	0.008847379	0.03593988	0.117297685	0.241265384	0.307215218	0.209121467	0.068666638	1.16E-02
Pain Level 9	0	0	0	0.064145078	0.122965751	0.194781238	0.24258524	0.223632157	0.119562172	0.032328364
Pain Level 10	0	0	0	0	0.162860802	0.188664809	0.200385809	0.192933694	0.162779658	0.092375227

U_2: 3 months to 6 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.181850191	0.175158314	0.170045755	0.16375551	0.157792572	0.151397658	0	0	0	0
Pain Level 2	0.209584762	0.18293126	0.160350851	0.138615339	0.119868315	0.101827672	0.086821801	0	0	0
Pain Level 3	0.29067585	0.233148215	0.155205354	0.115192704	0.083411154	0.055164369	0.036674571	0.030527783	0	0

Pain Level 4	0.049425007	0.306114341	0.297493326	0.172235672	0.094405156	0.038242629	0.015832605	0.012629614	0.01362165	0
Pain Level 5	0.002460924	0.042511254	0.286965067	0.370240813	0.18236939	0.064589559	0.01879859	0.011231162	0.010238942	0.010594299
Pain Level 6	0.002450956	0.003581507	0.050211894	0.225269619	0.373672409	0.219384174	0.076773331	0.028244609	0.012898589	0.007512911
Pain Level 7	0	0.006397459	0.010689358	0.061418595	0.192364475	0.341278918	0.251285065	0.09668944	0.032252097	0.007624592
Pain Level 8	0	0	0.008847379	0.03593988	0.117297685	0.241265384	0.307215218	0.209121467	0.068666638	1.16E-02
Pain Level 9	0	0	0	0.064145078	0.122965751	0.194781238	0.24258524	0.223632157	0.119562172	0.032328364
Pain Level 10	0	0	0	0	0.162860802	0.188664809	0.200385809	0.192933694	0.162779658	0.092375227

U_3: 6 months to 9 months

	Pain Level 1	**Pain Level 2**	**Pain Level 3**	**Pain Level 4**	**Pain Level 5**	**Pain Level 6**	**Pain Level 7**	**Pain Level 8**	**Pain Level 9**	**Pain Level 10**
Pain Level 1	0.153321436	0.161452512	0.169164941	0.174228273	0.173906368	0.167926469	0	0	0	0
Pain Level 2	0.115605579	0.133271087	0.150789652	0.162501354	0.161753843	0.147955205	0.12812328	0	0	0
Pain Level 3	0.084572799	0.114735882	0.146366667	0.167975939	0.166588613	0.141188014	0.105778754	0.072793333	0	0
Pain Level 4	0.065520854	0.106658205	0.151924984	0.183403864	0.181372071	0.1444271	0.094199824	0.050830834	0.021662265	0
Pain Level 5	0.060119088	0.105007922	0.155331955	0.190604129	0.188320905	0.146947067	0.09128672	0.044598455	0.01571936	0.002064399
Pain Level 6	0.06531117	0.106199869	0.151204663	0.182517268	0.180495576	0.143746739	0.093810674	0.050698358	0.021661479	0.004354204
Pain Level 7	0	0.117754775	0.150254302	0.172417198	0.170995571	0.144939905	0.108547033	0.074590093	0.046168449	0.014332674
Pain Level 8	0	0	0.151465762	0.163560271	0.16278898	0.148543595	0.128096657	0.107484643	0.086576278	0.051483813
Pain Level 9	0	0	0	0.162671292	0.162347335	0.156332049	0.147516076	0.138117547	0.127368361	0.10564734
Pain Level 10	0	0	0	0	0.17482013	0.172810373	0.169820461	0.166512815	0.162461108	0.153575113

U_4: 9 months to 12 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.688003593	0.202721373	0.047184218	0.032050047	0.018265152	0.011775617	0	0	0	0
Pain Level 2	0.019524819	0.63886363	0.25200044	0.052153078	0.020894581	0.010829405	0.005734047	0	0	0
Pain Level 3	0.008651465	0.00878778	0.620609667	0.295697289	0.042502205	0.014320756	0.00595472	0.003476117	0	0
Pain Level 4	0.002410581	0.006267544	0.007550527	0.588558357	0.350153779	0.029077512	0.009717609	0.003709753	0.002554338	0
Pain Level 5	0.001576913	0.003951607	0.006214729	0.011805593	0.548066142	0.400081072	0.015072646	0.0079944	0.002886072	0.002350825
Pain Level 6	0.001161293	0.002037969	0.003348652	0.007111423	0.016519821	0.496732837	0.446638732	0.015547724	0.008917252	0.001984296
Pain Level 7	0	0.002277223	0.00279055	0.004716624	0.011800572	0.039466593	0.461939766	0.4514359	0.0194926	0.006080173
Pain Level 8	0	0	0.002998124	0.004346649	0.008793558	0.020950832	0.056957946	0.460558919	0.434663449	0.010730523
Pain Level 9	0	0	0	0.005609136	0.009966583	0.0181413	0.032833187	0.076406789	0.444163148	0.412879858
Pain Level 10	0	0	0	0	0.014379621	0.021735392	0.034320012	0.064522644	0.21487708	0.65016525

U_5: 12 months to 15 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.688003593	0.202721373	0.047184218	0.032050047	0.018265152	0.011775617	0	0	0	0
Pain Level 2	0.019524819	0.63886363	0.25200044	0.052153078	0.020894581	0.010829405	0.005734047	0	0	0
Pain Level 3	0.008651465	0.00878778	0.620609667	0.295697289	0.042502205	0.014320756	0.00595472	0.003476117	0	0
Pain Level 4	0.002410581	0.006267544	0.007550527	0.588558357	0.350153779	0.029077512	0.009717609	0.003709753	0.002554338	0

Pain Level 5	0.001576913	0.003951607	0.006214729	0.011805593	0.548066142	0.400081072	0.015072646	0.0079944	0.002886072	0.002350825
Pain Level 6	0.001161293	0.002037969	0.003348652	0.007111423	0.016519821	0.496732837	0.446638732	0.015547724	0.008917252	0.001984296
Pain Level 7	0	0.002277223	0.00279055	0.004716624	0.011800572	0.039466593	0.461939766	0.4514359	0.0194926	0.006080173
Pain Level 8	0	0	0.002998124	0.004346649	0.008793558	0.020950832	0.056957946	0.460558919	0.434663449	0.010730523
Pain Level 9	0	0	0	0.005609136	0.009966583	0.0181413	0.032833187	0.076406789	0.444163148	0.412879858
Pain Level 10	0	0	0	0	0.014379621	0.021735392	0.034320012	0.064522644	0.21487708	0.65016525

U_6: 15 months to 18 months

	Pain Level 1	**Pain Level 2**	**Pain Level 3**	**Pain Level 4**	**Pain Level 5**	**Pain Level 6**	**Pain Level 7**	**Pain Level 8**	**Pain Level 9**	**Pain Level 10**
Pain Level 1	0.175124648	0.213437378	0.20132469	0.16840476	0.136175513	0.105533011	0	0	0	0
Pain Level 2	0.121077968	0.200434	0.220027538	0.178977132	0.132078783	0.089741417	0.057663161	0	0	0
Pain Level 3	0.057440162	0.136208568	0.228753124	0.230292228	0.167320788	0.101193859	0.055365049	0.023426221	0	0
Pain Level 4	0.015722477	0.052142184	0.145305976	0.261002568	0.252065496	0.154914121	0.079054067	0.029009426	0.010783685	0
Pain Level 5	0.003736485	0.016241412	0.054413717	0.150783275	0.280863633	0.260280653	0.149391532	0.062004507	0.012020552	0.010264233
Pain Level 6	0.002654719	0.005334759	0.017707608	0.05615111	0.142779906	0.292087539	0.288489666	0.14571486	0.047543003	0.001536831
Pain Level 7	0	0.003381859	0.00452925	0.018881912	0.059266822	0.141773898	0.282158178	0.314050974	0.14582705	0.030130058
Pain Level 8	0	0	0.006091543	0.008589303	0.024965406	0.071238739	0.154785718	0.281275642	0.320006474	0.133047176
Pain Level 9	0	0	0	0.008195943	0.01736498	0.044948181	0.095561732	0.179283998	0.312894772	0.341750394
Pain Level 10	0	0	0	0	0.022670963	0.047424893	0.084855709	0.141179662	0.242108515	0.461760258

U_7: 18 months to 21 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.175124648	0.213437378	0.20132469	0.16840476	0.136175513	0.105533011	0	0	0	0
Pain Level 2	0.121077968	0.200434	0.220027538	0.178977132	0.132078783	0.089741417	0.057663161	0	0	0
Pain Level 3	0.057440162	0.136208568	0.228753124	0.230292228	0.167320788	0.101193859	0.055365049	0.023426221	0	0
Pain Level 4	0.015722477	0.052142184	0.145305976	0.261002568	0.252065496	0.154914121	0.079054067	0.029009426	0.010783685	0
Pain Level 5	0.003736485	0.016241412	0.054413717	0.150783275	0.280863633	0.260280653	0.149391532	0.062004507	0.012020552	0.010264233
Pain Level 6	0.002654719	0.005334759	0.017707608	0.05615111	0.142779906	0.292087539	0.288489666	0.14571486	0.047543003	0.001536831
Pain Level 7	0	0.003381859	0.00452925	0.018881912	0.059266822	0.141773898	0.282158178	0.314050974	0.14582705	0.030130058
Pain Level 8	0	0	0.006091543	0.008589303	0.024965406	0.071238739	0.154785718	0.281275642	0.320006474	0.133047176
Pain Level 9	0	0	0	0.008195943	0.01736498	0.044948181	0.095561732	0.179283998	0.312894772	0.341750394
Pain Level 10	0	0	0	0	0.022670963	0.047424893	0.084855709	0.141179662	0.242108515	0.461760258

U_8: 21 months to 24 months

	Pain Level 1	Pain Level 2	Pain Level 3	Pain Level 4	Pain Level 5	Pain Level 6	Pain Level 7	Pain Level 8	Pain Level 9	Pain Level 10
Pain Level 1	0.94315987	0.05673605	1.11E-05	7.49E-05	1.80E-05	3.02E-08	0	0	0	0
Pain Level 2	0.000244906	0.920751306	0.078437135	0.000466885	6.26E-05	2.47E-05	1.24E-05	0	0	0
Pain Level 3	7.28E-06	0.000501003	0.913095883	0.085454407	0.000398207	0.000201398	0.000178946	0.00016288	0	0
Pain Level 4	3.60E-07	2.70E-06	0.000454169	0.911735358	0.085270109	0.001105402	0.00062045	0.000446936	0.000364514	0
Pain Level 5	1.08E-11	3.08E-06	8.48E-05	0.000539249	0.914730246	0.081405284	0.001891195	0.000767377	0.000562946	1.58E-05

Pain Level 6	1.65E-10	8.53E-07	1.01E-05	0.000272012	0.000708903	0.918990346	0.07468898	0.003872373	0.001000157	0.000456281
Pain Level 7	0	3.82E-07	3.28E-06	0.000104385	0.000451559	0.002694936	0.926237744	0.064687664	0.004692841	0.001127206
Pain Level 8	0	0	2.01E-06	4.98E-05	0.000255381	0.000697161	0.004957375	0.935502538	0.053263986	0.005271722
Pain Level 9	0	0	0	4.61E-05	0.000202435	0.000360452	0.001289356	0.008931354	0.949883909	0.039286423
Pain Level 10	0	0	0	0	0.000216471	0.000267874	0.000746235	0.002552044	0.014073889	0.982143486