DETERMINANTS OF PERCEIVED PAIN IN PHYSICAL THERAPY PATIENTS: A CASE STUDY OF A MIDWESTERN HEALTH CARE PROVIDER

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ABSTRACT

The purpose of this paper was to test a series of hypotheses about the determinants of perceived back pain using a sample of physical therapy patients from a large, Midwestern health care provider. In accordance with our intuition, we found that more treatment sessions reduced patient pain perceptions. We also find that putting off treatment decreases the likelihood of reducing perceived pain. This indicates that putting off treatment likely exacerbates the injury, making it more difficult to treat. Finally, we found that location in which a patient receives treatment has a significant impact on the likelihood of recovery (as measured by perceived pain outcomes). Interestingly, variables such as sex and the type of health insurance do not significantly affect the likelihood of a positive outcome.

INTRODUCTION AND PROBLEM STATEMENT

Over the past decade, health care providers have placed increased emphasis on the treatment of back injuries and/or pain. These injuries are easily sustained, are resistant to treatment, and may be mis-diagnosed (or not sufficiently diagnosed) by primary care practitioners (Patel 2000). As a result, back symptoms are a common cause of disability for individuals, especially those who are middle aged or younger (Preyde 2000; Guzman et al 2001). Since many people suffer from back pain or injury at some point in their lives, these problems can be expensive for society. People with severe back pain suffer lost wages and a lower quality of life. Firms experience lower worker productivity, which in turn reduces profitability. Health insurers (including government insurers such as the Medicare and Medicaid programs) also incur increased expenses to pay for the treatment of back-related injuries, a part of which may be passed along to individuals and firms in the form of higher premiums.

As a result, the Joint Commission for the Accreditation of American Healthcare Organizations (JCAHO) has made addressing patient pain a priority for health care providers. Rehabilitation providers, in particular, are under increased pressure to identify and respond to patient pain more efficiently and efficaciously. Consequently, these providers have begun using outcome tools to assist in communicating the results of their interventions with various patient populations. Specifically, patient satisfaction or patient self-reporting methods have become commonplace outcome measurement tools. These tools are particularly beneficial because the outcome is patient centered and is a reflection of how the individual perceives their improvement following physical therapy services. The net result is that patients are better able to communicate their pain levels (and consequently their progress in therapy) to providers, who, in turn, are better equipped to adjust interventions appropriately.

Once rehabilitation providers have a reliable and valid tool to measure pain perceptions (as well as reductions in perceived pain due to therapy), it becomes beneficial to identify some of the causal determinants of perceived pain, in particular pain deriving from back-related injuries. A number of studies have identified and tested the impacts of numerous possible determinants of perceived back (or pelvic) pain, including formal education (Dionne et al 2001), exercise (Mens et al 2000), indicators of provider quality (Van der Wedie et al 1999) and multidisciplinary bio-psycho-social rehabilitation techniques (Guzman et al 2001), among others. The purpose of this study is to contribute to this literature by assessing the outcomes of physical therapy treatment for patients with back-related impairments and reported pain that were referred to a large, Midwestern health care provider for outpatient physical therapy. In particular, our aim is to test the following hypotheses, which are expressed in null hypothesis form and implicitly hold constant the effects of all other specified determinants of perceived pain outcomes:

HYPOTHESIS I: There is no statistically significant relationship between the number of treatment sessions and the perceived outcome of the treatment.

HYPOTHESIS II: There is no statistically significant relationship between the amount of time between onset and initiation of physical therapy treatment and the perceived outcome of the treatment.

HYPOTHESIS III: There is no statistically significant difference in perceived outcome between patients with general back impairments compared to all other, more specific diagnoses.

HYPOTHESIS IV: There is no statistically significant difference in perceived outcome between patients who receive treatment at different outpatient rehabilitation centers maintained by the same provider.

The purpose of Hypothesis I is to determine whether going to treatment has a significant impact on perceived pain outcomes. Normally, one would expect that obtaining more treatment from the provider speeds recovery time, thereby reducing total perceived back pain and increasing the perceived outcome of the treatment. Consequently, we should not only expect to reject Hypothesis I, but also to find a positive causal relationship between these two variables.

Hypothesis II tests whether waiting to receive treatment for back injuries reduces the efficacy of treatment. Logic indicates that putting off treatment exacerbates an existing injury, making it more difficult to treat. Thus, we should expect to reject this hypothesis and find a negative relationship between the length of time from injury onset to injury treatment and the perceived outcome of the therapy.

Hypotheses III investigates whether general back injuries are more difficult to treat (in terms of the perceived outcome) than other specifically diagnosed back injuries. If they are more difficult to treat, then we should reject this hypothesis and find a negative relationship between these variables.

The purpose of this hypothesis is to provide some preliminary evidence about the precision of diagnoses by the primary care practitioners referring patients to therapy. Often, patients are referred to physical therapy under the diagnosis of general "back pain". However, if such preliminary diagnoses are incorrect or understate the magnitude of patients' conditions, then they are much more difficult to treat (compared to other back injuries) than the preliminary diagnoses indicated, possibly leading to less efficient and efficacious treatment as well as reduced perceived pain outcomes. Consequently, rejecting Hypothesis III provides tentative evidence indicating that patients are not being referred to therapy with a sufficiently precise diagnosis.

Finally, Hypothesis IV tests whether patients who go to particular outpatient therapy sites have better (worse) perceived pain outcomes than those patients who receive treatment at the remaining therapy sites. If there are few differences in patient (or population) characteristics, and if the firm provides the same quality to all of its physical therapy patients, then we would expect to fail to reject this hypothesis. However, significant (and unidentified) differences in patient characteristics and/or qualities of service may cause us to reject the null hypothesis. If the latter is the case, then the provider needs to investigate the source of this discrepancy in greater detail.

STUDY DESIGN AND DATA

The data come from a major, nonprofit medical center in a medium sized city (with a population of approximately 130,000) in the Midwestern United States. The city serves as a regional health care center for a relatively large (approximately 80 miles in diameter) geographic area. It employs a range of specialized and general health care practitioners as well as a wide array of medical services, including physical therapy. The provider also experiences competition in almost all of its services from another, similarly sized (nonprofit) medical center that resides within the same city. The center offers physical therapy services on an outpatient basis at one of three different locations, which are strategically located throughout the city. For simplicity, we define each of these locations based on their geographic settings: East, North and Downtown.[1] Most therapy sessions averaged 45 minutes in length, with a few sessions lasting as few as 30 minutes and as many as 60 minutes.

Beginning in October 2000 and ending September 30, 2001, all patients referred for outpatient therapy with a diagnosis involving the spine were asked to complete a perceived pain survey. The survey asked each patient to evaluate his/her perceived pain using a 0

[1]The provider also offers a limited number of physical therapy services at its two assisted living sites. Of the 205 patients included in this analysis, only one patient obtained services at these sites.

(no pain) to 10 (maximum pain) rating scale. Patients were also given the same assessment tool at discharge to determine the decrease in reported pain ratings. Other patient characteristics were also recorded, including the date of onset, the number of therapy sessions, age, sex, type of insurance and the treatment location.[2] A total of 246 patients were initially included in this study; however, missing or mis-measured data forced us to exclude 41 patients from the empirical analysis. Table 1 contains the names and definitions of all relevant variables used in the analysis. Table 2 presents some descriptive statistics for each of the variables listed in Table 1.

Using the results from Table 2, we are able to draw some initial inferences about the socioeconomic characteristics of the patients in our data set. Of the 205 patients, 40% were referred for general back impairments, 25% had cervical problems, 25% had specific lumbar diagnoses and 10% accounted for the remainder of the patients in the study. Examining the data based on location, we see that nearly half (47%) of the patients in this study went to the provider's eastern rehabilitation site, while 35% went to the center's downtown location. The remaining patients received treatment at either the north (18%) or the assisted living (less than 1%) sites. Additionally, most patients were either insured privately (52%) or through Workman's Compensation (31%). The average age of patients in the sample is 42, 58% of whom are female.

The data also allow us to examine some general trends concerning perceived pain and treatment outcomes. Specifically, the average person in our data set waited 3.5 months before seeking treatment, and upon entering treatment the average level of perceived pain was 6.28. Treatments, on average, lasted 6.47 sessions. After treatment, the average pain score falls to 2.45. Finally, average patient pain scores were reduced by 3.86 units by the end of treatment.

While general trends of perceived pain outcomes provide useful information about the effects of treatment, they do not tell the whole story. Rather, it is also interesting to consider the distribution of perceived pains scores and outcomes. Figure 1 presents an absolute frequency histogram for perceived pain both upon entering and exiting treatment. Upon entering treatment, the perceived pain scores with the highest frequencies are those between 8 and 10, indicating that initial pain perceptions were quite high. However, after treatment, the scores with the highest frequencies are between zero and three, with the score of zero carrying the highest absolute frequency. Clearly, perceived pain scores diminish after receiving treatment, indicating a positive progress in perceived pain outcomes.[3]

STATISTICAL METHODOLOGY

Having described the data, we are now able to utilize multiple regression analysis to test Hypotheses I – IV. Our dependent variable (or measure of perceived pain progress) of interest is Dumscore, which takes a value of 1 if a particular patient made positive perceived pain progress (so the difference between entering and exiting perceived pain scores is favorable) and takes a value of 0 otherwise.[4] We utilize a regression model that is linear in coefficients and explanatory variables. As such, our data allow us to identify the following variables as possible (exogenous) determinants of perceived pain progress:

Variables Measuring Location:
Downtown, North
Variables Measuring Insurance:
Wcomp, Govins, Noins
Variables Measuring Individual Characteristics:
Age, Sex
Variables Measuring Treatment Characteristics:
Sessions, Months, Back

which leads to the following functional form:

[2] Patients with recent injuries are usually able to report an exact date on which an injury was sustained. However, patients with chronic conditions or those who avoided therapy for an extended period of time are often unable to provide an exact injury onset date. As a result, we measure the date of onset to the nearest month in order to reduce the possibility of measurement error.

[3] We can also test the statistical significance of this claim. The variable DUMSCORE gives a value of one if a particular patient made a positive progress in perceived pain (i.e., if the difference between initial and exiting perceived pain scores was positive), and a value of zero otherwise. Consequently, the mean value of the variable gives the proportion of patients in the data set who make positive progress in perceived pain outcomes. In our data set, this proportion takes a value of 0.829. Under most reasonable null hypotheses (for example, the test H_o: $p \leq .5$ and H_A: $p > .5$, which claims that less than half of the population make positive perceived pain progress), this value is sufficient to reject the null hypothesis at a 95% level of confidence. Under the null hypothesis given in our example, the z-statistic is equal to 9.43, which easily rejects the one-tailed critical value at a 95% level of confidence.

[4] We choose this variable (rather than the difference in perceived pain scores) because it displays the same information, yet can be analyzed and interpreted in a much simpler format.

$$Prob(Dumscore_i) = \beta_0 + \beta_1 Downtown_i + \beta_2 North_i + \beta_3 Wcomp_i + \beta_4 Govins_i + \beta_5 Noins_i + \beta_6 Sex_i + \beta_7 Age_i + \beta_8 Sessions_i + \beta_9 Months_i + \beta_{10} Back_i + \varepsilon_i$$

where i indexes each observation (i = 1,…, 205), ε is the error term and the β's are the coefficients to be estimated.

There are three econometric concerns when estimating a regression model such as this. The first concern is that, because the dependent variable takes only 2 possible outcomes, we cannot use common regression techniques, such as ordinary least squares (OLS). Instead, we utilize logistic regression analysis, which rescales the dependent variable (Dumscore) in the following way:

$$Prob(Dumscore) = \ln\left(\frac{Dumscore_i}{1 - Dumscore_i}\right), \text{where}$$

ln(•) is the natural logarithm function. In essence, this new (dependent) variable measures *the cumulative probability that a particular patient will make positive perceived pain progress.*[5]

A second statistical issue is the interpretation of the coefficient estimates. Because the techniques underlying logistic regression are highly nonlinear, it is difficult to interpret the coefficient estimates (i.e., the estimates for the β's). Instead, we use these estimates to create *marginal effects* for each explanatory variable. For any particular explanatory (right hand side) variable, the marginal effect can be interpreted as *the impact of a one unit change in the explanatory variable on the cumulative probability that a particular individual will make positive perceived pain progress, holding constant the impacts of all other specified explanatory variables.* Each marginal impact is evaluated at the sample mean, and so measures the average impact of a one unit change in an explanatory variable on the cumulative probability. Standard deviations can also be calculated for each of these marginal effects, thereby allowing us to test hypotheses and measure statistical significance.

A final issue concerns the presence of multicollinearity, which occurs when two or more explanatory variables are *perfectly* (or very nearly perfectly) linearly related. When multicollinearity occurs, the regression technique will not work properly. For example, if we specified as explanatory variables all three location dummy variables (North, East and Downtown), then the sum of these three variables (which yields a constant value for 204 out of the 205 patients) would be nearly perfectly related to the intercept term (β_0) in a linear fashion. As a result, the regression technique will break down. The usual solution for multicollinearity is to drop one of the multicollinear variables. The constant term consequently absorbs the effect of the omitted variable *and the marginal effects for the included multicollinear variables are simply interpreted relative to the omitted variable.* So in our specification we have dropped the East location variable to prevent multicollinearity. As a result, a negative and statistically significant marginal effect for the North variable implies that receiving treatment at the north location leads to a lower cumulative probability of making progress in his/her perceived pain outcome than if the patient went to the east location, holding all other specified explanatory variables.

Having developed the statistical methodology, it becomes interesting to discuss how our methodology allows us to test Hypotheses I – IV. Hypothesis I claims that there is there no statistically significant relationship between the number of treatment sessions and the perceived outcome of the treatment. If this claim is correct, then the estimated marginal impact of Sessions on the dependent variable should be statistically insignificant from zero. Concomitantly, a statistically significant marginal impact for this variable leads us to reject this hypothesis. A similar approach allows us to test Hypothesis II; namely, a statistically significant marginal impact for the Months variable leads us to reject this hypothesis. A statistically insignificant (from zero) marginal effect for Months implies that we fail to reject this null hypothesis. An analogous deduction can be used to test Hypothesis III (using the marginal effect for the Back variable) and Hypothesis IV (using the marginal effects for the location variables).

STATISTICAL RESULTS

Table 3 contains the estimation results from the logistic regression model. Hypothesis I argues that the number of treatment sessions should not significantly impact the perceived pain outcome from treatment. The estimated

[5]The formula used to rescale Dumscore is derived from the logistic probability distribution, thus giving the regression technique its name: logistic regression. As a technical aside, also note that this rescaling forces the error term to take a logistic distribution as well.

marginal impact of Sessions on the cumulative probability that the patient makes perceived pain progress is positive, statistically significant from zero and carries an estimated value of 0.019. Thus, if a patient attends 1 additional treatment session, then (holding constant the effects of the other explanatory variables) the cumulative probability that he/she makes positive perceived pain progress increases, on average, by 1.9 percent. As a result, our empirical results lead us to reject this hypothesis.

Hypothesis II claimes that the amount of time between the onset of the injury and the initiation of therapy had no significant impact on the perceived outcome of the treatment. We test this hypothesis by examining the estimated marginal effect for the Months variable, which has an estimated mean effect of –0.0051. Consequently, if a patient waits an additional month before seeking treatment, then (holding constant the effects of the other explanatory variables) he/she can expect the probability that they will make positive perceived progress to decline by 0.51 percent. Even though this impact is relatively small, it is still statistically significant from zero at a 93.5% level of confidence. Consequently, our empirical analysis also rejects Hypothesis II.

Hypothesis III argues that there was no statistically significant difference in perceived outcome between patients with general back injuries and all other patients. The estimated marginal impact for the Back variable is negative, but statistically insignificant from zero. Consequently, we find no evidence that the precision of diagnosis significantly impacts the perceived outcome of treatment.

Hypothesis IV alleges that the location of treatment had no significant impact on the perceived outcome of treatment. We test this hypothesis by examining the marginal effects for the North and Downtown variables. Both estimated marginal effects are negative and statistically significant at the 95% level of confidence or better. The estimated impact for the North variable is –0.157, implying that receiving treatment at the North location as opposed to the East location (and holding constant the effects of the other explanatory variables) causes the cumulative probability that the patient will make positive perceived progress to fall by nearly 16 percent. A similar conclusion holds for the Downtown variable, except that the probability is reduced by 13 percent. Clearly, patients who receive treatment at the East (and possibly at the assisted living facilities) are much more likely to make positive pain progress.

Finally, it is interesting to examine whether any of the remaining control variables had a statistically significant marginal impact on the dependent variable. Our results indicate that the Age variable has a negative and statistically significant impact (albeit at the 90% level of confidence) on the cumulative probability of perceived pain progress. Thus, the older is a patient, the less likely is he/she to make positive perceived pain progress by the end of treatment. However, none of the remaining control variables have a statistically significant impact on the dependent variable. So an individual's sex and insurance carrier do not significantly impact his/her perceived pain progress. Rather, the probability of making pain progress appears to be a function of patient age, where patients receive treatment, the length of time they avoid treatment and the length of time they are in treatment.

While logistic regression models do not allow the calculation of R-square related measures, we do have some rough tools to measure our model's goodness-of-fit. In particular, Table 3 presents both a Chi-square test of the model's overall fit as well as a table of actual and predicted values.[6] The value of the Chi-square statistic is 22.867, which easily rejects the null hypothesis at a 95% level of confidence. Consequently, using the logistic regression model provides a better explanation of the dependent variable than had we resorted to using descriptive statistics. The table of predicted versus actual values indicates that the model predicted the Dumscore variable (on whom the cumulative probabilities are based) correctly for 172 out of the 205 possible patients. However, while the model was very successful at predicting Dumscore when observations took a value of one, it was not very successful at predicting the variable when its observations were zero.[7]

CONCLUSIONS

The purpose of this paper was to test a series of hypotheses about the determinants of perceived physical pain using a sample of physical therapy patients. In accordance with our intuition, we find that more

[6] The Chi-square test is similar to the standard F-test used under OLS in that its null hypothesis takes the following form – H_o: $\beta_1 = \beta_2 = \ldots = \beta_{10}$. That is, under the null hypothesis, the regression is of no value because none of the variables contribute significantly to explaining the dependent variable. Under this test, the statistic is distributed as Chi-square with k = 10 degrees of freedom, where k is the number of parameter restrictions.

[7] This finding is likely due to that fact that only about 17% of the observations for Dumscore took zero values. Had our data contained a more even proportion of 1's and 0's, the model would likely have been much better at predicting zero values and possibly worse at predicting the 1's.

treatment sessions reduced patient pain perceptions. We also find that putting off treatment decreases the likelihood of reducing perceived pain. This indicates that putting off treatment likely exacerbates the injury, making it more difficult to treat. Finally, we found that the location in which a provider receives treatment has a significant impact on the likelihood of recovery (as measured by perceived pain outcomes). Interestingly, while patient age has a negative and significant impact on perceived pain, variables such as a patient's sex and the type of health insurance do not significantly affect the likelihood of a positive outcome.

The results of this analysis allow us to make a number of policy recommendations, especially in relation to the health care provider whose patients we studied. The first is an affirmation of the general belief that cohesion and interaction between different health care practitioners, especially between primary care givers and physical therapists, is vital to the recovery of patients with back pain. We show that physical therapy has a significant impact on the perceived pain of patients with back injuries. Moreover, the longer a patient puts off treatment, the harder it is to recover. Consequently, it appears that it is important for primary care practitioners to work with physical therapists in establishing early referral patterns for the treatment of spine pain, so that patients with such injuries can begin treatment as quickly as possible.

A related recommendation concerns the assertion that primary care practitioners may not be diagnosing general back injuries precisely enough. We find that there were no significant differences in perceived pain progress between those patients who were referred to therapy with "general back pain" than those who were referred with more specific diagnoses, especially after controlling for a number of other factors. Thus, an initial diagnosis likely does not affect perceived pain reduction. However, while the precision of initial diagnosis may not significantly affect perceived patient outcomes, it may still affect the provider in other ways. For example, if a particular patient's diagnosis is incorrect or not precise enough, the patient may still fully recover, but it may force the therapist to utilize more resources (both in terms of time and physical resources) to identify and treat the particular injury. Since our analysis does not fully explore these issues, further research is necessary to fully understand the consequences of imprecise diagnoses.

A final issue concerns our finding that patients who receive treatment at different locations experience, on average, different perceived pain outcomes. Specifically, those patients who receive treatment at the provider's downtown and northern locations have significantly lower reductions in perceived pain than those who visit the provider's remaining sites (and in particular the eastern location). As stated in the theory section, these differences may come from one of many different sources, including (but not limited to) differences in population characteristics, such as income and demographic characteristics, differences in provider quality and differences in the types and/or severity of injuries treated at each facility. Further investigation is warranted to determine the causes of these discrepancies and subsequently make recommendations to reduce this phenomenon.

TABLE 1: VARIABLE DEFINITIONS

Variable	Definition
Sex	Takes a value of 1 if the subject is female and 0 if the subject is male.
Back	Takes a value of 1 if the subject has a back injury and 0 otherwise.
Cervical	Takes a value of 1 if the subject has a cervical injury and 0 otherwise.
Lumbar	Takes a value of 1 if the subject has a lumbar injury and 0 otherwise.
Other	Takes a value of 1 if the subject has a non- general back, non-cervical, non-lumbar injury or 0 otherwise.
Wcomp	Takes a value of 1 if the subject is insured under workman's comp and 0 otherwise.
Pvtins	Takes a value of 1 if the subject is insured under private plan and 0 otherwise.
Govins	Takes a value of 1 if the subject is insured under either Medicare or Medicaid and 0 otherwise.
Noins	Takes a value of 1 if the subject is uninsured and 0 otherwise.
Age	The age of each patient (in years).
East	Takes a value of 1 if the patient received treatment at the provider's eastern location, and 0 otherwise.
Downtown	Takes a value of 1 if the patient received treatment at the provider's downtown location and 0 otherwise.
North	Takes a value of 1 if the patient received treatment at the provider's northern location, and 0 otherwise.
Escore	Patient pain perception score upon entering treatment.
Dcscore	Patient pain perception score upon exiting treatment.
Dscore	The difference between Escore and DCscore.
Dumscore	Takes a value of 1 if Dscore is positive and 0 otherwise.
Months	The number of months between the onset of injury and the first treatment session.
Sessions	The number of treatments sessions for each patient.

TABLE 2: DESCRIPTIVE STATISTICS

Variable	Mean	Standard Deviation
AGE	42.29	14.90
SEX	0.5756	0.4955
INS	2.063	1.125
EAST	0.4683	0.5002
DOWNTOWN	0.3463	0.4770
NORTHPT	0.1805	0.3855
ESCORE	6.277	2.841
DCSCORE	2.454	2.841
DSCORE	3.856	3.073
BACK	0.4000	0.4911
LUMBAR	0.2537	0.4362
CERVICAL	0.2488	0.4334
OTHER	0.0976	0.2974
SESSIONS	6.473	4.144
MONTHS	3.512	7.252
DUMSCORE	0.8293	0.3772
WCOMP	0.3073	0.4625
PVTINS	0.5220	0.5007
GOVINS	0.0780	0.2689
NOINS	0.0927	0.2907

Number of observations = 205

TABLE 3: LOGISTIC REGRESSION RESULTS

Dependent Variable: Cumulative Probability of Dumscore

Predictors: (Standard Errors in Parentheses)	Coefficient Estimate	Marginal Effect Estimate
Constant	2.886**	0.3346**
	(0.9435)	(0.1048)
Downtown	-1.148**	-0.1331**
	(0.5128)	(0.0571)
North	-1.357**	-0.1574**
	(0.5892)	(0.0661)
Wcomp	0.2429	0.0282
	(0.4798)	(0.0555)
Govins	-0.3291	-0.0382
	(0.9155)	(0.1061)
Noins	-0.5714	-0.0662
	(0.6753)	(0.0781)
Sex	-0.00086	-0.0001
	(0.4313)	(0.0500)
Age	-0.0293*	-0.0034*
	(0.0173)	(0.0020)
Sessions	0.1653**	0.0192**
	(0.0675)	(0.0072)
Months	-0.04423*	-0.0051*
	(0.02324)	(0.0028)
Back	-0.1175	-0.0136
	(0.4119)	(0.0477)

Number of Observations = 205 Chi-Square Statistic = 22.867**

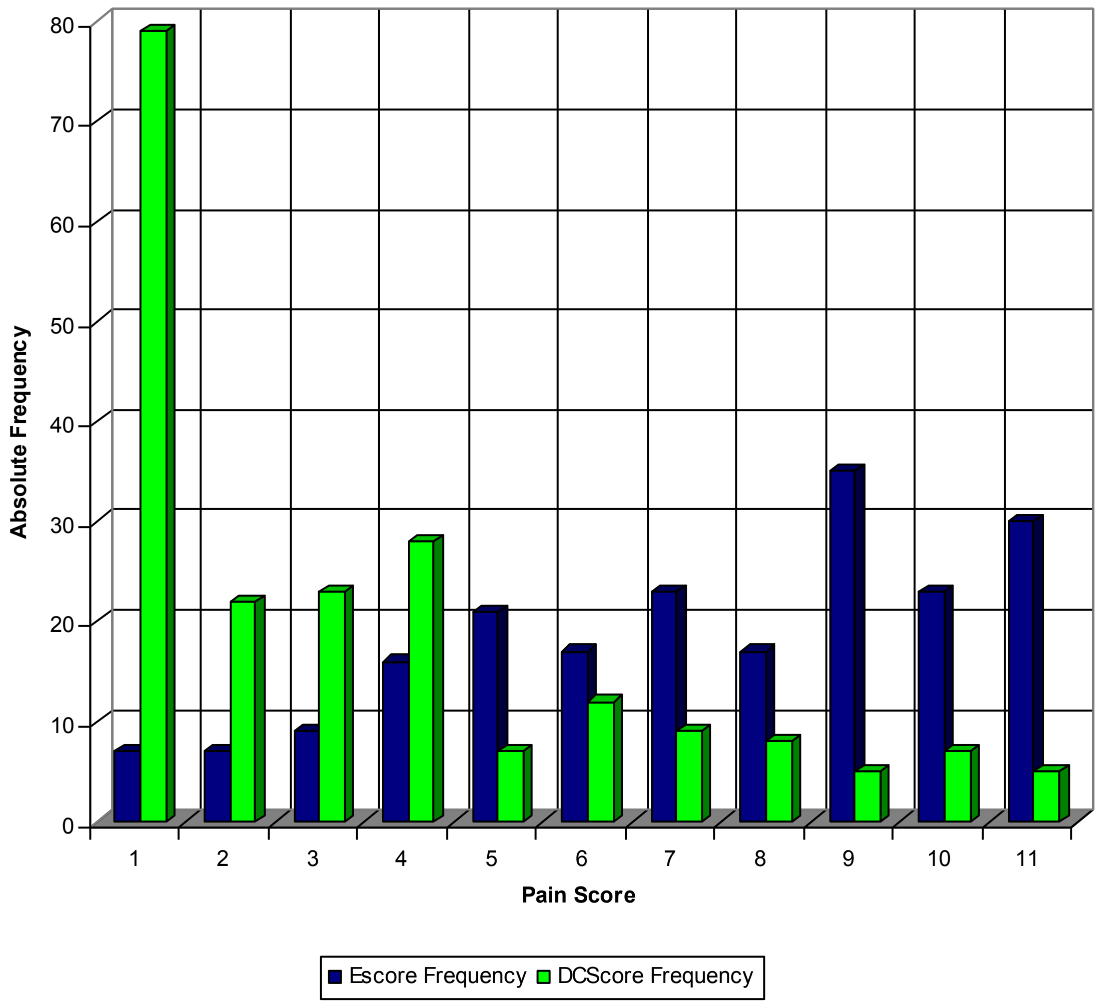
* indicates statistical significance at a 90% level of confidence or better

* indicates statistical significance at a 95% level of confidence or better

Table of Predicted and Actual Outcomes

	Predicted		
Actual	0	1	Total
0	3	32	35
1	1	169	170
Total	4	201	205

Figure 1: Pain Scores on Evaluation and Discharge



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