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Missing Work is a Pain: The Effect of Cox-2 Inhibitors on Sickness Absence and Disability Pension Receipt*

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Abstract

How does medical innovation affect labor supply? We analyze how the availability of Cox-2 inhibitors, pharmaceuticals used for treating pain and inflammation, affected the sickness absence and disability pension receipt of individuals with joint pain. We exploit the market entry of the Cox-2 inhibitor Vioxx and its sudden market withdrawal as exogenous sources of variation in drug use. Using Norwegian administrative data, we find Vioxx's entry decreased quarterly sickness absence days among individuals with joint pain by 7-11 percent. The withdrawal increased sickness days by 12-21 percent and increased the quarterly probability of receiving disability benefits by 0.4-0.6 percentage points.

1 Introduction

While early literature on human capital focused primarily on education and job training, more recently, the economics literature has focused on health capital. Healthier individuals are more productive, and this notion has been used to rationalize employer-sponsored provision of wellness programs. Furthermore, Sala-i-Martin (1997a,b) finds that health, in the form of life expectancy, is a positive and significant predictor of per capita GDP growth across a variety of empirical specifications. Many other studies have also found health is an important and robust determinant of economic growth and income variation (see for example Bloom et al., 2004; Weil, 2007). A key question then becomes: how does new medical technology affect the health capital, and thus, the productivity of workers?

Understanding how advances in medical technology affect health capital and consequently, worker productivity and labor supply, can have important implications for health care policy. In Europe and more recently in the United States, comparative-effectiveness programs have been established as part of larger health care reform efforts. Comparative-effectiveness research (CER) provides evidence on the effectiveness, benefits,

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and harms of different treatment options. In some European countries, CER is used to inform or determine the coverage and reimbursement of medical treatments.[1] While most countries' comparative-effectiveness entities focus on the payer perspective, some countries like Sweden and Norway have adopted a societal perspective. The societal perspective means both direct and indirect costs and benefits of treatments, such as gains or losses in worker productivity, should be considered regardless of who benefits or bears the costs (patients or payers), underscoring the importance of understanding the labor supply effects of advances in medical technology.

In this paper, we aim to estimate the impact of progress in the treatment for chronic joint pain on labor supply. In particular, we examine how the availability of Cox-2 inhibitors, pharmaceuticals prescribed for the treatment of chronic pain and inflammation, affected the sickness-related work absence and disability benefit receipt of individuals with joint pain in Norway. We do so by exploiting the market entry of Vioxx, a popular Cox-2 inhibitor, in 2001 and its unexpected worldwide market withdrawal in 2004 due to concerns over negative side effects as sources of exogenous variation in the use of Cox-2 inhibitors. Using administrative panel data on sickness absence and disability pension receipt, we find that Vioxx's entry led to a 7 to 11 percent decrease in quarterly sickness absence days among individuals with chronic joint pain, while Vioxx's withdrawal led to a 12 to 21 percent increase in the number of sickness absence days as well as a 0.4 to 0.6 percentage point increase in the quarterly probability of receiving disability pension.

Broadly, our paper fits into the literature that examines the impact of health on labor market outcomes. Many studies find that poor physical or mental health can adversely affect wages and labor supply (for a review of this literature see Currie and Madrian, 1999). In particular, some studies have focused on the labor market impacts of arthritis and pain (see for example Mitchell and Burkhauser, 1990; Mitchell, 1991; Kapteyn et al., 2008; Gaskin and Richard, 2012; Simons et al., 2012). Mitchell and Burkhauser (1990) find that hours worked are more adversely affected by arthritis than wage rates in the US, especially for men and younger women, which can translate into substantial earnings effects. Gaskin and Richard (2012) use data from 2008 to estimate the annual costs of pain in the US that are associated with lower worker productivity, and find the value of lost productivity due to pain ranged from $299 to $335 billion.

In addition, our paper contributes to a small but growing literature that analyzes how medical treatments affect labor supply and earnings. Thirumurthy et al. (2008) study the effect of antiretroviral treatments for HIV and AIDS on intensive and extensive margin labor supply in Kenya. Some studies have focused on the labor supply impacts of treatments for depression (for a review of this literature see Timbie et al., 2006). In the medical literature, there has been a focus on the impact of influenza vaccinations, particularly workplace-sponsored vaccinations, on worker absenteeism and productivity (see for example Nichol, 2001; Nichol et al., 2009). More recently, Epstein et al. (2013) study the effect of minimally invasive surgeries on medical expenditures and worker absenteeism, and find for 4 of the 6 types of surgeries they consider, minimally invasive procedures were associated with significantly fewer days of absence than standard

[1]For example, in the United Kingdom, the National Institute for Clinical Excellence (NICE) analyzes the clinical and cost-effectiveness of medical technologies, including diagnostic tests, surgical procedures, and pharmaceuticals, and NICE's research is used to determine which treatments will be covered by the UK's National Health Service. In Germany, the Institute for Quality and Efficiency in Health Care conducts comparative-effectiveness studies of medical treatments and procedures, and their studies are used to inform the reimbursement decisions made by another body, the Federal Joint Committee.

procedures. In addition, Papageorge (2014) estimates a dynamic structural model to determine the value of a treatment for HIV known as HAART. His model takes into account how side effects and the labor market affect the demand for medical treatment. One reason this literature is small is the difficulty in finding exogenous variation in the use of medical treatments with respect to labor supply. However, the market entry and sudden withdrawal of Vioxx provide plausibly exogenous variation in the use of Cox-2 inhibitors.[2]

Our work is most closely related to Garthwaite (2012) who estimates the effect of Cox-2 inhibitor use on the labor force participation of individuals with chronic joint conditions in the United States by exploiting the removal of Vioxx from the market in a difference-in-differences and instrumental variables framework. Garthwaite (2012) uses data from the Medical Expenditure Panel Survey (MEPS) from 2003 to 2007, and in his preferred specification, he finds Vioxx's removal and the resulting reduction in the use of all Cox-2 inhibitors decreased the probability of working for individuals with joint conditions by 22 percentage points. While Garthwaite (2012) focuses on the extensive margin labor supply response to Vioxx's withdrawal using survey data, we focus on intensive labor supply adjustments, particularly sickness absence days, as well as disability pension receipt using detailed administrative data from Norway. Understanding the relationship between medical innovation and sickness absence and disability pension receipt is especially important given the growth in disability benefit recipiency and spending in the United States, Norway, and other OECD countries, and the fact that the cost of disability and sickness absence programs in Norway amounts to almost 5 percent of the country's GDP. Further, different from Garthwaite (2012), we have data on sickness absence and disability pension receipt in the years before Vioxx enters the market, which allows us to analyze the impact of both the entry and exit of Vioxx to examine whether there were asymmetric effects of the availability of Cox-2 inhibitors. The existence of asymmetric effects has potentially important implications for the drug approval process and for predicting the consequences of withdrawing a pharmaceutical from the market.

The paper proceeds as follows. Section 2 provides background on Vioxx and Cox-2 inhibitors as well as the Norwegian sickness absence and disability pension programs. We discuss the data and provide descriptive statistics in Section 3. We describe our empirical strategy in Section 4. We discuss our results and analyze whether there were heterogeneous effects by individual characteristics in Section 5. Section 6 presents sensitivity analysis. In Section 7, we present a simple back-of-the-envelope calculation quantifying the costs of increased sickness absence after the removal of Vioxx to Norway's Social Security Administration as well as the increase in the number of individuals receiving disability pension. Section 8 provides a brief conclusion.

2 Institutional Background

2.1 Vioxx and Cox-2 Inhibitors

Cox-2 inhibitors are part of a broader class of medicines called non-steroidal anti-inflammatory drugs (NSAIDs). NSAIDs are usually indicated for the treatment of acute or chronic conditions involving pain and inflammation, particularly in the joints. Many conditions can lead to joint pain and inflammation including

[2]In a broader sense, our paper is also related to the literature on medical innovations that affect women's labor market behavior. For example, Goldin and Katz (2002) find the birth control pill led women to increase their human capital, and Bailey (2006) finds access to the pill increased women's labor supply in their late 20s and early 30s.

osteoarthritis, rheumatoid arthritis, bursitis, gout, strains, sprains, and other injuries. According to data from the 2006 wave of the National Health Interview Survey, about one third of adults in the US reported experiencing joint pain within the past 30 days. The Norwegian Institute of Public Health reports that chronic pain, which is most commonly musculoskeletal pain or pain associated with rheumatic disorders, affects about 30 percent of the adult Norwegian population.[3] Joint pain most commonly occurs in the knee, shoulder, and hip, and becomes increasingly common as individuals age. Before the introduction of Cox-2 inhibitors, most individuals with chronic pain were prescribed NSAID medications such as ibuprofen or naproxen.[4] However, for some patients these drugs cause serious gastrointestinal bleeding and ulcerations, and as a result, many patients with chronic pain who were prone to gastrointestinal problems faced very limited treatment options. Cox-2 inhibitors do not cause these gastrointestinal complications, and as a result, they were recommended and prescribed especially for individuals with joint pain and gastrointestinal problems (Griffin, 2000; Schnitzer and Hochberg, 2002).

Vioxx was approved first in the United States by the Food and Drug Administration in May 1999, entering the US market soon after the entry of the first Cox-2 inhibitor, Celebrex. Vioxx quickly became one of the most widely prescribed Cox-2 inhibitors, selling in more than 80 countries and enjoying $5.5 billion in global sales by 2004, but also faced controversy about its potential adverse cardiac side effects. The Vioxx GI Outcomes Research (VIGOR) study published in 2000 found an increase in serious heart problems for individuals taking Vioxx compared to those taking naproxen. Initially, the increased cardiac risks associated with Vioxx were attributed to naproxen lowering the risk of adverse cardiac events, making Vioxx look risky by comparison (Mukherjee et al., 2001). Subsequent epidemiological studies confirmed that while Vioxx was associated with decreased gastrointestinal complications, it indeed increased the relative risk of cardiac events even for low cardiac-risk patients (see for example Bresalier et al., 2005). In response to these findings, the manufacturer Merck voluntarily removed Vioxx from the worldwide market on September 30, 2004. The worldwide withdrawal of Vioxx heightened awareness about the cardiac risks of Cox-2 inhibitors, leading to a decrease in their use as well as the withdrawal of Bextra, another Cox-2 inhibitor, from the US and European markets.

2.2 Vioxx and Cox-2 Inhibitors in Norway

NSAIDs are among the most used pharmaceuticals in Norway (Rugstad, 2000). The left panel of Figure 1 shows that the sale of NSAIDs in Norway increased substantially after the market entry of Cox-2 inhibitors in 2000 and decreased after the worldwide removal of Vioxx from the market in 2004. The use of NSAIDs was about 25 defined daily doses (DDD) per 1000 inhabitants per day in 1995, 34 DDD in 2000, and over 50 DDD in 2004. The largest increase in NSAID sales occurred between 2000 and 2001 when the Norwegian Medicines Agency included Cox-2 inhibitors on its list of pharmaceuticals which are refunded

[3]Source: http://www.fhi.no/artikler/?id=88781

[4]Ibuprofen is known under the brand names Motrin and Advil in the US and Ibux in Norway. Naproxen is known under the brand name Aleve in the US and Napren in Norway.

by the national health care system.[5,6] Since Cox-2 inhibitors were introduced first in the US in 1999, by the time they were introduced in Norway in 2000 and were included in the list of reimbursed pharmaceuticals in July 2001, physicians were aware of the drugs and switched patients' prescriptions quickly.[7]

According to the Norwegian Medicines Agency, doctors were permitted to prescribe Cox-2 inhibitors to individuals with serious hip and knee osteoarthritis, rheumatoid arthritis, or chronic pain which reduced quality of life. In addition, patients had to have gastrointestinal problems that could lead to gastrointestinal bleeding when taking other NSAIDs. This restriction was implemented since Cox-2 inhibitors were more expensive than other common NSAIDs and the only stated difference was the reduced gastrointestinal side effects. In other words, Cox-2 inhibitors are no more effective in treating pain and inflammation than other NSAIDs. Thus, most patients who were switched to Cox-2 inhibitors were individuals with severe chronic joint pain who also had gastrointestinal problems. About one third of individuals in Nordic countries with severe chronic joint pain also report having gastrointestinal problems (Rugstad et al., 1994). For these patients, the main alternatives to taking Cox-2 inhibitors were to take other substitute NSAIDs but bear an increased risk of gastrointestinal bleeding or to abstain from NSAIDs and cope with pain and stiffness. Other alternatives include using weaker and less effective analgesics or drugs from the opioid group.[8] Another potential alternative for patients with hip or knee osteoarthritis was joint replacement surgery. Given that most of the alternative treatments for individuals using Cox-2 inhibitors were either less effective or involved gastrointestinal risk or surgery, these individuals may have responded to the entry of Cox-2 inhibitors by taking fewer sickness absence days and then taking more sickness absence when Cox-2 inhibitors became unavailable.

The right panel of Figure 1 displays the sale of Cox-2 inhibitors in Norway between 1998 and 2007. Whereas in 2000, 1.8 defined daily doses per 1000 inhabitants per day were sold in Norway, this number increased to 21.8 in 2004. Cox-2 inhibitors accounted for 42 percent of NSAID sales in 2004. The worldwide withdrawal of Vioxx from the market led to a sharp drop in Cox-2 inhibitor sales after 2004. The Norwegian health care authorities decided to no longer refund purchases of any Cox-2 inhibitors after May 1, 2005 based on a report from the European Medicines Agency that documented an increased risk for cardiovascular complications for all Cox-2 inhibitors. As a result, these types of drugs essentially vanished from the Norwegian market.

Celebrex was the first Cox-2 inhibitor to enter the Norwegian market in 2000, and was quickly followed

[5]Similar to most Western pharmaceutical markets, the Norwegian pharmaceutical market is extensively regulated. The regulatory body is the Norwegian Ministry of Health and Care Services and its agency named the Norwegian Medicines Agency. Producers of pharmaceuticals need government approval to enter the Norwegian market. Approval is based on clinical trials proving the drug affects patients' health positively and is not dangerous. The producer must also provide a positive cost-benefit analysis for the drug to be included on the list of reimbursed pharmaceuticals. Brekke et al. (2011) provide a detailed description of the Norwegian pharmaceutical market.

[6]Typically, the patient co-payment for reimbursed pharmaceuticals is between 36 to 38 percent of the drug price up to an annual ceiling. Once the ceiling has been reached, expenses are covered by the National Insurance Scheme. The annual ceiling on patient out-of-pocket health expenditures (on pharmaceuticals and outpatient care) is usually less than $250.

[7]Anecdotal evidence from articles in the *Journal of the Norwegian Medical Association* suggests that the increase in drug sales during the first year Cox-2 inhibitors were refundable was surprisingly large. This increase has been attributed partly to the same journal's encouragement of physicians to prescribe Cox-2 inhibitors when they became available (see Rugstad, 2000).

[8]Opioids are used for the treatment of acute pain. They may, however, lead to dependence and as a result are mainly used in palliative care to alleviate severe pain of the terminally ill. Opioids also have a series of negative side effects including nausea, vomiting, and drowsiness.

by Vioxx and several others including Bextra, Arcoxia, and Dynastat. It is important to note that while various Cox-2 inhibitors entered the Norwegian market at different times, they were all refundable starting in July 2001. Vioxx had the second largest market share among the Cox-2 inhibitors in Norway after Celebrex. About 4.5 percent of the Norwegian adult population (i.e. over the age of 18) used Vioxx at least once between January 1, 2004 and the date of withdrawal (Duratovic, 2007). About 60 percent of Vioxx users in 2004 were women. The average user was 53 years old and the median user was 52 years old. Since Vioxx was mostly used by patients suffering from arthritis and rheumatism which are more prevalent among the elderly, the highest rate of usage was among the 70 to 79 year old population. In this age group 6.3 percent used Vioxx at least once in the first nine months of 2004. About 30 percent of the individuals using Vioxx were users with severe chronic pain consuming the drug for at least three consecutive months. Among this long-term user group, the median age was 64 years old and 70 percent were women. About 20 percent of the long-term users also used other NSAIDs and about a third received prescriptions for pharmaceuticals in the opioid group while using Vioxx (Duratovic, 2007).

In the three months after the withdrawal of Vioxx from the market, 40 percent of Vioxx users switched to other Cox-2 inhibitors. Since refunds for the other Cox-2 inhibitors stopped in 2005, most former Vioxx users then used other pharmaceuticals from the NSAID group. About 20 percent of former Vioxx users were switched to pharmaceuticals in the opioid group immediately after the withdrawal and this share doubled in 2005 after the other Cox-2 inhibitors were no longer available. 33 percent of the former Vioxx users did not receive any analgesics during the three months after the withdrawal. This number, however, fell to 13 percent two years after the withdrawal (Duratovic, 2007).

The Norwegian System of Patient Injury Compensation (Norsk Pasientskadeerstatning) reports that 114 patients who had Vioxx prescriptions were plausibly harmed due to Vioxx's side effects and subsequently received compensation payments. In total, NOK 37 million were paid, with the largest compensation payment amounting to NOK 2.8 million. The most frequent reason for compensation payments was side effects such as heart attack, heart weakness, brain stroke, or other cardiac diseases. In 19 cases, compensation was paid to surviving dependents of individuals who died from Vioxx's side effects.

2.3 Sickness Absence in Norway

Sickness insurance is mandatory in Norway and regulated by law. It covers all workers who have been employed at the same employer for at least four weeks. The replacement rate is 100 percent up to an amount of 6G (approximately $85,000 in 2013) from the first day of sickness absence up to a maximum of one year.[9] For absences lasting more than three days, a medical certificate is required.[10] Sickness spells lasting more than eight weeks carry stricter requirements—a primary care physician or a physician at a medical emergency center must provide a more detailed certificate to the Social Security Administration (NAV) including diagnosis and an assessment of the employee's prognosis. As discussed in more detail below,

[9] G is an inflation-adjusted unit for calculation of social benefits in Norway.

[10] Individuals who are frequently absent require certification starting from the first day of absence (Markussen et al., 2011). Individuals can take at most four uncertified absence spells per year.

starting in mid-2004, physicians were required to provide (even more) extended documentation for sickness spells lasting more than eight weeks if no work-related activity was performed by the employee. Individuals are protected against dismissals during their sickness absence and cannot be laid off due to their sickness.

The sickness absence benefits are covered by the employer initially and then by the Social Security Administration. The employer is obliged to pay the full wage for the first 16 days. From day 17 onwards, the Social Security Administration covers the full benefits. The benefits from the Social Security Administration are funded by uniform payroll taxes.[11] The compensation scheme is relatively generous and absence rates are high in Norway compared to other OECD countries. About 4 percent of the labor force is on sickness benefits, resulting in a sickness absence rate of 7 percent (measured as man-days lost due to own sickness as a percentage of contractual man-days) and program expenditures amounting to 2.5 percent of GDP. Absence rates are highest among older workers and female employees.

On July 1, 2004, Norwegian authorities implemented a reform in the sickness absence policy which changed the physician certification regulations. The reform required physicians to provide an extended medical certification for workers with leave spells lasting more than eight weeks if no work-related activities were performed, documenting that inactivity is necessary and part of the treatment (Markussen, 2009). The reform also instructed physicians to encourage the use of partial sickness leave for workers with a health problem but some work ability.[12] Sickness leave fell by around 20 percent at the time of the reform (Markussen, 2009). There may be concern that the policy reform occurred around the same time as Vioxx's withdrawal from the market. It is, however, unlikely that the reform impacted those with joint pain more or less than those without joint pain. We address concerns about the timing of this reform and the timing of Vioxx's removal in Section 3.5.

2.4 Disability Pension in Norway

Norwegian residents aged 18 to 67 are entitled to a disability pension if their ability to work is permanently reduced by at least 50 percent due to an illness, injury, or impairment that has lasted for at least one year. Eligibility depends on a minimum insurance period of three years immediately before the disability occurs. That is, an individual has to be a Norwegian resident or a non-resident Norwegian employee for at least three years to qualify for disability benefits. Similar to the sickness leave benefits, disability pension benefits are part of the Norwegian Social Security System and funded by payroll taxes.[13] The disability benefit is considered a replacement for income loss due to disability, and the level of income replacement is determined by an individual's past earnings where the proportion of replaced income decreases as past earnings increase.[14] All relevant medical treatment and rehabilitation measures have to be tried before enrolling on disability insurance. That is, disability pension is only offered to workers unable to return to work from sickness absence and possibly after also completing a rehabilitation program (typically less generous, with a replacement rate

[11] For a further description of the Norwegian Social Security System and sickness leave, see Markussen (2012) and Rieck and Vaage (2012).

[12] For a detailed summary of the reform, see Markussen (2009).

[13] Kostøl and Mogstad (2014) provide a more detailed description of the disability insurance system in Norway.

[14] See Rege et al. (2009) for a detailed description of the formula used to determine disability insurance benefits and a comparison with the US disability insurance system.

around 66 percent). Rehabilitation via vocational training or further medical treatment is often determined unlikely to be successful and subsequently dismissed as a requirement for receiving disability benefits. Thus, it is common to see individuals apply for and enter disability directly from sickness leave (Rege et al., 2009). As sickness benefits have a replacement rate of 100 percent, staying on sickness benefits until they expire at one year and then transferring to disability pension is optimal for most workers. Different from US disability programs such as Social Security Disability Insurance (SSDI) or Supplemental Security Income (SSI), the Norwegian program allows workers to apply for disability pension while still officially employed.

Rheumatoid arthritis and arthrosis, severe forms of chronic joint pain, are among the official diagnosis categories that qualify an individual for disability benefits. That is, individuals with these diagnoses may claim disability benefits if the pain prevents them from working. Diagnoses for severe chronic joint pain are mainly based on blood tests and X-rays. In addition, conditions such as rheumatoid arthritis and arthrosis are generally considered to be non-reversible. As a result, enrolling on disability insurance based on severe and work-limiting chronic joint pain is rather straightforward.

The take-up of disability pension benefits has risen substantially over the last few decades and is high in Norway relative to other OECD countries. More than 10.3 percent of the population between 18 and 66 years of age were on the disability pension rolls at the start of 2008. Among individuals aged 50 to 66, 23.5 percent received disability benefits. Public spending on disability pension makes up more than 2 percent of Norway's total GDP. About 8 percent of individuals receiving disability benefits are enrolled due to rheumatoid arthritis, arthrosis, or closely related conditions.

3 Data

The primary data source used is the Norwegian Registry Data, a linked administrative dataset that covers the population of Norwegians up to 2012. The data are maintained by Statistics Norway and provide information about educational attainment, labor market status, earnings, and a set of demographic variables.[15] Earnings are measured as annual earnings for taxable income as reported in the tax registry. These earnings are not top-coded and include labor earnings, taxable sickness benefits, unemployment benefits, parental leave payments, and pensions. Educational attainment is taken from the educational database provided by Statistics Norway. Since 1974, educational attainment is reported annually by educational institutions directly to Statistics Norway, thereby minimizing measurement error due to misreporting. For individuals who completed their education before the 1973-1974 academic year, we use information from the 1970 Census. Census data are self-reported. The information is, however, considered to be very accurate (Black et al., 2005). We discretize education into three categories—less than high school, high school completion, and at least some college. These data are merged to the sickness absence data, disability pension data, and health survey data described below using personal identification numbers.

[15] See Møen et al. (2003) for a detailed description of these data.

3.1 Sickness Absence

The data on sickness leave is reported by the Social Security Administration. It contains start and end dates for all certified sickness-related work absence spells exceeding the first 16 days (paid by the employer) in Norway from 1992 through 2008. We only consider sickness spells taken for the employee's own sickness (i.e. absence due to illness of other family members is ignored). The data also includes a variable indicating the degree of sickness benefit as a percentage for cases in which it has been determined difficult but not impossible for an individual to work (commonly referred to as graded or partial sickness leave). For example, a physician may determine that an individual's work capacity is 50 percent. That individual must work at 50 percent capacity (at his or her normal wage), and sickness pay applies for the remaining 50 percent (Markussen et al., 2012). About a quarter of the individuals on sickness leave in our sample are on partial sickness leave ranging from 20 to 90 percent. For individuals on partial sickness leave, we weight the days of sickness absence reported in the administrative data by the fraction of work capacity that is lost due to sickness.[16]

3.2 Disability Pension

Similar to sickness leave, the disability pension data are reported by the Social Security Administration. The data include information on the date when disability insurance benefits were awarded and the level of benefits received. An individual is defined as being enrolled on disability insurance in a given quarter-year period if he receives benefits during that quarter-year period.

3.3 Health Surveys

The data on an individual's health status and pain comes from the Cohort of Norway (CONOR) data and the National Health Screening Service's Age 40 Program data. These are two population-based and nationwide surveys carried out from 1988 to 2003 by the National Institute of Public Health. The information contained in both surveys has been gathered through questionnaires and short health examinations. For the most part, the same information was collected in both surveys. In particular, questions are asked about general health, specific diseases, pharmaceutical use, physical activity, and smoking and drinking habits.

The goal of the Age 40 Program was to survey all men and women aged 40 to 42 between 1988 and 1999. It covers all counties in Norway except Oslo and the response rate is between 55 and 80 percent, yielding 374,090 observations. In addition, we use data from the CONOR dataset which includes Oslo, Norway's capital and largest city. CONOR is a research collaboration network that includes several large Norwegian health surveys which were carried out by the National Health Screening Service between 1994 and 2003. This data source includes 56,863 respondents.[17]

From these two health surveys, we observe an individual's health status when they are about 40 years old. While our data on sickness absence and disability pension are longitudinal, the health data are cross-sectional (i.e. we only observe each person once in the health survey). We observe most individuals before 2000 and

[16] For example, if an individual is reported to take 50 days of sickness leave in the administrative data and is on 40 percent graded sickness leave, we assign that individual 20 sickness leave days in the empirical implementation.

[17] Black et al. (2015) provide a more detailed description of the dataset and the representativeness of the sample of respondents.

thus before Vioxx and other Cox-2 inhibitors became available. We do not exclusively focus on Vioxx and Cox-2 inhibitor users but on potential Vioxx and Cox-2 inhibitor users, who we define as those who suffer from chronic joint pain or stiffness. Both health surveys include questions on whether respondents faced pain or stiffness that lasted at least three months and where the pain occurred. We define joint pain as pain in the ankle, knee, hip, wrist, elbow, or shoulder.[18] This information allows us to compare individuals who suffer from chronic joint pain around age 40 with individuals who do not suffer from joint pain.

3.4 Sample Selection and Descriptive Statistics

Vioxx (along with other Cox-2 inhibitors) entered the Norwegian market in 2000, was listed as a refundable pharmaceutical in 2001, and was withdrawn worldwide in 2004. To consider enough years before and after the market entry and removal, we use data from 1998 to 2008. Our sample contains quarterly observations of men and women aged 40 to 60 for whom we have non-missing data on health (around age 40) and labor force participation. Since we are interested in those who are eligible to take sickness leave, an individual must be employed, self-employed, or receiving a work-related social security pension (e.g. unemployment benefits or maternity leave benefits) to be included in the sample used for the sickness leave analysis.[19] In the case of missing information on labor force participation or social security pension in at least one year we exclude all the observations for that individual. The sample used for the disability pension analysis additionally includes individuals who have already been receiving disability insurance benefits, and thus no longer employed.[20] We restrict the sample to individuals who are at least 40 years old since the health surveys are conducted beginning at age 40. The upper age bound of 60 corresponds to the age of the oldest cohorts in the health surveys in year 2008. Moreover, the paper focuses on individuals with chronic joint pain (due for example to arthritis) and the probability of developing such a condition increases with age. Therefore, we find it most relevant to focus on individuals in the latter part of their working years. Last, we restrict the sample to individuals who completed the health survey before 2001. We do this because there could be some concern that individuals no longer suffering from joint pain (or suffering less) after Vioxx's entry could generate bias in the estimated effect of the entry.[21]

We define the affected or treated group as individuals with chronic joint pain and compare how they were affected by the entry and removal of Vioxx to individuals without joint pain in a difference-in-differences framework.[22,23] Table 1 contains descriptive statistics for those with and without joint pain separately by

[18] We do not classify neck pain as joint pain since neck pain (especially whiplash) is difficult to medically diagnose.

[19] Our results are nearly identical when we exclude self-employed individuals.

[20] We include these individuals because we want to allow for transitions off the disability pension rolls. Such transitions are rare, but we want to allow for them, particularly when Cox-2 inhibitors entered the market.

[21] Our results are quantitatively similar when we include those individuals who completed the health survey between 2001 and 2003. There are no individuals in our sample who complete the health survey after 2003 so we do not have a similar concern about the effect of the removal.

[22] Alternatively, one might consider individuals with other types of pain such as back or chest pain as control groups. However, the parallel trends assumption necessary for difference-in-differences estimation discussed in Section 4.3 is violated in our data when comparing individuals with joint pain to individuals with chest pain or back pain.

[23] Ideally, we would like to estimate the effect of actual Cox-2 inhibitor use on sickness absence and disability benefit receipt and exploit the entry and removal of Vioxx as instruments for Cox-2 inhibitor use. However, we only have detailed information on the use of prescribed pain relievers for about 5 percent of the sample. In addition, we only observe individuals' health status once when they are about 40 years old (and usually before Vioxx's entry). The pharmaceuticals these individuals

gender prior to Vioxx's entry for both the sickness absence and disability pension samples. As individuals are approximately 40 when they complete the health surveys, there is no age difference in individuals reporting chronic joint pain and the control group. Compared to individuals without joint pain, on average those with chronic joint pain are slightly less educated, more likely to be female, and have lower yearly earnings. These patterns have also been found in US data (Garthwaite, 2012). Individuals with chronic joint pain report absence from work due to sickness more often and are more likely to be on the disability insurance rolls.

A possible concern is that our analysis and estimation sample might be impacted by mortality risk associated with using Vioxx. Figure 2 shows the death rate from 1990 to 2010 due to cardiac events for individuals between ages 40 and 60 in the full Norwegian population using data from the Cause of Death Registry. The mortality rate is relatively low for individuals between ages 40 and 60 and experiences a decreasing trend. The trend in mortality risk is, however, not visibly altered around the years of Vioxx's entry and exit. In addition, as mentioned above, the Norwegian System of Patient Injury Compensation identified 114 patients who were plausibly harmed due to Vioxx's side effects, which is an extremely small share of the Vioxx users in Norway.

3.5 Policy Reform Concerns

As discussed in Section 2.3, there was a change in the sickness absence policy in Norway on July 1, 2004—the same year Vioxx was removed from the market. If the reform impacted individuals with joint pain more or less than those without joint pain, our results might capture the differential impact of the policy reform in addition to the availability of Vioxx. Figure 3 shows the average number of sickness absence days (exceeding the first 16 days paid by the employer) per month from January 2003 to December 2005 for individuals with joint pain and individuals without joint pain at age 40. There is no visible change in the number of sickness days immediately after the July 2004 reform for either group. In fact, it seems there is evidence of anticipation of the reform since sickness absence days fall for both groups in early 2004. Markussen (2009) and Markussen et al. (2011) also present evidence that there was a drop in sickness absence prior to the reform.

We perform a more rigorous exercise to analyze whether the reform differentially affected those with and without joint pain. We estimate a difference-in-differences equation of the form:

$$\begin{aligned} SickDays_{imt} = \phi_0 + \phi_1 Pain_i + \phi_2 Reform_{mt} \times Pain_i \\ + \phi_3 X_{imt} + \sum_{j=40}^{60} \eta_j I(Age_{imt} = j) + \lambda_{mt} + \varepsilon_{imt}, \end{aligned} \tag{1}$$

where $SickDays_{imt}$ is the number of sickness absence days individual i took in month m in year t. $Pain_i$ is an indicator for whether individual i responded that he suffers from chronic joint pain or stiffness in one of the health surveys, and $Reform_{mt}$ is an indicator for whether the sickness absence reform has been implemented. We define $Reform_{mt}$ to be one starting in July 2004. X_{imt} are demographic characteristics of individual i, η_j allows for age fixed effects, λ_{mt} are a series of month-year interactions, and ε_{imt} is a mean zero error term. X_{imt} includes indicators for gender, education, county, and years since individual i completed the health survey. We run this monthly analysis from January 1, 2002 through September 30, 2004 and thus exclude

use could change over the years we observe them, but the fact that they suffer from chronic joint pain should be less variable. We therefore compare individuals with and without chronic joint pain and estimate an intention to treat effect.

any months before Vioxx was introduced and after it was removed from the market. This provides us with three months where the reform was in place to examine whether those with and without joint pain responded differentially in the short run. If the coefficient on the interaction $Reform_{mt} \times Pain_i$ is significant, that would cast doubt on our treatment and control groups being affected similarly by the reform. Table 2 presents the results of the regression described above as well as those that include individual fixed effects. Across the specifications, the coefficient on the interaction term is near zero and insignificant, which gives us confidence that any estimated effects of Vioxx's removal on individuals with joint pain are not capturing reform effects.

4 Empirical Strategy

To measure the effects of progress in the treatment for chronic pain on sickness absence and disability pension receipt, we exploit the market entry and removal of Vioxx. We use a reduced-form difference-in-differences approach similar to Garthwaite (2012), but we focus on different outcome variables—sickness days and whether an individual receives disability pension—and the data allows us to also analyze the impact of Vioxx's entry.

4.1 Basic OLS Specification

We start by estimating the reduced-form relationship between the removal of Vioxx from the pharmaceutical market and sickness days as well as disability pension receipt. We first estimate the following OLS equation:

$$y_{it} = \alpha_0 + \alpha_1 Pain_i + \alpha_2 Remove_t \times Pain_i + \alpha_3 X_{it} + \sum_{j=40}^{60} \eta_j I(Age_{it} = j) + \tau_t + \varepsilon_{it}, \tag{2}$$

where y_{it} either measures the number of days of sickness absence individual i took at time t (where time is measured in quarters) or is an indicator for whether the individual receives disability pension from the Social Security System at time t. $Pain_i$ is an indicator for whether individual i responded that he suffers from chronic joint pain or stiffness in one of the health surveys, and $Remove_t$ is an indicator for whether Vioxx has been removed from the market. We define $Remove_t$ to be one starting in quarter 4 of 2004. X_{it} are demographic characteristics of individual i at time t, η_j allows for age fixed effects, τ_t are time dummies, and ε_{it} is a mean zero error term. X_{it} includes indicators for gender, education, county, and years since individual i completed the health survey. We cluster the standard errors at the individual level. Individuals complete the health survey around the age of 40 and we control for age, time, and years since completing the health survey; thus, we capture any systematic responses to the health surveys in certain years and control for how far into the past individuals reported pain. The coefficient of interest is α_2, which measures the change in sickness absence days (or the probability of receiving disability pension) for individuals with joint pain following the removal of Vioxx compared to individuals without joint pain.

4.2 Fixed Effects Specification

To control for individual time-invariant unobserved heterogeneity that may influence an individual's response to Vioxx's removal, we also estimate equation 2 with individual fixed effects:

$$y_{it} = \gamma_0 + \gamma_1 Remove_t \times Pain_i + \gamma_2 X_{it} + \sum_{j=40}^{60} \eta_j I(Age_{it} = j) + \tau_t + \delta_i + \varepsilon_{it}, \tag{3}$$

where δ_i are individual-specific fixed effects. Note that $Pain_i$ drops out because we do not know whether the individual suffers from pain in every time period t, but only the year in which they complete the health survey. Thus, $Pain_i$ does not vary over time within individuals. In this specification, the coefficient of interest, γ_1, is identified off the within-individual change in sickness days (or receipt of disability pension) for those with joint pain compared to the within-individual change for individuals without joint pain before and after the removal of Vioxx.

4.3 Specification with Market Entry

It is unclear whether the market entry of Vioxx or its withdrawal should have a larger effect on sickness days and disability pension receipt or whether the effects are symmetric. Anecdotal evidence suggests physicians in Norway were aware of Cox-2 inhibitors since they existed on the US market for several months prior to their entry in Norway. However, it still may have taken time for some physicians to learn about the efficacy of Cox-2 inhibitors and to switch patients' prescriptions. Chintagunta et al. (2009) argue that doctors not only have imperfect information about drug quality, but they are also uncertain about the match quality between pharmaceuticals and patients. Thus, doctors are sometimes reluctant to prescribe new drugs before learning about patients' satisfaction. It is also possible that compliance and adherence to prescribed regimens were not followed strictly when Cox-2 inhibitors were first introduced. On the other hand, the Vioxx withdrawal may have led to an (over)reaction by individuals to the information about the drug's negative side effects. Further, the withdrawal could have provided a negative signal about related drugs. Collins et al. (2013) find that Vioxx's withdrawal had negative spillover effects on the prescriptions of other Cox-2 inhibitors and positive spillover effects for other competing NSAIDs in the US. In Europe, the negative side effects of Cox-2 inhibitors received attention from official medical authorities as well as the media, which may have led to a particularly large response by individuals to Vioxx's withdrawal. Last, if individuals became heavily dependent on or even addicted to Vioxx to alleviate pain, their response to the withdrawal may be especially large. The magnitude of the above-mentioned effects is not clear, thus we allow for the entry and exit of Vioxx to have differential effects on sickness absence days and the probability of receiving disability pension.

Since we observe sickness absence and disability pension receipt over many years, we can analyze the impact of the market entry of Vioxx. As noted above, Vioxx was approved to enter the Norwegian market in 2000, but Cox-2 inhibitors were only included in the list of reimbursed pharmaceuticals by the national health system in July 2001. It was the approved financial coverage that led to the large and rapid increase in the use of Vioxx and other Cox-2 inhibitors in Norway. Therefore, we define July 2001 as the market entry and estimate the following equation:[24]

$$\begin{aligned} y_{it} = \beta_0 + \beta_1 Pain_i + \beta_2 Enter_t \times Pain_i + \beta_3 Remove_t \times Pain_i \\ + \beta_4 X_{it} + \sum_{j=40}^{60} \eta_j I(Age_{it} = j) + \tau_t + \varepsilon_{it}, \end{aligned} \tag{4}$$

[24]Since we define Vioxx's entry as the date it was approved as a refundable pharmaceutical, and all other Cox-2 inhibitors were approved at the same time, when we refer to Vioxx's entry onto the market, we are also capturing the entry of all Cox-2 inhibitors onto the market.

where $Enter_t$ is an indicator for whether Vioxx has entered the market, defined to be one in quarter 3 of 2001 up to and including quarter 3 of 2004. In this way, we can see if there were asymmetric effects of Vioxx's entry and withdrawal on sickness absence and disability pension receipt. We also estimate equation 4 with individual-specific fixed effects.

The key identifying assumptions of the difference-in-differences specification are (1) the exogeneity of the entry and removal of Vioxx with respect to sickness absence and disability benefit receipt, and (2) common trends in the outcome variable for the groups prior to the entry and withdrawal. The entry of Vioxx onto the Norwegian market was the result of regulatory decision-making by the Norwegian Medicines Agency based on clinical trials and cost-effectiveness analysis. The removal of Vioxx was sudden and unexpected. For example, Merck's stock price fell 27 percent the day after its withdrawal announcement (Rubin, 2004; Garthwaite, 2012). Thus, the entry and removal provide plausibly exogenous variation in Cox-2 inhibitor use, and differences in the use of Cox-2 inhibitors in the years after Vioxx's entry and after Vioxx's removal should be uncorrelated with unobserved factors that influence labor supply. Figure 4 shows that the usual parallel trends assumption appears valid for the average number of days on sickness leave per quarter both pre-entry and pre-removal when comparing individuals with chronic joint pain with individuals without joint pain in the raw data. Figure 5 shows that the trends in the proportion of individuals receiving disability benefits are also relatively parallel. Thus, the figures suggest that individuals without joint pain are a reasonable comparison group for those with joint pain.

We also perform a more rigorous analysis to see whether there is evidence of differential pre-trends in sickness days or disability pension receipt for the treatment and control groups. We estimate a generalized version of the difference-in-differences specification described above:

$$\begin{aligned} y_{it} = \theta_0 + \theta_1 Pain_i + \sum_{\ell=1998q1}^{2008q4} \pi_\ell I(t=\ell) \times Pain_i \\ + \theta_2 X_{it} + \sum_{j=40}^{60} \eta_j I(Age_{it}=j) + \tau_t + \varepsilon_{it}, \end{aligned} \tag{5}$$

where the coefficients of interest are π_ℓ, which are event-study type estimates that measure the evolution of outcomes among individuals with joint pain reported around age 40 in the quarters before and after Vioxx enters and exits the market (see for example Jacobson et al., 1993; Autor, 2003; Bailey and Goodman-Bacon, 2015). The indicators for quarters in 1999 are omitted; thus, the π_ℓ coefficients describe the evolution of the outcomes relative to 1999, before Vioxx entered the market.[25] This specification provides us with both a visual and statistical depiction of differential and pre-existing trends. Figures 6 and 7 show plots of the π_ℓ coefficients from equation 5 along with 95 percent confidence interval bars for OLS and fixed effects estimations with both genders pooled and fixed effects estimations separately by gender. The figures show trends in sickness absence and disability pension receipt in the years prior to Vioxx's entry and during Vioxx's entry (but before the removal) appear similar for the treatment and control groups. The lack of

[25]The results are not sensitive to the choice of omitted quarters. For example, the results are very similar when we omit quarters in 1998 or 2000 rather than 1999.

significant differences in sickness absence or disability benefit receipt trends in the years prior to the entry of Vioxx and prior to the removal of Vioxx provide support for our identifying assumptions.

5 Results

5.1 Sickness Absence Results

As described above, the withdrawal of Vioxx from the global market resulted in a large decrease in the use of Cox-2 inhibitors in Norway. To analyze the importance of the availability of Vioxx and Cox-2 inhibitors more generally, we first examine the relationship between the withdrawal of Vioxx and sickness leave of individuals with chronic joint pain, and then we examine the impact of the entry and the removal. Note, the results should be interpreted as the impact on sickness days in excess of the first 16 days paid for by the employer.

Panel A in Table 3 presents the results from the estimation of equations 2 and 3. Column 1 presents results from our basic OLS specification and column 2 shows the results from the fixed effects specification. Columns 3 and 4 display the results from the fixed effects estimations separately by gender. In all specifications, we find the market removal of Vioxx significantly increased the quarterly sickness absence days of individuals with joint pain. The OLS estimates imply the Vioxx withdrawal increased sickness leave by 0.43 days per quarter. The average quarterly number of sickness days in the year before the market entry for those with chronic joint pain was 2.5 days. This suggests the removal increased the number of sickness days by 17 percent. We find the effect of the removal is slightly larger in the fixed effects specification—the removal increased sickness leave by 0.52 days per quarter or by 21 percent compared to the pre-entry level. Columns 3 and 4 show that the effect is larger for women. Whereas men's sickness leave increased by 0.43 days, women's sickness leave increased by 0.56 days. The average quarterly number of sickness days before the market entry for men and women with chronic joint pain was 2.1 and 2.7, respectively. The effect therefore corresponds to a 20 percent increase for men and 21 percent increase for women.

Panel B in Table 3 presents the results from the estimation of equation 4 where we analyze whether there were asymmetric effects of Vioxx's entry and withdrawal on sickness absence. In all specifications, we again find the removal significantly increased the sickness absence days of individuals with chronic joint pain, with the results implying a 12 to 17 percent increase in sickness days per quarter. The impact of the entry of Vioxx on quarterly sickness absence days is smaller, negative, and significant. In the OLS and fixed effects estimations with both genders pooled, Vioxx's market entry decreased sickness leave by 0.28 and 0.21 days per quarter, respectively. This corresponds to an 8 to 11 percent decrease compared to the pre-entry level. The effect of Vioxx's entry is relatively similar for men and women, but we again find women's sickness days increased more than those of men following the Vioxx withdrawal. Thus, while Vioxx's entry decreased sickness absence among those with joint pain, the increase in sickness days due to Vioxx's removal three years later was larger in magnitude.

5.2 Disability Pension Results

Columns 1 and 2 of Panels A and B in Table 4 show that Vioxx's removal increased the quarterly probability of receiving disability pension for an individual with joint pain by 0.5 to 0.6 percentage points compared to

an individual without joint pain, while Vioxx's entry had no significant effect on the probability of receiving disability benefits.[26] Our estimates imply about a 12 percent increase in the quarterly probability of receiving disability pension relative to the pre-entry level. Unlike the sickness absence results, we find the impact of the removal was similar for men and women, increasing their quarterly probability of receiving disability pension by 0.5 and 0.4 percentage points, respectively. These results suggest the unavailability of Cox-2 inhibitors not only affected sickness absence days in the short run, but also led to permanent physical impairments that hindered work capacity, and thereby increased an individual's likelihood of receiving disability benefits.

5.3 Summary Discussion of Baseline Results

We find the market withdrawal of Vioxx increased the sickness absence days of individuals with joint pain in Norway as well as their probability of receiving disability pension. As noted above, for patients who relied on Cox-2 inhibitors because they suffered from chronic joint pain and gastrointestinal conditions, the alternative treatment options were taking other NSAIDs with an increased risk of severe gastrointestinal bleeding or to abstain from NSAIDs and potentially take weaker analgesics and suffer from pain. Drugs from the opioid group are mostly used in palliative care and are not aimed for working-age individuals with joint pain. Further, artificial joint replacements are only an option for very specific diagnoses. Hence, our results are consistent with the fact that most alternative treatments to Cox-2 inhibitors involve a decrease in patients' well-being and would increase sickness absence as well as the likelihood of entering the disability insurance rolls.

We find that the effect of the market entry of Vioxx on sickness days was smaller than the effect of the removal. Furthermore, we find the removal increased the probability of receiving disability benefits, but find no significant effect of Vioxx's entry on disability pension receipt. Our results are consistent with physicians taking time to learn about the efficacy of Cox-2 inhibitors and to determine who to switch to the new drugs. Nonetheless, our results suggest that individuals work more when they receive effective treatment for pain. The Vioxx withdrawal, on the other hand, appears to have potentially led to a large reaction to the information about the cardiovascular risks. Figure 8 displays the monthly sales of Celebrex (marketed under the name Celebra in Norway) in Norway from 2004 to 2008.[27] Soon after the Vioxx removal, the sales of Celebrex peaked as many Vioxx prescriptions were switched to other Cox-2 inhibitors. Celebrex sales fell substantially in the beginning of 2005 before the Norwegian Medicines Agency decided to no longer refund all Cox-2 inhibitors. This large decrease in sales might indicate individuals' and physicians' reaction to the information about the negative side effects.

The asymmetry of the effect of Vioxx availability has potential implications for the speed of the drug approval process. The fact that the removal of a pharmaceutical from the market can have negative labor supply effects that are larger in magnitude than the positive effects of the drug being available underscores the need to make certain the drug's efficacy and safety before its market entry. Furthermore, in the event a drug

[26] As most individuals are enrolled on sickness benefits for a full year before transferring to disability pension, the removal of Vioxx is not necessarily expected to have an immediate effect on disability pension receipt. We provide evidence of time-varying effects of the removal in Section 5.4.

[27] Celebrex had the largest market share among the Cox-2 inhibitors in the US and also in Norway prior to the Vioxx market withdrawal. The drug is still available in the US and Norway. The Norwegian National Insurance Scheme only refunds expenditures for Celebrex in very limited cases.

needs to be withdrawn, the relevant government agencies should keep in mind that the labor supply effects of such action cannot necessarily be inferred simply by analyzing the impact of the drug's current availability.

Further, we find that women's sickness absence was more responsive to the market removal of Vioxx than men's sickness absence. This finding corresponds to the fact that women were the majority of Vioxx users in Norway and are more likely to suffer from chronic joint pain and inflammation. In addition, Markussen et al. (2011) find that depending on family situation and type of sickness, females' entry rates into certified sickness absence spells are between 33 and 75 percent higher than those of similar males. Some studies in the sociology literature have attributed the higher rate of sickness absence among women in Norway to the "double burden" of a labor market career and family obligations (Bratberg et al., 2002).

It is important to keep in mind that our reduced-form estimates capture possible spillover effects of Vioxx's entry and removal on the usage of other Cox-2 inhibitors, NSAIDs, and opioids, and not just changes in the use of Vioxx. Garthwaite (2012) also provides reduced-form estimates of the impact of Vioxx's removal on labor supply, but focuses on the extensive margin response in the US. His reduced-form estimates imply the removal decreased the probability an individual with a joint condition worked by 2.3 to 3.9 percentage points, which amounts to about a 10 percent decrease in labor force participation.[28] Our reduced-form estimates provide further evidence that Vioxx availability had an economically meaningful impact on labor supply. In addition, our results show that the removal of Vioxx affected labor supply both at the intensive margin via more sickness absence days and the extensive margin, increasing the probability of exit from the labor force and entry onto the disability pension rolls.

5.4 Time-Varying Effects

We next examine whether the effects of Vioxx's removal were heterogeneous over time, recognizing that the removal may not have had immediate effects. We do so by replacing $Remove_t \times Pain_i$ in equation 4 with interactions between $Pain_i$ and individual time indicators that correspond to periods in which Vioxx was removed. Figure 9 shows the coefficient estimates on those interactions as well as confidence interval bars when quarterly sickness absence is the outcome. We find the effect of the removal on sickness absence days increased and peaked around 2006, then decreased slightly, and increased again in 2008. The peak in the effect around 2006 is likely explained by the fact that between Vioxx's removal and May 2005, other Cox-2 inhibitors were still refunded, but after May 2005, no Cox-2 inhibitors were refunded in Norway, limiting treatment options for those with joint pain (and gastrointestinal problems). These individuals may not have been able to cope with the pain or find alternative treatment options. The dip in the impact of the removal in 2007 could be explained by some individuals with very severe joint pain enrolling on disability insurance.

Figure 10 shows the evolution of the effects of the removal on the probability of receiving disability pension. Not surprisingly, given that most individuals are on sickness leave for a year before transferring to a disability pension, we find the effect of the removal was not immediate. The removal did not significantly

[28]The instrumental variable estimates in Garthwaite (2012), however, are much larger, and imply that the change in the use of Cox-2 inhibitors due to Vioxx's removal decreased the probability of working for individuals with joint conditions by 22 percentage points.

increase the probability of disability benefit receipt until mid-2006 and the effect then continued to increase through 2008. Thus, we suspect the decrease in the effect of Vioxx's removal on sickness days in 2007 is explained at least in part by individuals transferring to the disability rolls.

5.5 Heterogeneous Effects

In addition to gender, the effects of Vioxx's entry and removal may vary with other individual characteristics. We analyze whether there were heterogeneous effects of Vioxx's entry and removal by occupation and marital status.

Individuals with joint pain who work in physically demanding jobs may have responded differently to the entry and removal since pain may especially affect their ability to work. We classify occupations using the occupations listed as physically demanding for older workers in Rho (2010), and we base the categorization on the individual's most recent job.[29] Panel A in Tables 5 and 6 reports the estimates of the impact of Vioxx's entry and removal on sickness absence days and the probability of receiving disability pension, respectively, on individuals suffering from joint pain separately by physically and non-physically demanding occupations. The effect of Vioxx's entry on sickness absence days is similar for those with and without physically demanding jobs. Surprisingly, the coefficient estimates imply that the removal had a larger effect on the sickness absence days of individuals with non-physically demanding jobs. However, we test whether these differences are significant and cannot reject the hypotheses that the effects of the entry and removal on sickness absence are the same for those with and without physically demanding jobs at conventional significance levels in any of the fixed effects specifications.

We find the entry of Vioxx significantly decreased the quarterly probability of disability pension receipt for those with physically demanding jobs, with the effect being driven by women. The entry did not have a significant effect on the disability pension receipt of those with non-physically demanding jobs. We find Vioxx's removal had no significant impact on the probability of disability pension receipt for those with physically demanding jobs, but significantly increased that probability among those with non-physically demanding jobs, particularly females. In this case, the effects of the entry and removal are significantly different across the two subgroups. While these results are surprising, it could be that individuals with joint pain and physically demanding jobs had previously developed ways to cope with pain, while individuals with non-physically demanding jobs did not have such a need to cope with pain before and were subsequently more affected by the removal.

Panel B in Tables 5 and 6 shows the estimates of the impact of the entry and removal on individuals with joint pain by marital status. Married individuals are those who are legally married or registered as cohabiting in Norway. Cohabiting couples who are not officially registered are treated as single individuals. The estimates suggest Vioxx's entry decreased sickness leave more for single individuals relative to married individuals. The effect of the removal does not exhibit as clear a pattern. We find the removal had a larger effect on the sickness days of single men compared to married men, but had a larger effect on married women's sickness absence relative to single women. However, when we test whether these differences are significant, we find the impacts

[29] Occupations that are categorized as physically demanding include those that involve large amounts of lifting or standing such as janitors and building cleaners, retail salespersons, nurses, and elementary and middle school teachers, among others.

of the entry and removal are not significantly different for married and single individuals with joint pain.

In terms of disability pension receipt, we find the entry had no significant effect on married individuals but significantly decreased the probability of receipt for single individuals with joint pain. On the other hand, the removal significantly increased the probability of disability pension receipt among married individuals but had no effect on singles. The effects here are significantly different across single and married individuals. Single individuals may be more income constrained than married individuals and thus had less ability to exit from the labor force and enroll on disability insurance in response to Vioxx's removal. Given such constraints, the entry of Vioxx may have allowed single individuals with joint pain to avoid enrolling on disability insurance. Married individuals may have more than one source of labor income and would be expected to respond less to Vioxx's entry and more to its removal.

6 Sensitivity Analysis

We present a variety of sensitivity analyses. First, we perform placebo tests focusing on populations that should not have been affected by the availability of Cox-2 inhibitors; then, placebo tests assuming the Vioxx entry and removal occurred at different times than they truly did; and, finally, placebo tests analyzing sickness absence days taken for another family member's illness.[30]

To analyze populations that should not have been affected by Vioxx's entry and removal, we compare individuals suffering from asthma with individuals suffering from diabetes around age 40 (Panel A in Tables 7 and 8), and second, we compare individuals with back pain with individuals with chest pain around age 40 (Panel B in Tables 7 and 8). In Norway, prescriptions of Cox-2 inhibitors were targeted to individuals with joint pain and inflammation (combined with gastrointestinal problems), not to individuals with chest pain and much less so to individuals with back pain. Thus, when estimating our difference-in-differences model on these individuals, we should not find any significant effects of the entry or removal. The estimates of the effects of the entry and removal on sickness days and the probability of disability benefit receipt are not statistically significant and provide support that our results are driven by the change in Cox-2 inhibitor availability.

We also perform a placebo test imposing Vioxx's market entry and removal before they actually happened. The removal is chosen to happen two years before any Cox-2 inhibitors entered the Norwegian market (1998), and the entry is chosen to happen three years prior to the placebo removal (1995). Data from the years after Vioxx's true market entry are excluded from this placebo analysis. There should be no effect of the placebo entry or removal on the number of sickness days or disability pension receipt as there were no changes in pharmaceutical availability for individuals with chronic joint pain at those times. Panel C in Tables 7 and 8 shows that we find no significant effects of the placebo entry or removal.

The final placebo test analyzes whether the number of sickness absence days an individual with joint pain takes due to another family member's sickness was affected by the entry and removal of Vioxx. We should expect to find no significant effect. Panel D in Table 7 shows we find no significant effects of the entry or re-

[30]We also performed a robustness check to ensure the results are not driven by those with low labor market attachment. We did so by eliminating individuals with very low earnings and found those results (available upon request) are nearly identical to those presented here.

moval of Vioxx on the sickness absence days taken for another family member's illness among individuals with joint pain, further providing support that our results are driven by the change in Cox-2 inhibitor availability.

7 Discussion

To better understand the economic magnitude of our results, we present a simple back-of-the-envelope calculation quantifying the costs of increased sickness absence after the market removal of Vioxx to Norway's Social Security Administration. Before the removal, the average annual earnings of male and female individuals between the ages of 40 and 60 with chronic joint pain, conditional on being in the labor force, were approximately NOK 363,383 and NOK 236,818, respectively. Regular working days in Norway amount to 227.5 days per year,[31] and thus the average daily earnings for males and females were NOK 1,594 and NOK 1,039, respectively. Our estimates aggregated to the annual level suggest that sickness days taken by men increased by about 1.2 days per year due to the removal of Vioxx and by 1.8 days per year for women, resulting in an increase in average costs per male and female with chronic joint pain of NOK 1,894 and NOK 1,899, respectively. The Norwegian labor force in 2004 consisted of 604,000 men and 554,000 women between 40 and 60 years old, and 14.8 percent of men and 18.6 percent of women in the labor force in 2004 reported chronic joint pain at the age of 40. Hence, the additional costs paid by the Social Security Administration amounted to about NOK 365 million or $60 million. To put this number in perspective, the Norwegian Social Security Administration's total annual expenses for sickness leave benefits were about NOK 27.5 billion on average in the 2000s. Hence, the additional expenses due to the removal of Vioxx amount to 1.3 percent of the annual sickness leave payments.[32] As discussed in Section 2.2, the total compensation payments for patients suffering from Vioxx's side effects in Norway were NOK 37 million and thereby about 10 percent of the annual extra expenses caused by the drug removal.

We use the same simple back-of-the-envelope calculation to quantify the decrease in costs after the introduction of Cox-2 inhibitors and find that the savings for the Social Security Administration were NOK 45.8 million or $7.7 million. Thus, the savings due to the market entry of Cox-2 inhibitors were about 0.2 percent of the annual sickness leave payments in Norway. Our back-of-the-envelope calculations should be interpreted cautiously. We can only study short-term effects of the market removal of Vioxx. Individuals may learn to better manage their pain over time without Cox-2 inhibitors and the effect of Vioxx's removal might be smaller over a longer time horizon.

We also present a simple back-of-the-envelope calculation to quantify the increase in the number of individuals receiving disability insurance after the market withdrawal of Vioxx. In 2004, about 670,000 men and 650,000 women between 40 and 60 years old were either employed or on disability insurance. Among those, 14.3 percent of men and 18.7 percent of women reported chronic joint pain at the age of 40. In 2004, 66,497 men and 95,181 women between the ages of 40 and 60 received disability pension. That is, the percentage of men and women receiving disability insurance was about 9.9 and 14.6 percent, respectively. Among those receiving

[31] The official working days are computed as the number of weekdays minus the number of public holidays minus 25 days for personal holidays.

[32] Note that the expenses paid by the Social Security Administration exclude the first 16 days of sickness absence which are paid directly by the employer.

disability pension, 28 percent of men and 35 percent of women reported having chronic joint pain at the age of 40. Our estimates aggregated to the annual level show that the annual probability of receiving disability pension for an individual with chronic joint pain increased by 2 percentage points for men and 1.6 percentage points for women due to the removal of Vioxx. Hence, our results indicate that the Vioxx removal led to an increase of 1,916 men and 1,945 women with chronic joint pain on the disability insurance rolls per year. These increases are equivalent to 2.9 percent of the men and 2 percent of the women on disability insurance in 2004.

8 Conclusion

This paper analyzed the impact of progress in the treatment for chronic pain on sickness absence and disability pension receipt. Specifically, we examine how the availability of Cox-2 inhibitors affected sickness absence days and the probability of receiving disability pension among individuals with chronic joint pain in Norway. We exploited the market entry and the unexpected withdrawal of Vioxx from the Norwegian pharmaceutical market as exogenous sources of variation in Cox-2 inhibitor use. Our reduced-form estimates imply the market entry of Vioxx decreased quarterly sickness absence days among individuals with joint pain by 7 to 11 percent and the withdrawal led to a 12 to 21 percent increase in sickness absence days. While the entry of Vioxx did not affect the quarterly disability pension receipt of individuals with joint pain, we found the removal increased the probability of receipt by 0.4 to 0.6 percentage points. We find the sickness leave effects were larger for women, consistent with many studies which show females have higher sickness absence rates in Norway and the fact that women were the majority of Vioxx users in Norway.

Our results underscore the economic importance of developing a pain medication that does not have gastrointestinal side effects and does not increase cardiac risks. The estimates suggest such a medication could increase the productivity of individuals with joint pain and allow them to return to (or stay at) work. More broadly, our paper emphasizes the importance of accounting for economic impacts when determining the net benefits of advances in medical and pharmaceutical technology. Considering labor supply effects and not just focusing on clinical outcomes and medical costs has important implications for regulatory decision-making and the coverage and reimbursement policies of insurance plans and national health care systems. Further, including labor supply effects when calculating the net benefits of medical and pharmaceutical innovation has potential implications for treatment decisions and care plans made by physicians and patients.

References

Autor, D. H. (2003): "Outsourcing at Will: The Contribution of Unjust Dismissal Doctrine to the Growth of Employment Outsourcing," *Journal of Labor Economics*, 21, 1–42.

Bailey, M. and A. Goodman-Bacon (2015): "The War on Poverty's Experiment in Public Medicine: The Impact of Community Health Centers on the Mortality of Older Americans," *American Economic Review*, Forthcoming.

Bailey, M. J. (2006): "More Power to the Pill: The Impact of Contraceptive Freedom on Women's Life Cycle Labor Supply," *The Quarterly Journal of Economics*, 121, 289–320.

Black, S. E., P. J. Devereux, and K. G. Salvanes (2005): "The More the Merrier? The Effect of Family Size and Birth Order on Children's Education," *The Quarterly Journal of Economics*, 120, 669–700.

——— (2015): "Losing Heart? The Effect of Job Displacement on Health," *Industrial Labor Relations Review*, Forthcoming.

Bloom, D. E., D. Canning, and J. Sevilla (2004): "The Effect of Health on Economic Growth: a Production Function Approach," *World Development*, 32, 1–13.

Bratberg, E., S.-A. Dahl, and A. E. Risa (2002): "'The Double Burden': Do Combinations of Career and Family Obligations Increase Sickness Absence Among Women?" *European Sociological Review*, 18, 233–249.

Brekke, K. R., T. H. Holmas, and O. R. Straume (2011): "Reference Pricing, Competition, and Pharmaceutical Expenditures: Theory and Evidence from a Natural Experiment," *Journal of Public Economics*, 95, 624–638.

Bresalier, R. S., R. S. Sandler, H. Quan, J. A. Bolognese, B. Oxenius, K. Horgan, C. Lines, and et al. (2005): "Cardiovascular Events Associated with Rofecoxib in a Colorectal Adenoma Chemoprevention Trial," *New England Journal of Medicine*, 352, 1092–1102.

Chintagunta, P. K., R. Jiang, and G. Z. Jin (2009): "Information, Learning, and Drug Diffusion: The Case of Cox-2 Inhibitors," *Quantitative Marketing and Economics*, 7, 399–443.

Collins, J. M., K. I. Simon, and S. Tennyson (2013): "Drug Withdrawals and the Utilization of Therapeutic Substitutes: The Case of Vioxx," *Journal of Economic Behavior and Organization*, 86, 148–168.

Currie, J. and B. C. Madrian (1999): "Health, Health Insurance and the Labor Market," in *Handbook of Labor Economics*, ed. by O. C. Ashenfelter and D. Card, vol. 3C, 3309–3416.

Duratovic, S. (2007): "En analyse av rofekoksib-brukere i Norge før og etter tilbaketrekningen av rofekoksib (Vioxx) fra verdensmarkedet: en reseptregisterstudie," Master's thesis.

Epstein, A. J., P. W. Groeneveld, M. O. Harhay, F. Yang, and D. Polsky (2013): "Impact of Minimally Invasive Surgery on Medical Spending and Employee Absenteeism," *Journal of the American Medical Association Surgery*, 148, 641–647.

Garthwaite, C. L. (2012): "The Economic Benefits of Pharmaceutical Innovations: The Case of Cox-2 Inhibitors," *American Economic Journal: Applied Economics*, 4, 116–137.

Gaskin, D. J. and P. Richard (2012): "The Economic Costs of Pain in the United States," *The Journal of Pain*, 13, 715–724.

Goldin, C. and L. F. Katz (2002): "The Power of the Pill: Oral Contraceptives and Women's Career and Marriage Decisions," *Journal of Political Economy*, 110, 730–770.

Griffin, M. R. (2000): "The Cox-2 Report: The Good, the Bad, and the Unknown," *Journal of Clinical Outcomes Management*, 7, 62–66.

Jacobson, L. S., R. J. LaLonde, and D. G. Sullivan (1993): "Earnings Losses of Displaced Workers," *American Economic Review*, 83, 685–709.

Kapteyn, A., J. P. Smith, and A. Van Soest (2008): "Dynamics of Work Disability and Pain," *Journal of Health Economics*, 27, 496–509.

Kostøl, A. and M. Mogstad (2014): "How Financial Incentives Induce Disability Insurance Recipients to Return to Work," *American Economic Review*, 104, 624–655.

Markussen, S. (2009): "Closing the Gates? Evidence from a Natural Experiment on Physicians' Sickness Certification," Working Paper 2009,19, Department of Economics, University of Oslo.

——— (2012): "The Individual Cost of Sick Leave," *Journal of Population Economics*, 25, 1287–1306.

Markussen, S., A. Mykletun, and K. Røed (2012): "The Case for Presenteeism-Evidence from Norway's Sickness Insurance Program," *Journal of Public Economics*, 96, 959–972.

Markussen, S., K. Røed, O. J. Røgeberg, and S. Gaure (2011): "The Anatomy of Absenteeism," *Journal of Health Economics*, 30, 277–292.

Mitchell, J. M. (1991): "Work Behavior After the Onset of Arthritis," *Medical Care*, 29, 362–376.

Mitchell, J. M. and R. V. Burkhauser (1990): "Disentangling the Effect of Arthritis on Earnings: A Simultaneous Estimate of Wage Rates and Hours Worked," *Applied Economics*, 22, 1291–1309.

Møen, J., K. G. Salvanes, and E. Ø. Sørensen (2003): "Documentation of the Linked Empoyer Employee Data Base at the Norwegian School of Economics," Working paper, The Norwegian School of Economics.

Mukherjee, D., S. E. Nissen, and E. J. Topol (2001): "Risk of Cardiovascular Events Associated with Selective Cox-2 Inhibitors," *Journal of the American Medical Association*, 286, 954–959.

Nichol, K. L. (2001): "Cost-Benefit Analysis of a Strategy to Vaccinate Healthy Working Adults Against Influenza," *Archives of Internal Medicine*, 161, 749–759.

Nichol, K. L., S. J. Heilly, M. E. Greenberg, and E. Ehlinger (2009): "Burden of Influenza-Like Illness and Effectiveness of Influenza Vaccination among Working Adults Aged 50-64 Years," *Clinical Infectious Diseases*, 48, 292–298.

Papageorge, N. W. (2014): "Why Medical Innovation is Valuable: Health, Human Capital, and the Labor Market," Johns Hopkins University, Mimeo.

Rege, M., K. Telle, and M. Votruba (2009): "The Effect of Plant Downsizing On Disability Pension Utilization," *Journal of the European Economic Association*, 7, 754–785.

Rho, H. J. (2010): "Hard Work? Patterns in Physically Demanding Labor Among Older Workers," Mimeo, Center for Economic and Policy Research.

Rieck, K. and K. Vaage (2012): "Social Interactions at the Workplace: Exploring Sickness Absence Behavior," Working Papers in Economics 11/12, University of Bergen, Department of Economics.

Rubin, R. (2004): "Merck Halts Vioxx Sales," *USA Today*, September 30.

Rugstad, H. (2000): "COX-2-hemmere," *Tidsskrift for Den norske legeforening*, 120, 1398–1398.

Rugstad, H., K.-E. Giercksky, G. Husby, and I. Holme (1994): "Effect of Cimetidine on Gastrointestinal Symptoms in Patients Taking Nonsteroidal Anti-inflammatory Drugs: A Large Double-blind Placebo Controlled Study," *Scandinavian Journal of Rheumatology*, 23, 177–182.

Sala-i-Martin, X. X. (1997a): "I Just Ran Four Million Regressions," Working Paper 6252, National Bureau of Economic Research.

——— (1997b): "I Just Ran Two Million Regressions," *American Economic Review Papers and Proceedings*, 87, 178–183.

Schnitzer, T. J. and M. C. Hochberg (2002): "Cox-2-selective Inhibitors in the Treatment of Arthritis," *Cleveland Clinic Journal of Medicine*, 69, SI–20–30.

Simons, W. R., L. C. Rosenblatt, and D. N. Trivedi (2012): "The Economic Consequences of Rheumatoid Arthritis: Analysis of Medical Expenditure Panel Survey 2004, 2005, and 2006 Data," *Journal of Occupational and Environmental Medicine*, 54, 48–55.

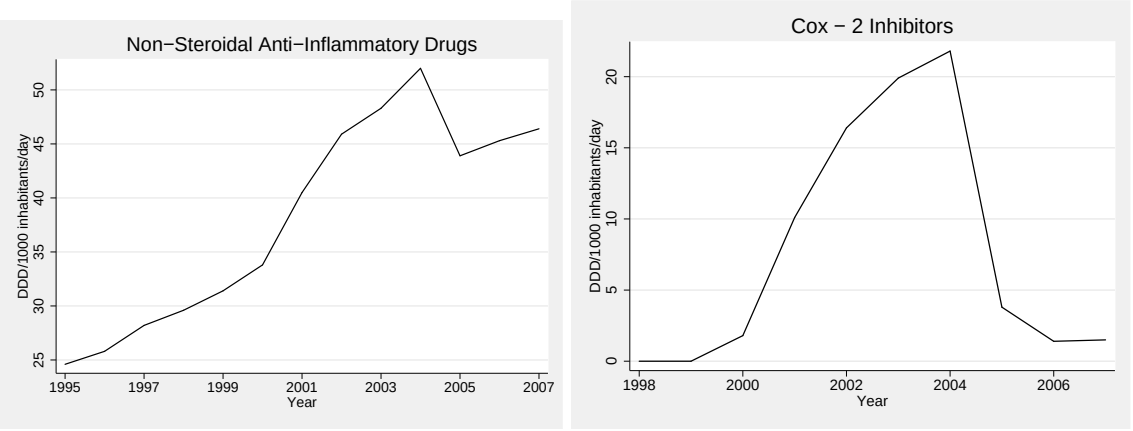
Thirumurthy, H., J. G. Zivin, and M. Goldstein (2008): "The Economic Impact of AIDS Treatment: Labor Supply in Western Kenya," *Journal of Human Resources*, 43, 511–552.

Timbie, J. W., M. Horvitz-Lennon, R. G. Frank, and S.-L. T. Normand (2006): "A Meta-Analysis of Labor Supply Effects of Interventions for Major Depressive Order," *Psychiatric Services*, 57, 212–218.

Weil, D. N. (2007): "Accounting for the Effect of Health on Economic Growth," *The Quarterly Journal of Economics*, 122, 1265–1306.

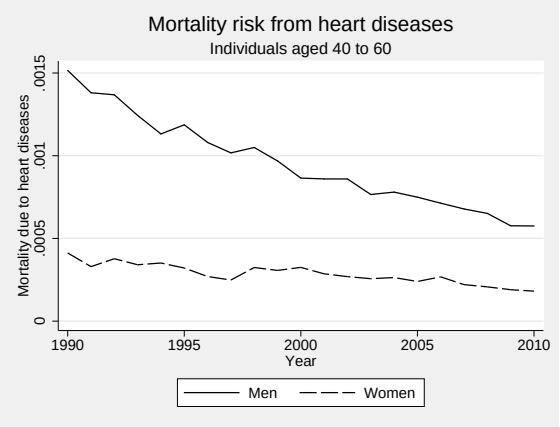
9 Tables and Figures

Figure 1: Sales of Non-Steroidal Anti-Inflammatory Drugs (NSAIDs) and Cox-2 Inhibitors in Norway



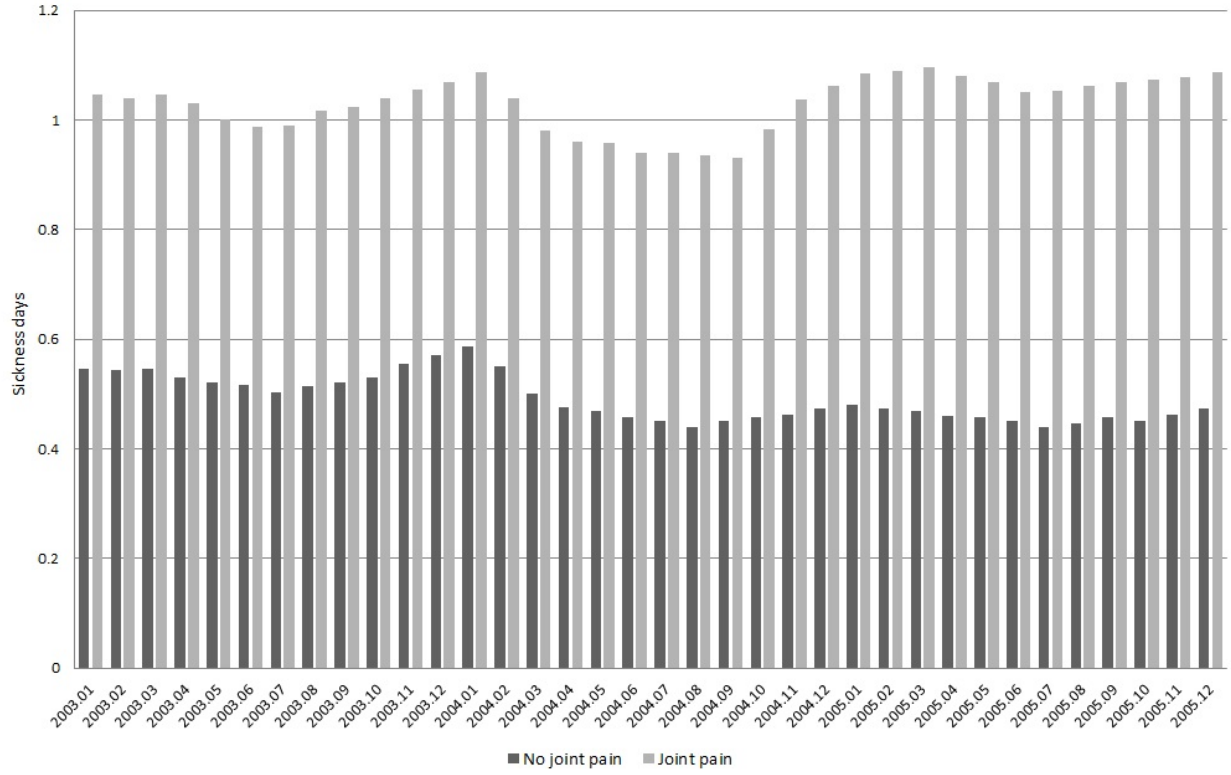
Data Source: Health Statistics in the Nordic Countries 2003, 2004, 2006. NOMESCO, Copenhagen.

Figure 2: Mortality Rate From Heart Disease



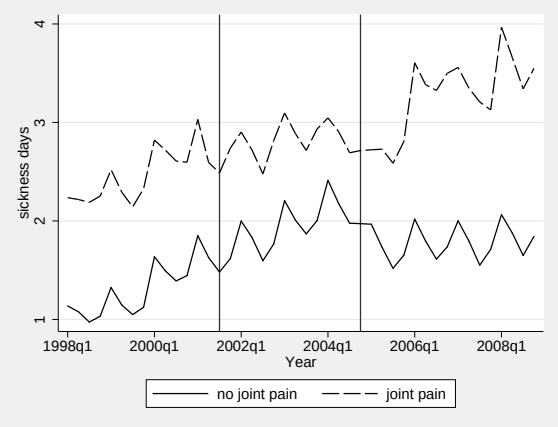
Notes: The figure shows the proportion of individuals who died from heart disease from 1990 to 2010. The sample includes all men and women in the Cause of Death Registry who pass away between ages 40 and 60.

Figure 3: Number of Sickness Absence Days per Month by Pain Status



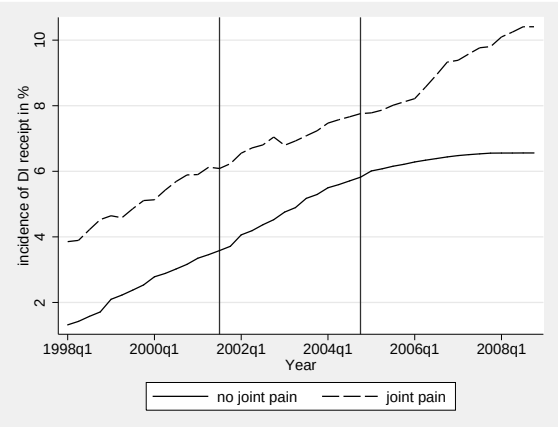
Notes: The figure shows the average number of sickness absence days (exceeding the first 16 days paid by the employer) per month from January 2003 to December 2005. The lighter bars represent the treatment group including all individuals who report chronic joint pain around the age of 40. The dark bars represent the control group including all individuals who report no joint pain around the age of 40.

Figure 4: Number of Sickness Absence Days per Quarter by Pain Status



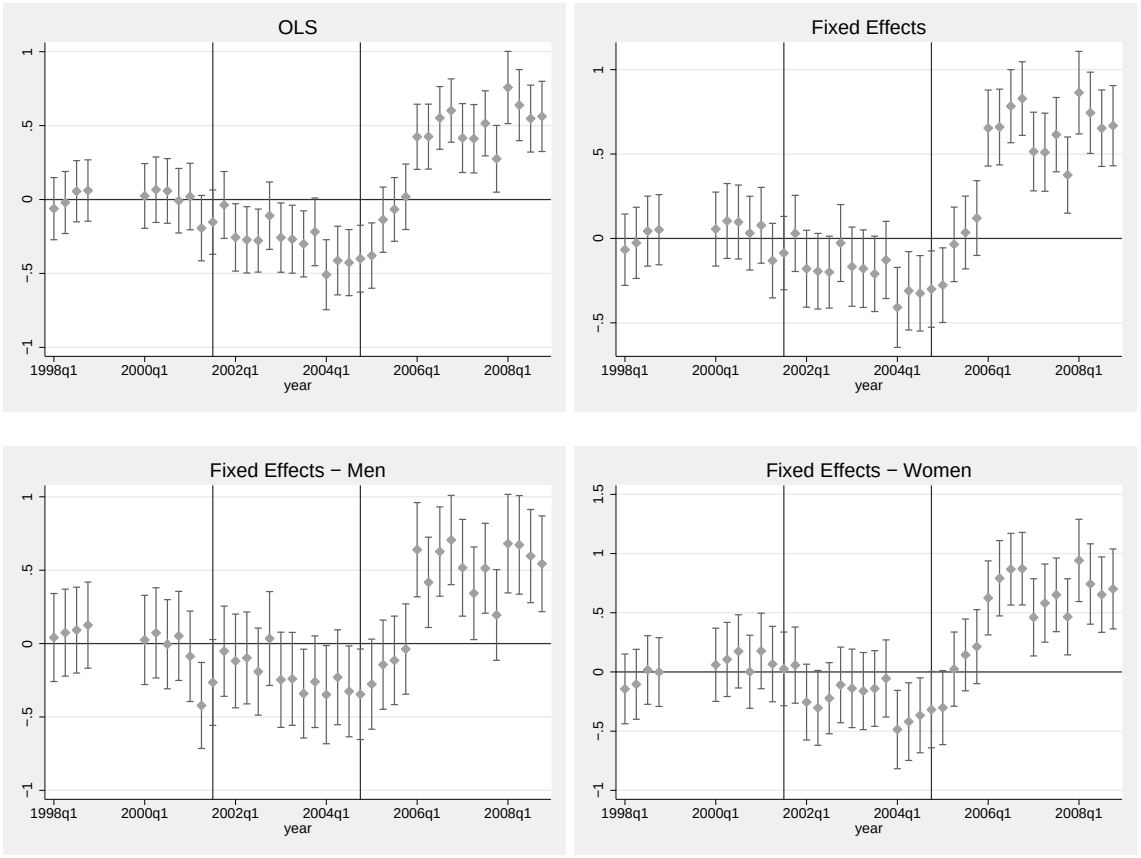
Notes: The figure shows the average number of sickness absence days (exceeding the first 16 days paid by the employer) per quarter from 1998 to 2008. The dashed line is the treatment group including all individuals who report chronic joint pain around the age of 40. The solid line is the control group including all individuals who report no joint pain around the age of 40.

Figure 5: Incidence of Disability Pension Receipt per Quarter by Pain Status



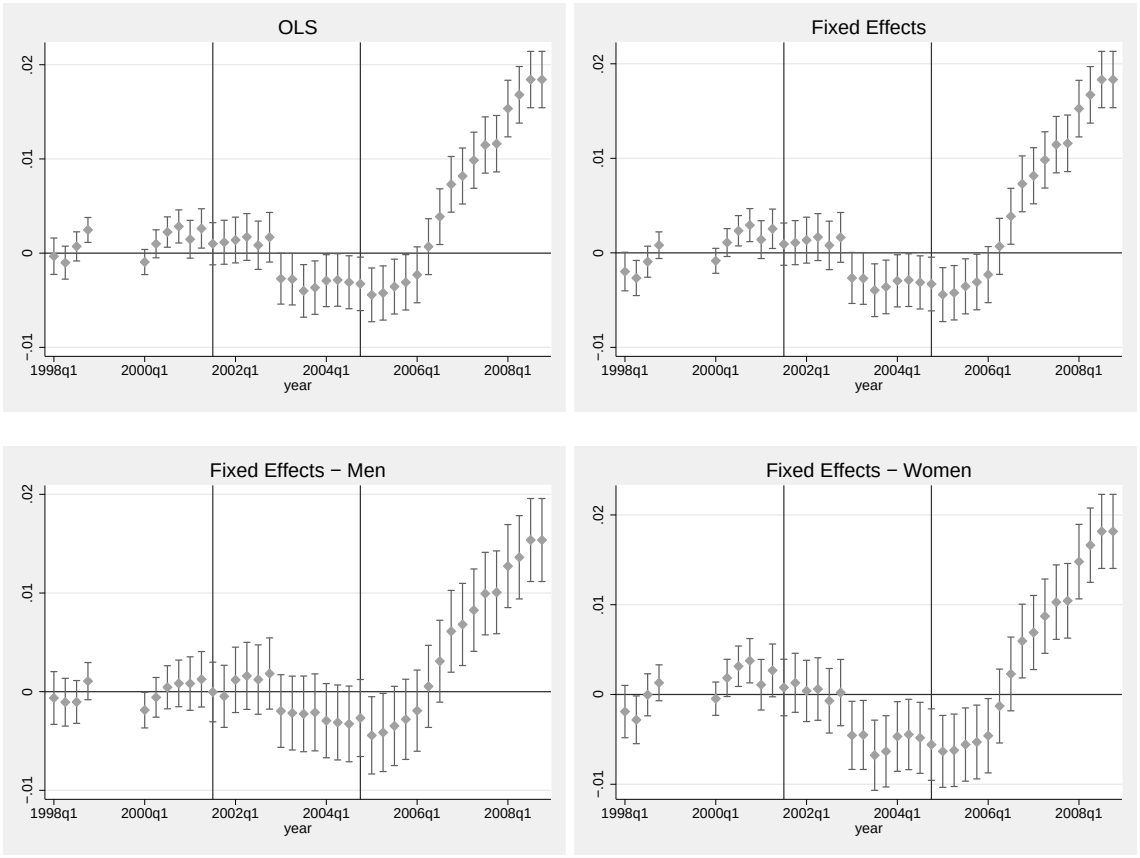
Notes: The figure shows the proportion of individuals receiving disability pension benefits per quarter from 1998 to 2008. The dashed line is the treatment group including all individuals who report chronic joint pain around the age of 40. The solid line is the control group including all individuals who report no joint pain around the age of 40.

Figure 6: Sickness Absence Days: Generalized Difference-in-Differences Coefficients



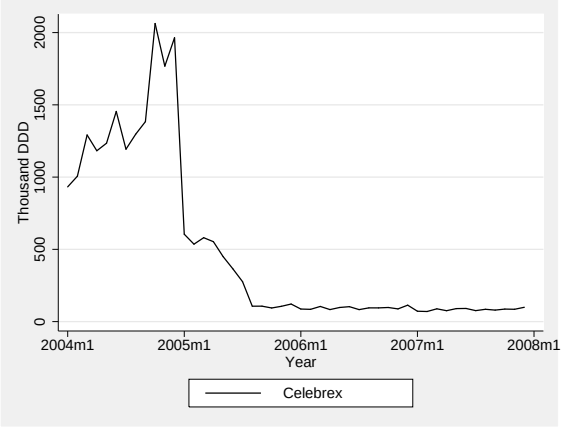
Notes: Each panel contains plots of the estimates of π_ℓ from equation 5 with 95 percent confidence interval bars where quarterly sickness absence days is the outcome. Standard errors are clustered at the individual level.

Figure 7: Disability Pension Receipt: Generalized Difference-in-Differences Coefficients



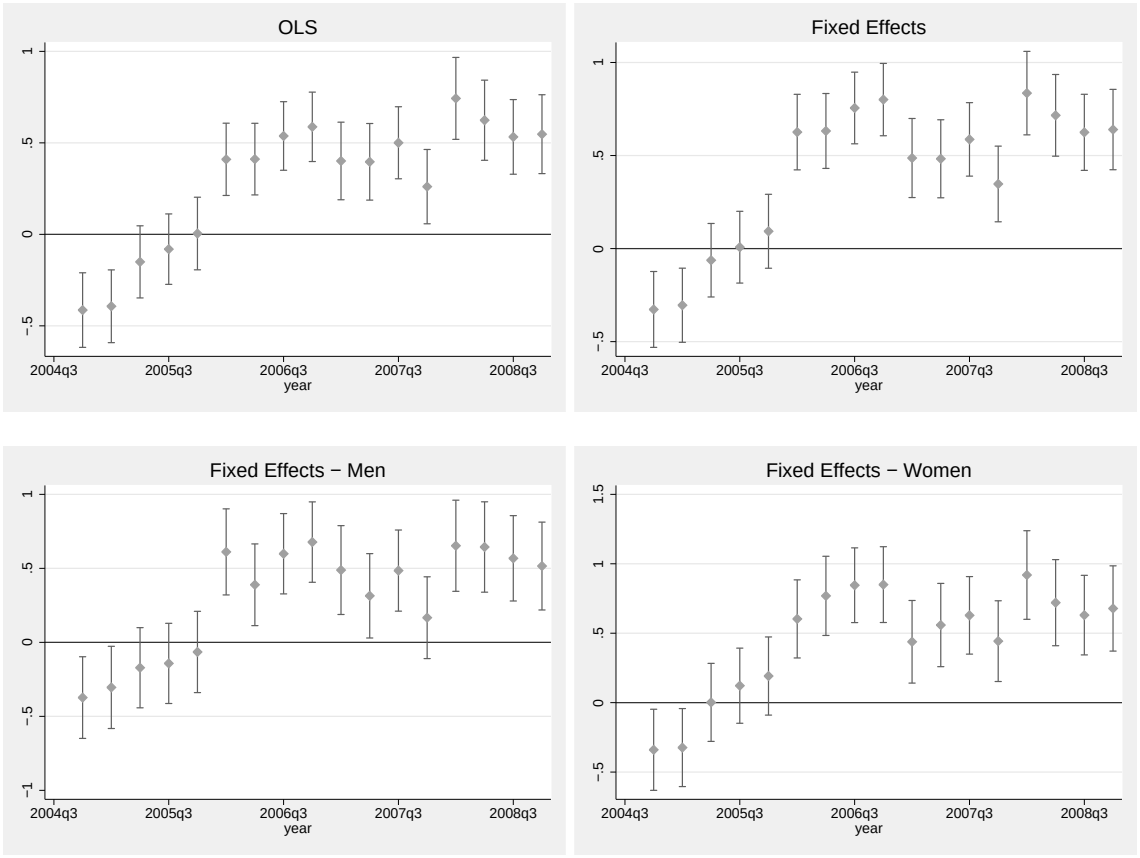
Notes: Each panel contains plots of the estimates of π_ℓ from equation 5 with 95 percent confidence interval bars where the probability of disability pension receipt is the outcome. Standard errors are clustered at the individual level.

Figure 8: Monthly Sales of Celebrex in Norway, 2004-2008



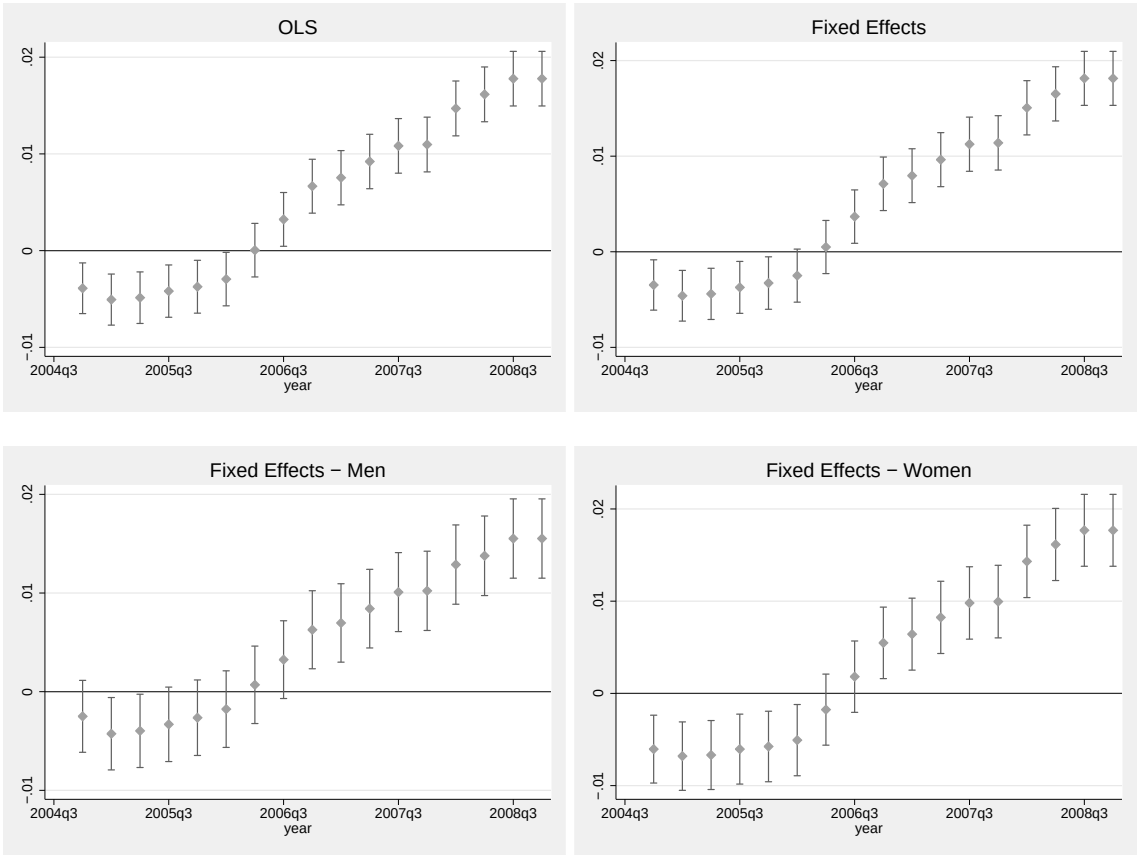
Data Source: Norwegian Prescription Database.

Figure 9: Time-Varying Effects of Vioxx Removal on Sickness Absence Days



Notes: Each panel contains plots of the coefficients on interactions between $Pain_i$ and individual time indicators that correspond to the removal periods with 95 percent confidence interval bars. Standard errors are clustered at the individual level.

Figure 10: Time-Varying Effects of Vioxx Removal on Disability Pension Receipt



Notes: Each panel contains plots of the coefficients on interactions between $Pain_i$ and individual time indicators that correspond to the removal periods with 95 percent confidence interval bars. Standard errors are clustered at the individual level.

Table 1: Descriptive Statistics by Pain Status and Gender Prior to Vioxx Entry

	Men		Women	
	No joint pain	Joint pain	No joint pain	Joint pain
	Panel A: Sickness Absence Sample			
Age	44.0	43.3	44.0	43.4
Years of education	12.4	11.7	12.2	11.7
% married	70.0	67.9	70.6	68.0
Yearly earnings	343309	302582	213307	191515
Quarterly sickness absence days[a]	1.0	2.1	1.6	2.8
% physically demanding occupation	69.3	75.4	64.6	68.4
% on sickness leave per quarter	1.7	3.1	2.5	4.0
% on partial sickness leave per quarter	0.3	0.6	0.6	1.0
Number of observations	1357555	207372	1407570	288251
	Panel B: Disability Pension Sample			
Age	44.0	43.4	44.0	43.5
Years of education	12.3	11.6	12.1	11.5
% married	69.1	66.2	70.2	67.1
Yearly earnings	333030	281826	199540	165264
Quarterly sickness absence days[a]	1.2	2.3	1.7	2.9
% physically demanding occupation	70.1	76.8	66.4	71.9
% receiving disability pension per quarter	1.7	3.3	3.1	6.2
Number of observations	1402764	223472	1524800	341576

Notes: [a]Sickness days are the number of days exceeding the first 16 paid for by the employer.

Table 2: Effect of Reform on Sickness Absence Days

	OLS	Fixed Effects	FE Men	FE Women
Panel A: 2004 Sickness Leave Reform				
reform × pain	-0.017	-0.018	-0.014	-0.019
	(0.019)	(0.020)	(0.029)	(0.029)
Number of observations	4811801	4811801	2281957	2529844
Number of individuals		151365	71340	80025

Significance Levels: ** 1% level, * 5% level

Notes: Entries represent the estimated difference-in-differences coefficients with standard errors in parentheses from OLS and fixed effects regressions of the effect of the sickness leave reform on the number of sickness days per month of individuals between the ages of 40 and 60 with joint pain. Unreported covariates include indicator variables for age, gender, education, county, and years since completing the health survey as well as month-year interactions. Standard errors are clustered at the individual level.

Table 3: Sickness Absence Days Baseline Results

	OLS	Fixed Effects	FE Men	FE Women
Panel A: Drug Removal				
remove × pain	0.435**	0.518**	0.428**	0.563**
	(0.04)	(0.044)	(0.062)	(0.062)
Panel B: Drug Entry and Removal				
entry × pain	-0.276**	-0.206**	-0.248**	-0.200**
	(0.051)	(0.051)	(0.071)	(0.071)
remove × pain	0.291**	0.409**	0.297**	0.457**
	(0.050)	(0.051)	(0.071)	(0.071)
Number of observations	6299675	6299675	3014685	3284990
Number of individuals		155031	72644	82387

Significance Levels: ** 1% level, * 5% level

Notes: Entries represent the estimated difference-in-differences coefficients with standard errors in parentheses from OLS and fixed effects regressions of the effect of the entry and removal of Vioxx on the number of sickness days per quarter of individuals between the ages of 40 and 60 with joint pain. Unreported covariates include indicator variables for age, gender, education, county, time (measured in quarters), and years since completing the health survey. Standard errors are clustered at the individual level.

Table 4: Probability of Receiving Disability Pension Baseline Results

	Panel A: Drug Removal			
	OLS	Fixed Effects	FE Men	FE Women
remove × pain	0.006**	0.006**	0.005**	0.005**
	(0.001)	(0.001)	(0.001)	(0.001)
	Panel B: Drug Entry and Removal			
	OLS	Fixed Effects	FE Men	FE Women
entry × pain	-0.001	-0.001	-0.001	-0.003
	(0.001)	(0.001)	(0.001)	(0.001)
remove × pain	0.005**	0.006**	0.005**	0.004*
	(0.001)	(0.001)	(0.002)	(0.002)
Number of observations	6873144	6873144	3193660	3679484
Number of individuals		158314	73588	84726

Significance Levels: ** 1% level, * 5% level

Notes: Entries represent the estimated difference-in-differences coefficients with standard errors in parentheses from OLS and fixed effects regressions of the effect of the entry and removal of Vioxx on the quarterly probability of receiving disability pension for individuals between the ages of 40 and 60 with joint pain. Unreported covariates include indicator variables for age, gender, education, county, time (measured in quarters), and years since completing the health survey. Standard errors are clustered at the individual level.

Table 5: Heterogeneous Effects on Sickness Absence Days

Panel A: Physically Demanding Occupations					
		OLS	Fixed Effects	FE Men	FE Women
Physical	entry × pain	-0.307**	-0.224**	-0.272**	-0.210*
		(0.063)	(0.063)	(0.086)	(0.091)
	remove × pain	0.219**	0.365**	0.293**	0.396**
		(0.061)	(0.062)	(0.085)	(0.089)
Non-Physical	entry × pain	-0.221**	-0.193*	-0.245*	-0.196
		(0.084)	(0.084)	(0.123)	(0.112)
	remove × pain	0.506**	0.540**	0.337**	0.600**
		(0.088)	(0.087)	(0.129)	(0.119)
Panel B: Marital Status					
		OLS	Fixed Effects	FE Men	FE Women
Married	entry × pain	-0.238**	-0.172**	-0.200*	-0.171*
		(0.059)	(0.059)	(0.082)	(0.083)
	remove × pain	0.317**	0.431**	0.242**	0.534**
		(0.059)	(0.059)	(0.082)	(0.084)
Single	entry × pain	-0.365**	-0.286**	-0.355**	-0.272*
		(0.097)	(0.097)	(0.136)	(0.137)
	remove × pain	0.240*	0.375**	0.422**	0.295*
		(0.095)	(0.096)	(0.136)	(0.135)

Significance Levels: ** 1% level, * 5% level

Notes: Entries represent the estimated difference-in-differences coefficients with standard errors in parentheses from OLS and fixed effects regressions of the effect of the entry and removal of Vioxx on the number of sickness days per quarter of individuals between the ages of 40 and 60 with joint pain. Unreported covariates include indicator variables for age, gender, education, county, time (measured in quarters), and years since completing the health survey. Standard errors are clustered at the individual level.

Table 6: Heterogeneous Effects on Probability of Receiving Disability Pension

		OLS	Fixed Effects	FE Men	FE Women
Panel A: Physically Demanding Occupations					
Physical	entry × pain	-0.007**	-0.007**	-0.003	-0.011**
		(0.001)	(0.002)	(0.002)	(0.002)
	remove × pain	-0.002	-0.002	0.002	-0.004
		(0.002)	(0.002)	(0.002)	(0.003)
Non-Physical	entry × pain	0.001	0.001	0.003*	0.001
		(0.002)	(0.001)	(0.001)	(0.002)
	remove × pain	0.018**	0.020**	0.007**	0.025*
		(0.002)	(0.002)	(0.003)	(0.003)
Panel B: Marital Status					
		OLS	Fixed Effects	FE Men	FE Women
Married	entry × pain	0.001	0.001	0.002	-0.001
		(0.001)	(0.001)	(0.002)	(0.002)
	remove × pain	0.009**	0.009**	0.010**	0.006*
		(0.002)	(0.002)	(0.002)	(0.002)
Single	entry × pain	-0.007**	-0.006**	-0.007**	-0.007**
		(0.002)	(0.002)	(0.003)	(0.003)
	remove × pain	-0.003	-0.003	-0.006	-0.001
		(0.002)	(0.002)	(0.004)	(0.003)

Significance Levels: ** 1% level, * 5% level

Notes: Entries represent the estimated difference-in-differences coefficients with standard errors in parentheses from OLS and fixed effects regressions of the effect of the entry and removal of Vioxx on the quarterly probability of receiving disability pension for individuals between the ages of 40 and 60 with joint pain. Unreported covariates include indicator variables for age, gender, education, county, time (measured in quarters), and years since completing the health survey. Standard errors are clustered at the individual level.

Table 7: Sickness Absence Days Placebo Analysis

Panel A: Placebo Groups - Diabetes vs. Asthma				
	OLS	Fixed Effects	FE Men	FE Women
entry × diabetes	0.316	0.311	0.128	0.541
	(0.266)	(0.267)	(0.332)	(0.419)
remove × diabetes	0.520	0.528	0.193	0.646
	(0.296)	(0.265)	(0.326)	(0.417)
Number of observations	134978	134978	64054	91546
Number of individuals		3506	1602	1999
Panel B: Placebo Groups - Back Pain vs. Chest Pain				
	OLS	Fixed Effects	FE Men	FE Women
entry × back pain	-0.103	-0.058	-0.094	0.062
	(0.199)	(0.197)	(0.223)	(0.371)
remove × back pain	0.012	0.056	0.340	-0.281
	(0.196)	(0.195)	(0.231)	(0.351)
Number of observations	826004	826004	364024	461980
Number of individuals		21477	9121	12356
Panel C: Placebo Entry Year: 1995; Placebo Removal Year: 1998				
	OLS	Fixed Effects	FE Men	FE Women
placebo entry × pain	-0.039	0.028	0.162	-0.099
	(0.088)	(0.089)	(0.126)	(0.123)
placebo remove × pain	0.024	0.187	0.227	0.014
	(0.092)	(0.096)	(0.135)	(0.133)
Number of observations	3551803	3551803	1704239	1847564
Number of individuals		154336	72512	81824
Panel D: Placebo - Absence Due to Family Member's Sickness				
	OLS	Fixed Effects	FE Men	FE Women
entry × pain	-0.007	-0.003	0.002	-0.007
	(0.008)	(0.005)	(0.007)	(0.008)
remove × pain	-0.008	-0.001	0.008	-0.008
	(0.008)	(0.005)	(0.008)	(0.008)
Number of observations	6299675	6299675	3014685	3284990
Number of individuals		155031	72644	82387

Significance Levels: ** 1% level, * 5% level

Notes: Entries represent the estimated difference-in-differences coefficients with standard errors in parentheses from OLS and fixed effects regressions of the effect of the entry and removal of Vioxx on the number of sickness days per quarter of individuals between the ages of 40 and 60 with diabetes, back pain, or joint pain, respectively. Unreported covariates include indicator variables for age, gender, education, county, time (measured in quarters), and years since completing the health survey. Standard errors are clustered at the individual level. Panel C is only based on data from the years before the market entry of Vioxx.

Table 8: Probability of Receiving Disability Pension Placebo Analysis

Panel A: Placebo Groups - Diabetes vs. Asthma				
	OLS	Fixed Effects	FE Men	FE Women
entry × diabetes	0.001	0.000	0.009	-0.006
	(0.006)	(0.006)	(0.008)	(0.009)
remove × diabetes	0.009	0.008	0.012	0.009
	(0.009)	(0.009)	(0.012)	(0.013)
Number of observations	161112	161112	72304	88808
Number of individuals		3695	1658	2037
Panel B: Placebo Groups - Back Pain vs. Chest Pain				
	OLS	Fixed Effects	FE Men	FE Women
entry × back pain	0.001	-0.000	-0.002	0.006
	(0.004)	(0.004)	(0.004)	(0.009)
remove × back pain	0.004	0.004	0.001	0.015
	(0.006)	(0.006)	(0.007)	(0.010)
Number of observations	956252	956252	401552	554700
Number of individuals		22125	9295	12830
Panel C: Placebo Entry Year: 1995; Placebo Removal Year: 1998				
	OLS	Fixed Effects	FE Men	FE Women
placebo entry × pain	0.001	0.002	0.002	0.002
	(0.001)	(0.002)	(0.003)	(0.003)
placebo remove × pain	0.001	0.003	0.002	0.003
	(0.001)	(0.003)	(0.004)	(0.004)
Number of observations	3806410	3806410	1772014	2034396
Number of individuals		157744	73300	84444

Significance Levels: ** 1% level, * 5% level

Notes: Entries represent the estimated difference-in-differences coefficients with standard errors in parentheses from OLS and fixed effects regressions of the effect of the entry and removal of Vioxx on the quarterly probability of receiving disability pension for individuals between the ages of 40 and 60 with diabetes, back pain, or joint pain, respectively. Unreported covariates include indicator variables for age, gender, education, county, time (measured in quarters), and years since completing the health survey. Standard errors are clustered at the individual level. Panel C is only based on data from the years before the market entry of Vioxx.