



# Comorbidities in Workers Compensation

## INTRODUCTION

While the average medical cost for a workers compensation claim is approximately \$6,000, the medical cost of an individual claim can be a few hundred dollars or millions of dollars. In 2010, an NCCI study found that claims with an obesity comorbidity diagnosis incurred significantly higher medical costs than comparable claims without such a comorbidity diagnosis [1]. Relative to that study, this study expands the number of comorbidities examined and provides additional information on both the types of claimants receiving comorbidity diagnoses and the types of providers submitting comorbidity diagnoses.

## KEY FINDINGS

- The share of workers compensation claims with a comorbidity diagnosis nearly tripled from Accident Year<sup>1</sup> 2000 to Accident Year 2009, growing from a share of 2.4% to 6.6%
- Claims with a comorbidity diagnosis have about twice the medical costs of otherwise comparable claims
- Comorbidity diagnoses for hypertension are the most prevalent of those investigated
- The initial comorbidity diagnosis tends to occur early in the life of a claim
- Hospital and physician visits account for a majority of visits resulting in a recorded comorbidity diagnosis
- Only a small portion of visits result in the recording of a comorbidity diagnosis

## STUDY DESIGN

### Data

The data set used in this study is from a nationwide<sup>2</sup> sample of transactions provided by carriers. The data set includes medical services provided between 1996 and 2010 on both lost-time and medical-only claims that occurred between 1994 and 2010. The data set is evaluated as of July 1, 2011.

### Identification of Comorbidities

This study identifies comorbidities by matching the International Classification of Diseases, 9th Revision, or ICD9, diagnostic codes on individual claim transactions against the table of Comorbidity and ICD9 code mappings in Appendix 1. The D'Hoore, Sicotte, and Tilquin [2] adaptation of the Charlson Comorbidity Index [3] serves as the main basis for both (1) the comorbidities included in this study and (2) the table of Comorbidity and ICD9 code mappings.

<sup>1</sup> The *accident year* for a claim is the year during which the injury occurred. We look at costs by *accident year* (used interchangeably with *injury year*) because workers compensation insurance coverage continues (potentially for many years) following the date of injury. This "long-tail" feature of workers compensation subjects the line to substantial long-term cost pressures.

<sup>2</sup> All US states (including DC) except ND, OH, WA, WV, and WY.

For this study, a *comorbidity diagnosis* is defined as any medical transaction<sup>3</sup> with a recorded ICD9 code indicating a specified comorbidity. Such transactions may or may not represent treatments for the comorbid condition. Comorbidity diagnoses indicate the presence of the condition. They do not indicate whether care was provided for the condition directly or indirectly. We have not filtered transactions based on Current Procedural Terminology (CPT) codes, which indicate the procedure performed.

### Inclusion of Medical-Only Claims

This study includes both medical-only and lost-time claims for two reasons:

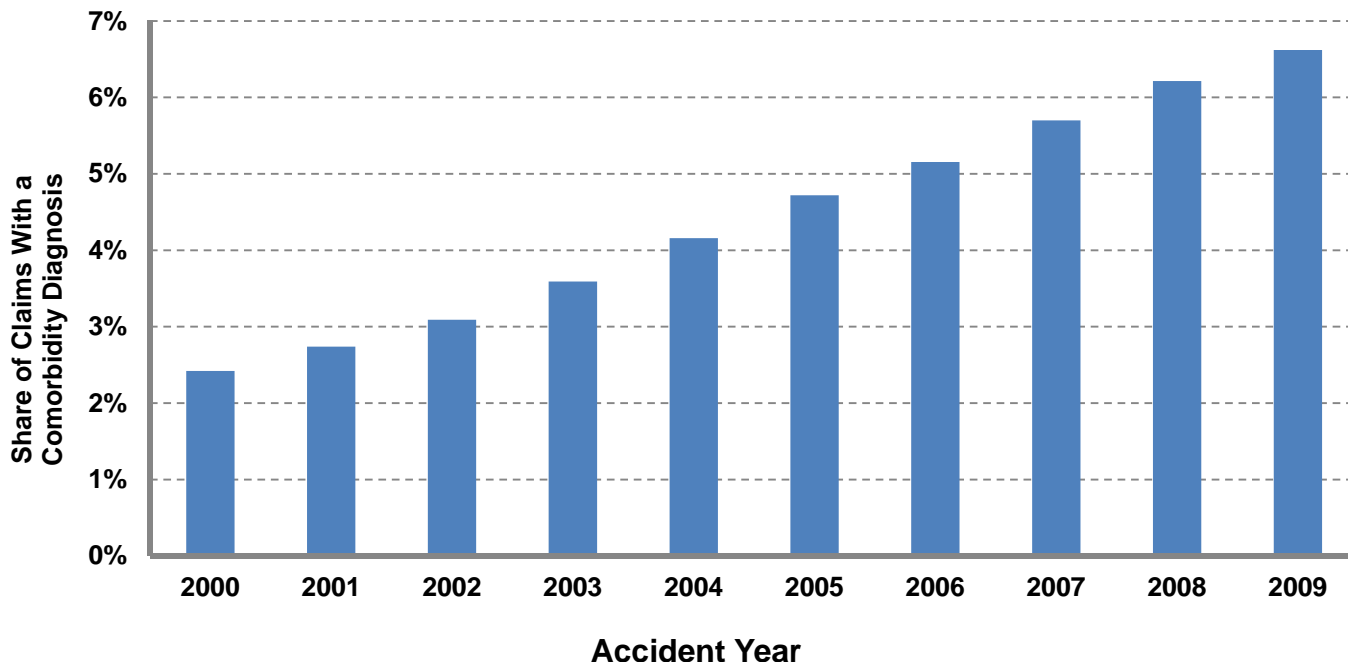
1. While lost-time status can serve as a proxy for the degree to which a claimant is injured, using it as such introduces an abrupt dividing line. As lost-time status is defined in relation to the waiting period, which can be as long as seven days, a lost-time claim might have only one more day away from work than a similar medical-only claim.
2. Complications resulting from a comorbidity could transform an otherwise medical-only claim into a lost-time claim. Limiting the analysis to only lost-time claims or matching by lost-time status would disregard costs associated with such crossovers.

## DISCUSSION OF FINDINGS

### Who Receives Comorbidity Diagnoses?

The share of claims with a comorbidity diagnosis is increasing, as shown in Exhibit 1. This share has almost tripled since Accident Year 2000 with 6.6% of all Accident Year 2009 claimants receiving a comorbidity diagnosis.

**Claims With a Comorbidity Diagnosis Are Increasing**



A claim is considered to be a comorbidity claim if its first comorbidity diagnosis occurs within 12 months after injury. Analysis based on sample data provided by carriers for all US states and DC except ND, OH, WA, WV, and WY.

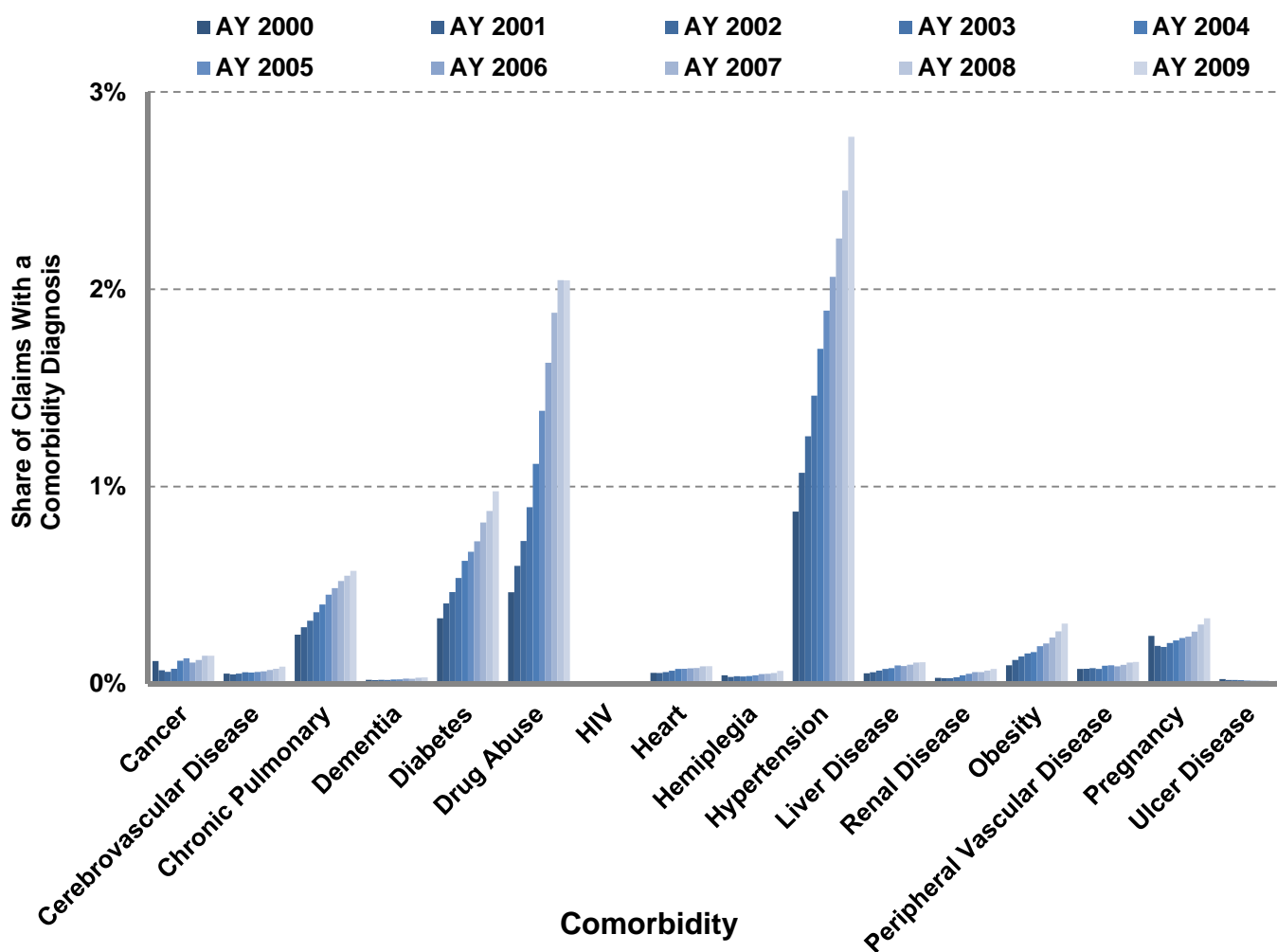
**Exhibit 1**

<sup>3</sup> Each such transaction must be incurred and recorded through the workers compensation system. Transactions incurred and recorded apart from the workers compensation system are not available for use in this study.

Exhibit 2 shows the share of claims with comorbidity diagnoses for specific comorbidities. Claims with diagnoses for multiple comorbidities are included in the statistics for each such comorbidity. Over a nine-year span, the share of claims with drug-abuse diagnoses (inclusive of alcohol and tobacco) more than quadrupled, and the shares for diabetes, hypertension, and obesity diagnoses have tripled.

Many states have statutes in place that presume that some conditions (e.g., heart attack, cancer) are work related for firefighters or police officers. These statutes shift the burden of proof from the employee, who must typically prove that the condition is work related in order to receive compensation under the workers compensation system, to the employer, who must then prove that the condition is not work related in order to be released from this obligation [4]. Future research may investigate the degree to which such statutes impact Exhibits 1 and 2.

### Claims With a Comorbidity Diagnosis Are Increasing



A claim is considered to be a comorbidity claim if its first comorbidity diagnosis occurs within 12 months after injury  
 Analysis based on sample data provided by carriers for all US states and DC except ND, OH, WA, WV, and WY

Exhibit 2

This study relies on a recorded comorbidity diagnosis to identify claimants suffering from a comorbidity. Exhibit 3 compares the percentage of workers compensation (WC) claims with a comorbidity diagnosis to the Centers for Disease Control (CDC) estimates of the nationwide share of those suffering from the same condition. Whereas the CDC measures the prevalence of the condition in the general population, the workers compensation figures include only claims for which a medical provider actually rendered and billed a service with an ICD9 code corresponding to the specified comorbidity. For more information on the CDC estimates, see Appendix 2.

The workers compensation shares are significantly lower than those from the CDC, suggesting that most workers compensation claimants with a given comorbidity are not diagnosed through the workers compensation system for that comorbidity.

This exhibit also indicates that the growth rate of workers compensation claims with a comorbidity diagnosis is outpacing the growth rates of the given conditions in the US population. Possible reasons for this include:

- Medical billing records are increasing in detail with no change in actual services rendered
- Medical providers are expanding their treatment beyond the work-related injury or disease

### Illness Rates in the General Population Are Increasing

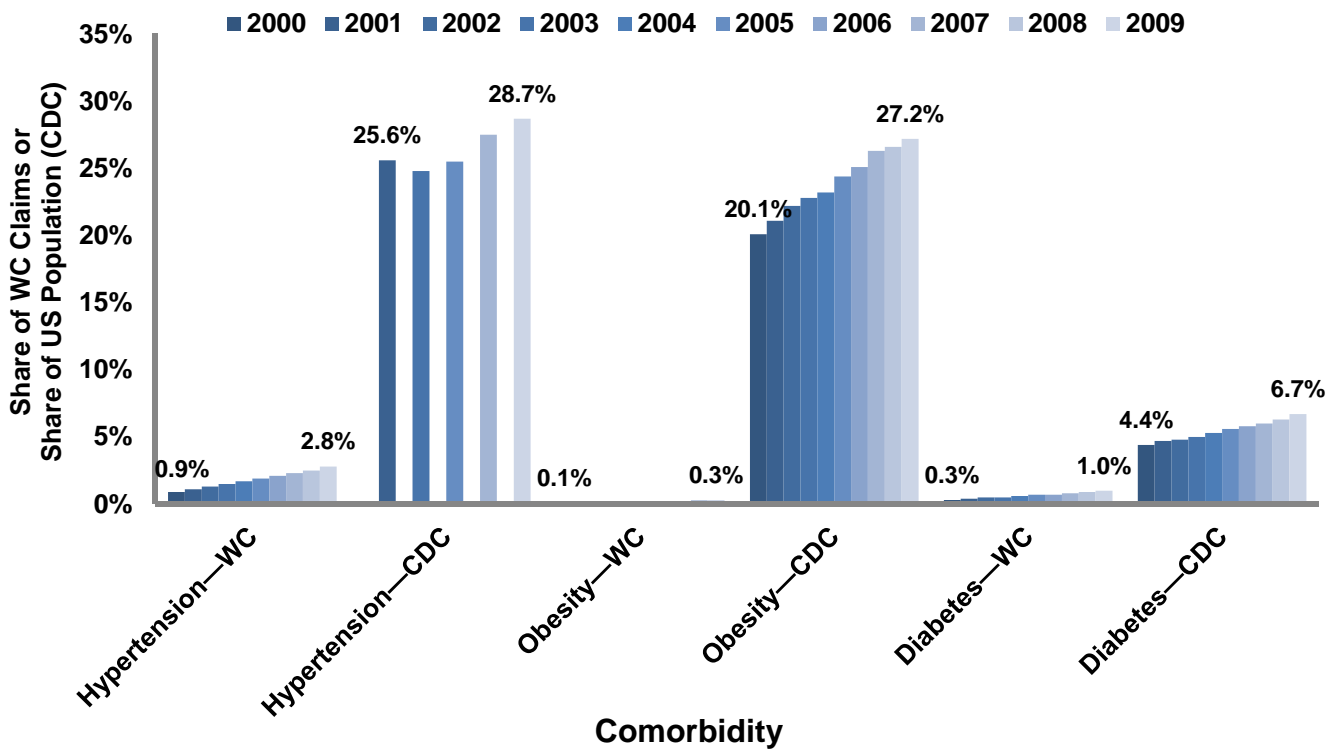
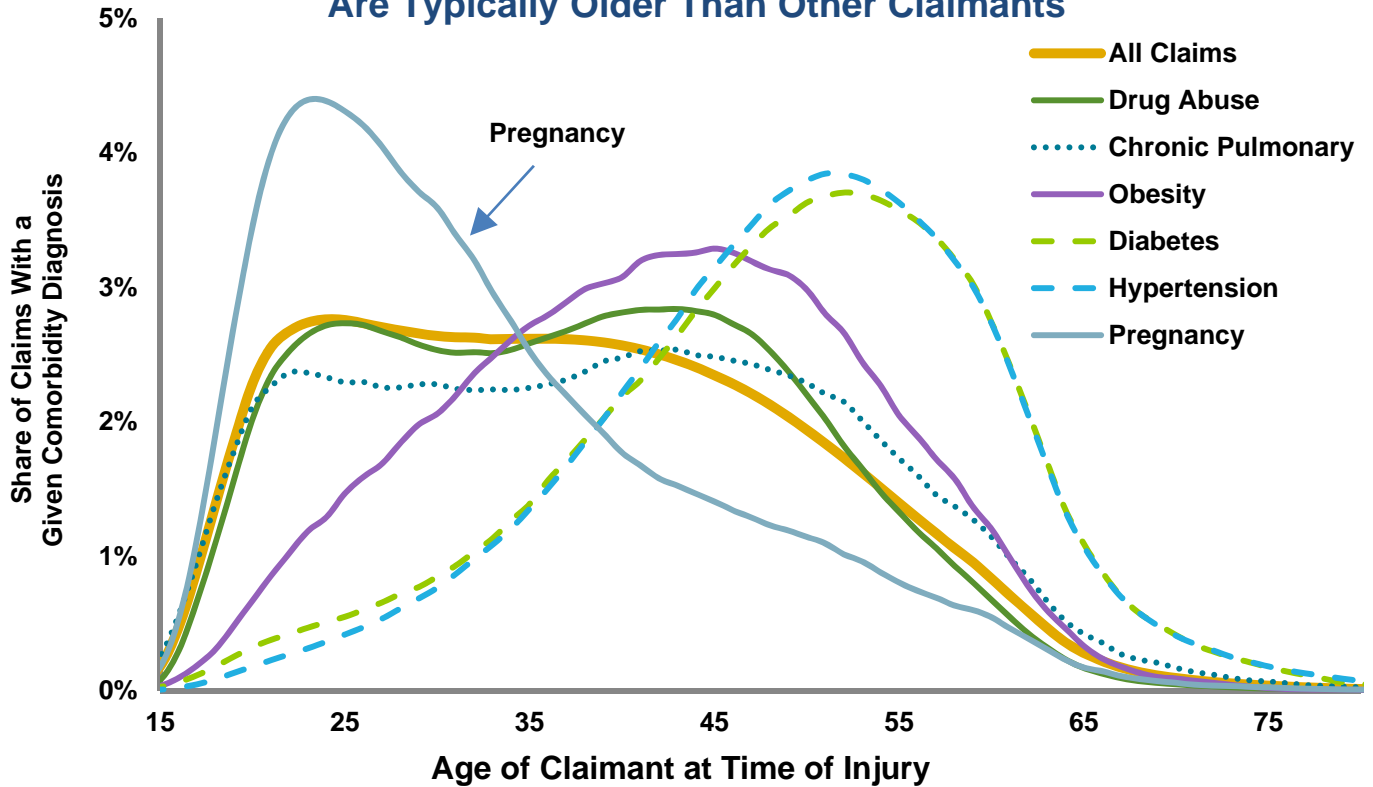


Exhibit 4 shows the distributions by age at the time of injury for claimants with certain comorbidity diagnoses. Most of these distributions are shifted to the right of the All Claims distribution (with or without a comorbidity diagnosis), indicating that claimants with the corresponding comorbidity diagnosis tend to be older than the average claimant. This is not surprising because older individuals are more likely than younger individuals to suffer from some of these conditions. Similarly, it is not surprising that claimants receiving a comorbidity diagnosis related to pregnancy are generally younger than average. Bear in mind that these distributions are affected by the age distribution of the working population.

### Claimants With Comorbidity Diagnoses Are Typically Older Than Other Claimants



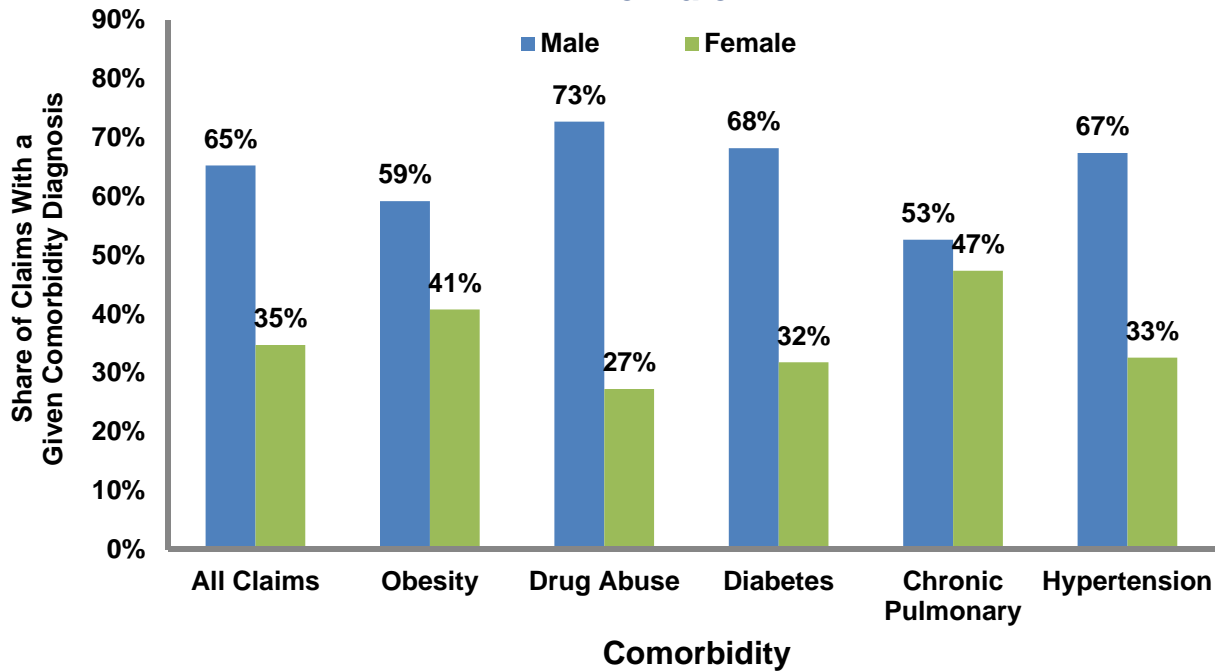
Injury Years 1996 through 2009  
 All Claims includes claims with and without a comorbidity diagnosis  
 A claim is considered to be a comorbidity claim if its first comorbidity diagnosis occurs within 12 months after injury  
 Shares by age are smoothed  
 Analysis based on sample data provided by carriers for all US states and DC except ND, OH, WA, WV, and WY

**Exhibit 4**

Although women make up about half of the workforce over the period of this study, they account for only 35% of claims. One reason is that hazardous jobs are predominantly held by men. According to the International Labour Organization, men are more likely to work in jobs with exposure to injuries and more likely to be involved in work-related deaths [5].

Exhibit 5 displays the gender distribution of claimants with given comorbidity diagnoses. For comparison purposes, the gender distribution of All Claims (with or without a comorbidity diagnosis) is also shown. More males receive a drug-abuse diagnosis than would be expected given the All Claims distribution. Research done by the National Survey on Drug Use and Health (NSDUH) finds that men are more likely than women to use, abuse, and be dependent on alcohol or illicit drugs [6]. On the other hand, the gender distribution for claimants with a diagnosis for chronic pulmonary disease is more evenly split than any other category, including the general population itself. The American Lung Association study found that women are about twice as likely as men to be diagnosed with chronic bronchitis [7]. This result suggests an explanation for the higher-than-average proportion of female claimants in the Chronic Pulmonary category.

### The Majority of Claimants With Comorbidity Diagnoses Are Male



Injury Years 1996 through 2009

All Claims includes claims with and without a comorbidity diagnosis

A claim is considered to be a comorbidity claim if its first comorbidity diagnosis occurs within 12 months after injury

Women represent about 47% of the workforce over this period

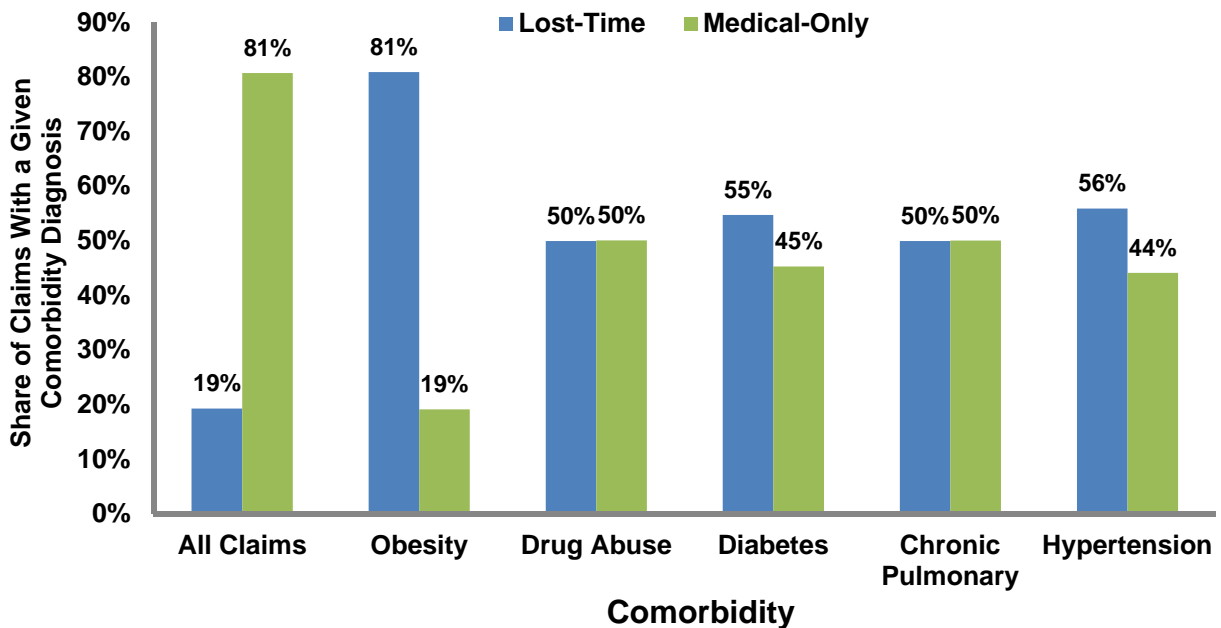
Analysis based on sample data provided by carriers for all US states and DC except ND, OH, WA, WV, and WY

#### Exhibit 5

Claims with a comorbidity diagnosis are more likely than the average claim to be lost-time, as shown in Exhibit 6. This exhibit displays the lost-time versus medical-only distribution of claims with a diagnosis for the specified comorbidities and the same distribution for All Claims (with or without a comorbidity diagnosis). For All Claims, the vast majority of claims are medical-only. Conversely, claims with a comorbidity diagnosis are generally evenly split between lost-time and medical-only. The one exception is that claims with an obesity diagnosis are more than four times as likely to be lost-time.

Exhibit 6 does not (nor does most of this study) indicate causation; this exhibit only points out observed correlations. In particular, this exhibit does not show that the presence of a comorbidity diagnosis is likely to cause an otherwise medical-only claim to become a lost-time claim. In fact, the causation could run in the other direction. The fact that a claim is lost-time might make it more likely to incur a transaction indicating a comorbidity diagnosis because lost-time claims generally have more treatments.

### Claims With a Comorbidity Diagnosis Are More Likely to Be Lost-Time



Injury Years 1996 through 2009

All Claims includes claims with and without a comorbidity diagnosis

A claim is considered to be a comorbidity claim if its first comorbidity diagnosis occurs within 12 months after injury

The lost-time status of a claim is determined 12 months after injury

Analysis based on sample data provided by carriers for all US states and DC except ND, OH, WA, WV, and WY

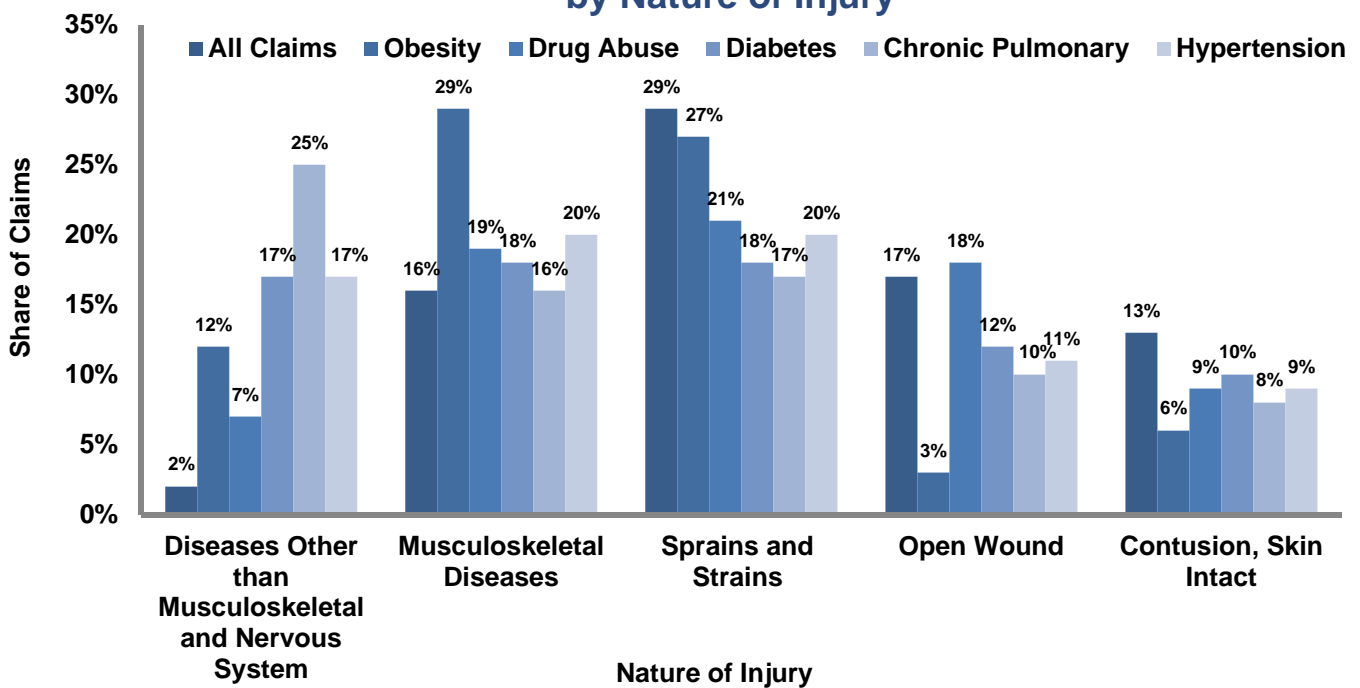
**Exhibit 6**

The nature of injury distributions for claims receiving certain comorbidity diagnoses are presented in Exhibit 7. Natures of injury are based on the first ICD9 code on a claim. (This definition for nature of injury differs from the definition used for NCCI's **Statistical Plan**. For more information on nature of injury and how the first ICD9 code is determined, see Appendix 3.)

The bar for a given comorbidity in a nature of injury group shows the share of claims with a diagnosis for that comorbidity sustaining the specified nature of injury. For example, 12% of claims with a diabetes comorbidity diagnosis are for Open Wounds. Bars for a given comorbidity condition (plus the All Other bar, which is not shown) total 100%. For comparison purposes, the nature of injury distribution for All Claims (with or without a comorbidity diagnosis) is also shown. Claims receiving a comorbidity diagnosis are more likely to be disease claims than the average claim.

“Obesity seems to be an important modifiable risk factor for the onset of” certain diseases of the musculoskeletal system [8]. This might explain the higher-than-average likelihood that claims receiving obesity diagnoses are claims related to Musculoskeletal Diseases.

### Distribution of Claims With a Comorbidity Diagnosis by Nature of Injury



Injury Years 1996 through 2009

All Claims includes claims with and without a comorbidity diagnosis

A claim is considered to be a comorbidity claim if its first comorbidity diagnosis occurs within 12 months after injury

There are 22 natures of injury based on first ICD9 (non-comorbidity) code occurring on the claim

Only natures of injury with more than 12% in at least one category are displayed

Analysis based on sample data provided by carriers for all US states and DC except ND, OH, WA, WV, and WY

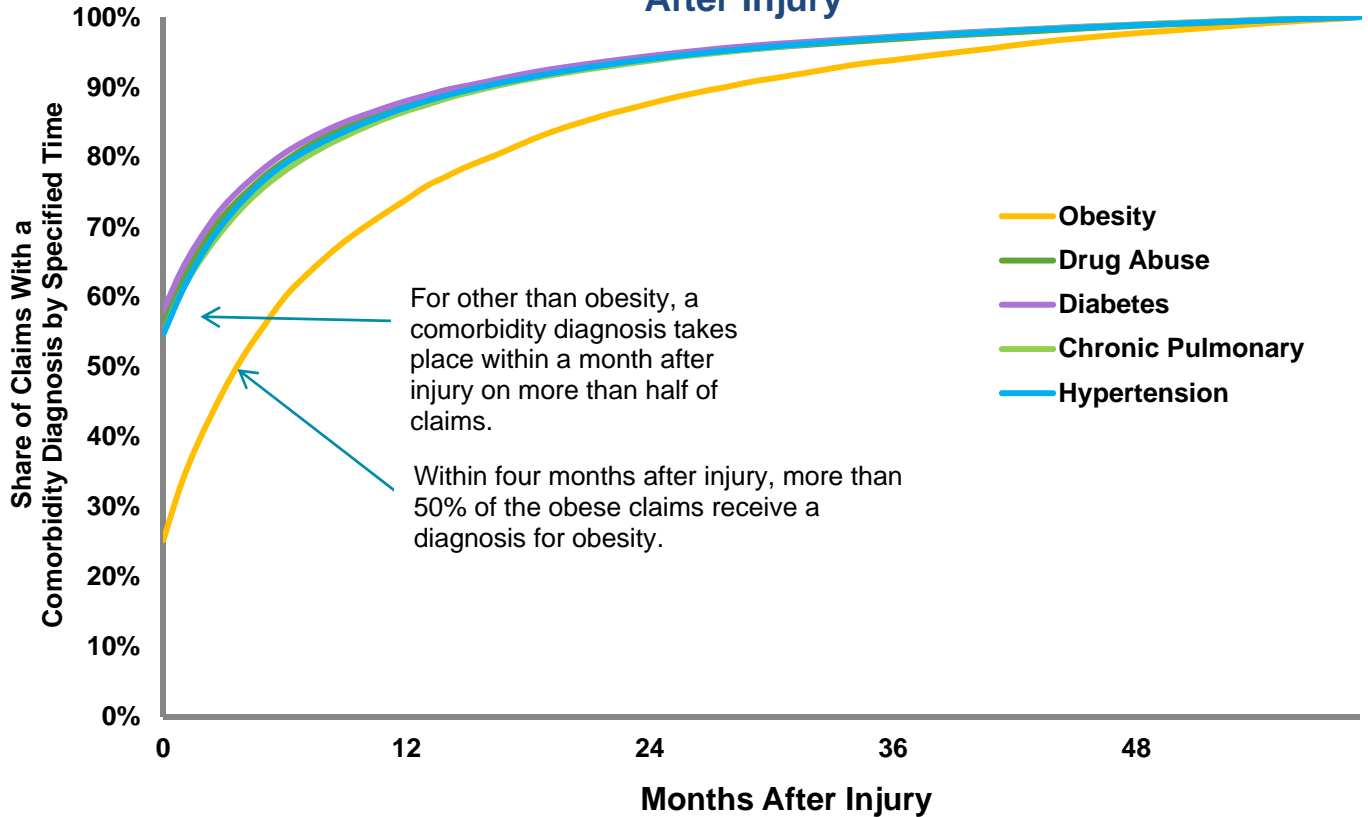
**Exhibit 7**



### When Does the Initial Comorbidity Diagnosis Occur?

The initial comorbidity diagnosis tends to occur early in the life of a claim. For claims with at least one workers compensation comorbidity diagnosis within five years of the date of injury, Exhibit 8 shows the cumulative shares of claims receiving their first comorbidity diagnosis within the given periods. For most comorbidity diagnoses, more than 85% of claims that will have a comorbidity diagnosis within five years had their first comorbidity diagnosis within a year after injury. In fact, other than claims with an obesity diagnosis, more than half of the claimants receiving a comorbidity diagnosis within five years of the date of injury are first diagnosed within one month after injury.

### A Claim's First Comorbidity Diagnosis May Occur Many Months After Injury



Injury Years 1996 through 2005

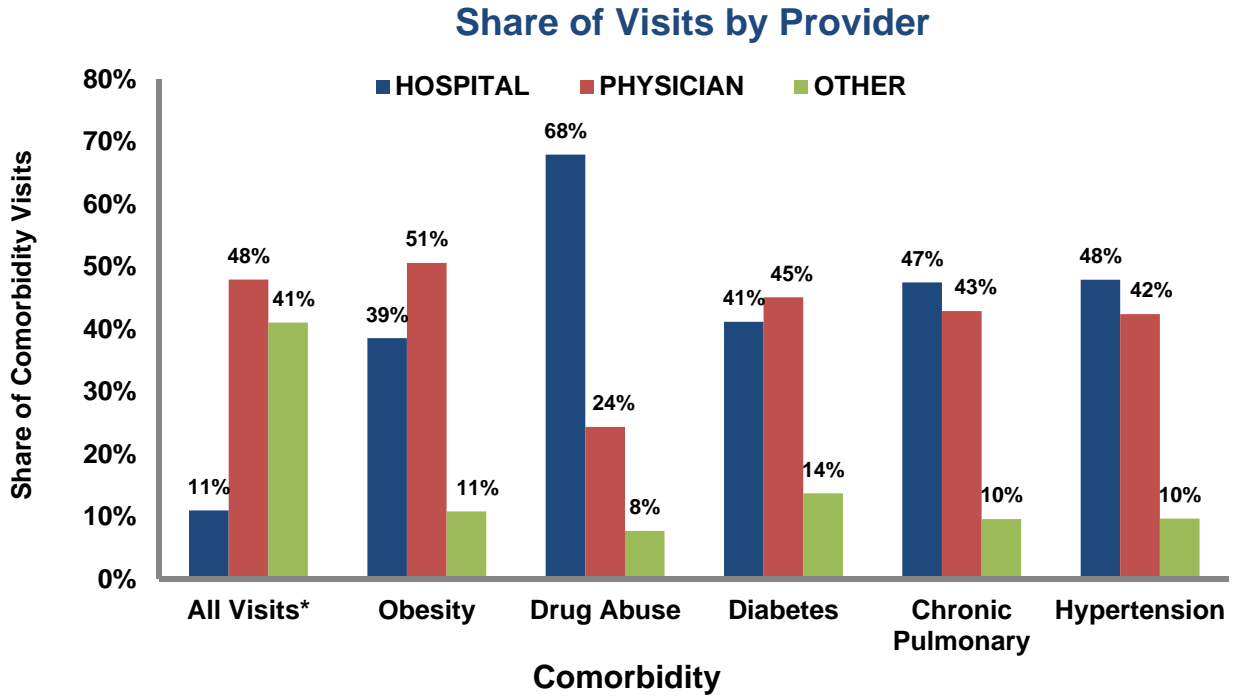
A claim is considered to be a comorbidity claim if its first comorbidity diagnosis occurs within 60 months after injury

Analysis based on sample data provided by carriers for all US states and DC except ND, OH, WA, WV, and WY

Exhibit 8

### Who Submits Comorbidity Diagnoses?

Exhibit 9 shows the distribution of visits resulting in a comorbidity diagnosis<sup>4</sup> by provider type for select comorbidities. The distribution of All Visits (resulting in a comorbidity diagnosis or not) gives a benchmark for comparison. This exhibit indicates that hospitals provide a high proportion of visits resulting in a comorbidity diagnoses when compared to the proportion of All Visits they provide. The provider distribution for visits resulting in a drug-abuse diagnosis shows an even higher shift toward hospital providers.



Other Providers consists of allied health professionals, nonhospital facilities, and other services  
 Service Years 2008 through 2010  
 Analysis based on sample data provided by carriers for all US states and DC except ND, OH, WA, WV, and WY  
 \*All Visits includes comorbidity and noncomorbidity visits

**Exhibit 9**

<sup>4</sup>The total number of visits resulting in a comorbidity diagnosis represents the total number of unique days from each provider on which each claimant receives a comorbidity diagnosis.

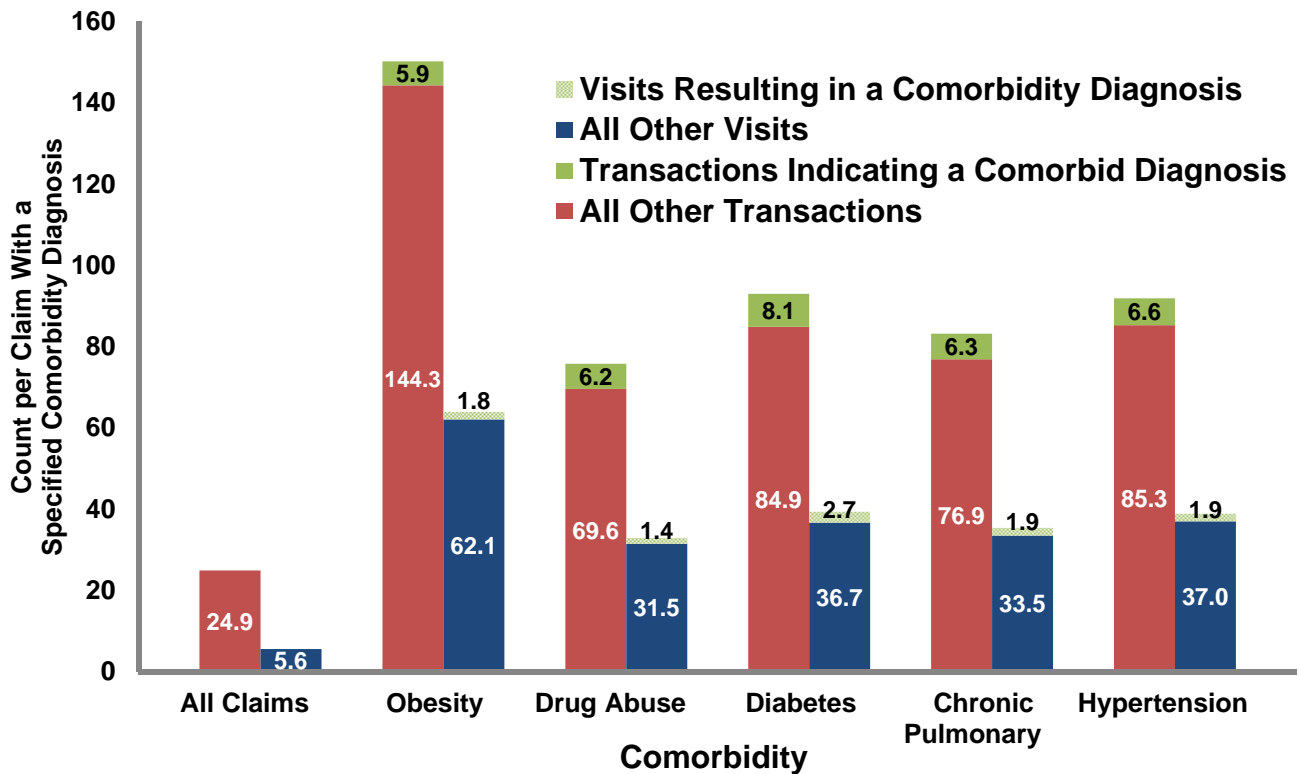
### What Are the Cost Implications?

This section looks at the impact of comorbidity diagnoses on workers compensation claim costs. We begin by looking at the portion of transactions and the related costs that are associated with a comorbidity diagnosis. We then measure the mix-adjusted cost relativity of claims with a comorbidity diagnosis to otherwise comparable claims. Finally, we present findings from a Bayesian multilevel model that measures the correlation of claim characteristics with the differences in the cost relativities of claims with a comorbidity diagnosis to otherwise comparable claims. The details of the model are presented in Appendix 4.

#### Claim Costs Associated with Transactions Involving a Comorbidity Diagnosis

Claims with a comorbidity diagnosis are typically more complex than claims without a comorbidity diagnosis. Exhibit 10 shows the number of transactions and visits generated by claims with a comorbidity diagnosis. In comparison to All Claims (with or without a comorbidity diagnosis), claims with a comorbidity diagnosis have about three times the number of transactions and seven times the number of visits. Note that the portion of transactions and visits that result in a comorbidity diagnosis represent only a small portion of all medical services.

### Claims With a Comorbidity Diagnosis Generally Receive More Medical Services



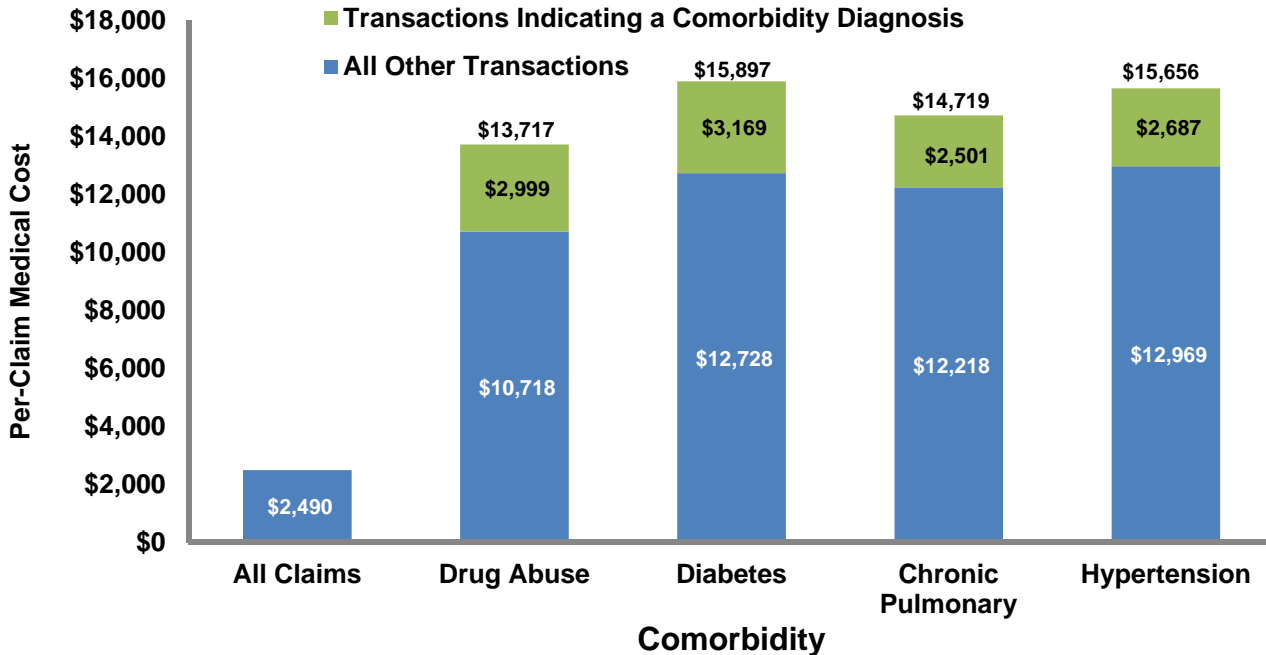
Injury Years 1996 through 2007  
 Relative Service Years 1 through 4  
 A claim is considered to be a comorbidity claim if its first comorbidity diagnosis occurs within 12 months after injury  
 Analysis based on sample data provided by carriers for all US states and DC except ND, OH, WA, WV, and WY

Exhibit 10

Given the higher number of transactions on claims with a comorbidity diagnosis in Exhibit 10, one might expect these claims to cost more than the average claim. Exhibit 11 confirms this and separates per-claim costs into those arising from transactions indicating a comorbidity diagnosis and all other transactions. The share of per-claim costs associated with comorbidity diagnoses ranges from 17% (Chronic Pulmonary and Hypertension) to 22% (Drug Abuse).

Exhibit 11 also compares the per-claim cost for claims with a comorbidity diagnosis to All Claims (with or without a comorbidity diagnosis). As we have shown, the characteristics of the population of claims with a comorbidity diagnosis differ markedly from those of the general population. Such differences in demographics contribute significantly to the six fold increase in per-claim costs for claims with a comorbidity diagnosis over All Claims.

### Claims With a Comorbidity Diagnosis Are Generally More Costly Than Other Claims



Injury Years 1996 through 2007  
 Relative Service Years 1 through 4  
 All Claims includes claims with and without a comorbidity diagnosis  
 A claim is considered to be a comorbidity claim if its first comorbidity diagnosis occurs within 12 months after injury  
 Analysis based on sample data provided by carriers for all US states and DC except ND, OH, WA, WV, and WY

**Exhibit 11**

**Mix-Adjusted Cost Relativities**

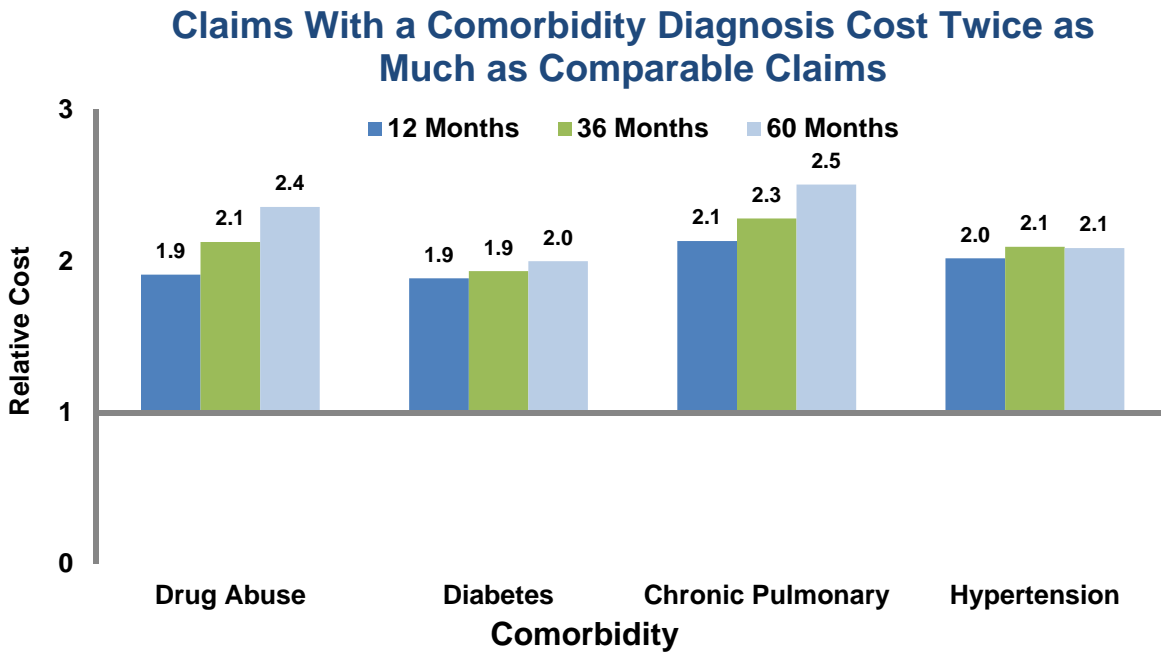
Exhibit 12 measures the relativity of the per-claim workers compensation costs for claims with a comorbidity diagnosis to otherwise comparable claims after controlling for differences in demographics. To this end, a matched-pairs analysis is performed. First, claims with a diagnosis for a particular comorbidity are identified. Second, potential matches for each of these claims are identified from the population of claims without a similar comorbidity diagnosis and at least one medical transaction occurring (relative to date of injury) after the first comorbidity diagnosis of the other claim. This last restriction is designed to correct for the inherent immortal time bias [9].

Potential matches must share the following characteristics of the claim with a comorbidity diagnosis:

- State of Jurisdiction
- Injury Year
- Gender
- NCCI Industry Group
- The first three digits of each claim’s primary ICD9 code

Because of the need to match by Industry Group, the matched-pairs analysis is restricted to 39 jurisdictions: AK, AL, AR, AZ, CO, CT, DC, FL, GA, HI, IA, ID, IL, IN, KS, KY, LA, MD, ME, MI, MO, MS, MT, NC, NE, NH, NM, NV, OK, OR, RI, SC, SD, TN, TX, UT, VA, VT, and WI. This set of potential matches, is filtered once more by selecting only those matches with the most similar “degree of youngness,” which results in an approximate age match. See Appendix 5 for more details on the matching process (which parallels work done in “Reserving in the Age of Obesity” [1]), the immortal time bias, and the “degree of youngness.”

Exhibit 12 shows that claims with a comorbidity diagnosis have about double the medical costs of otherwise comparable claims.



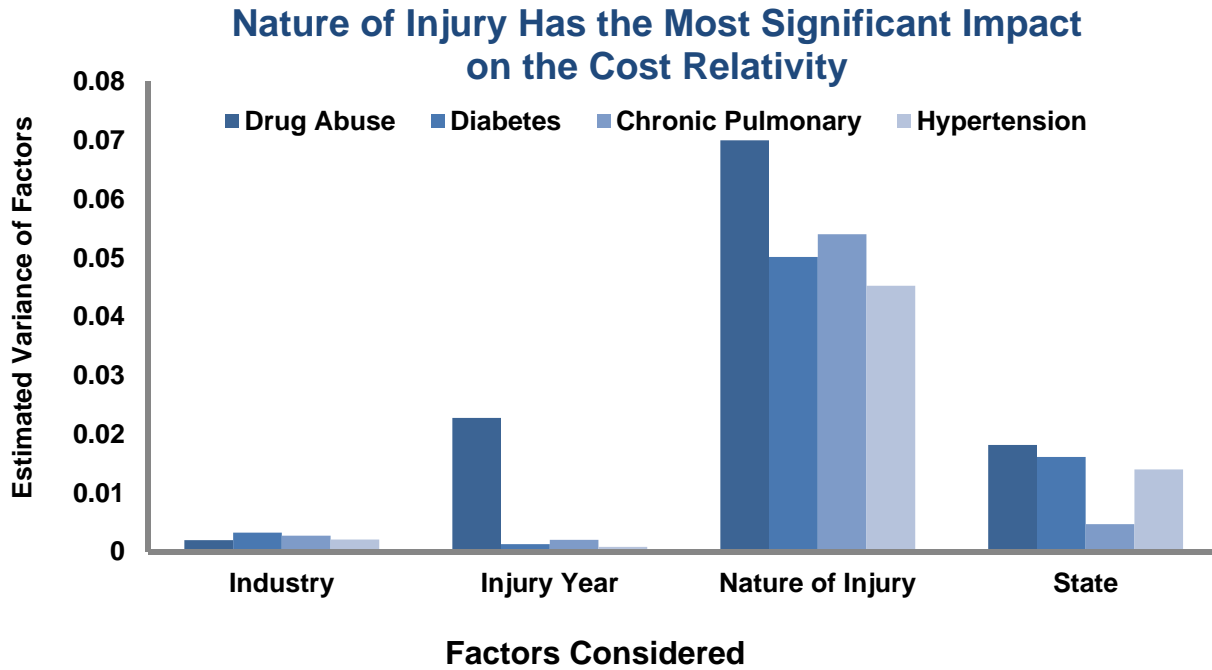
Injury Years 1998 through 2004 (evaluated at 60 months), 2006 (36 months), or 2008 (12 months)  
 Analysis based on sample data provided by carriers for all US states and DC except CA, DE, MA, MN, ND, NJ, NY, OH, PA, WA, WV, and WY

**Exhibit 12**

**Differences in Mix-Adjusted Cost Relativities**

In order to estimate the relations between particular claim characteristics and differences in cost relativities while controlling for other characteristics, we have applied a multilevel model. The dependent variable in the model is the ratio of the medical dollars paid for a claim with a comorbidity diagnosis to the medical dollars paid for the claim's match.

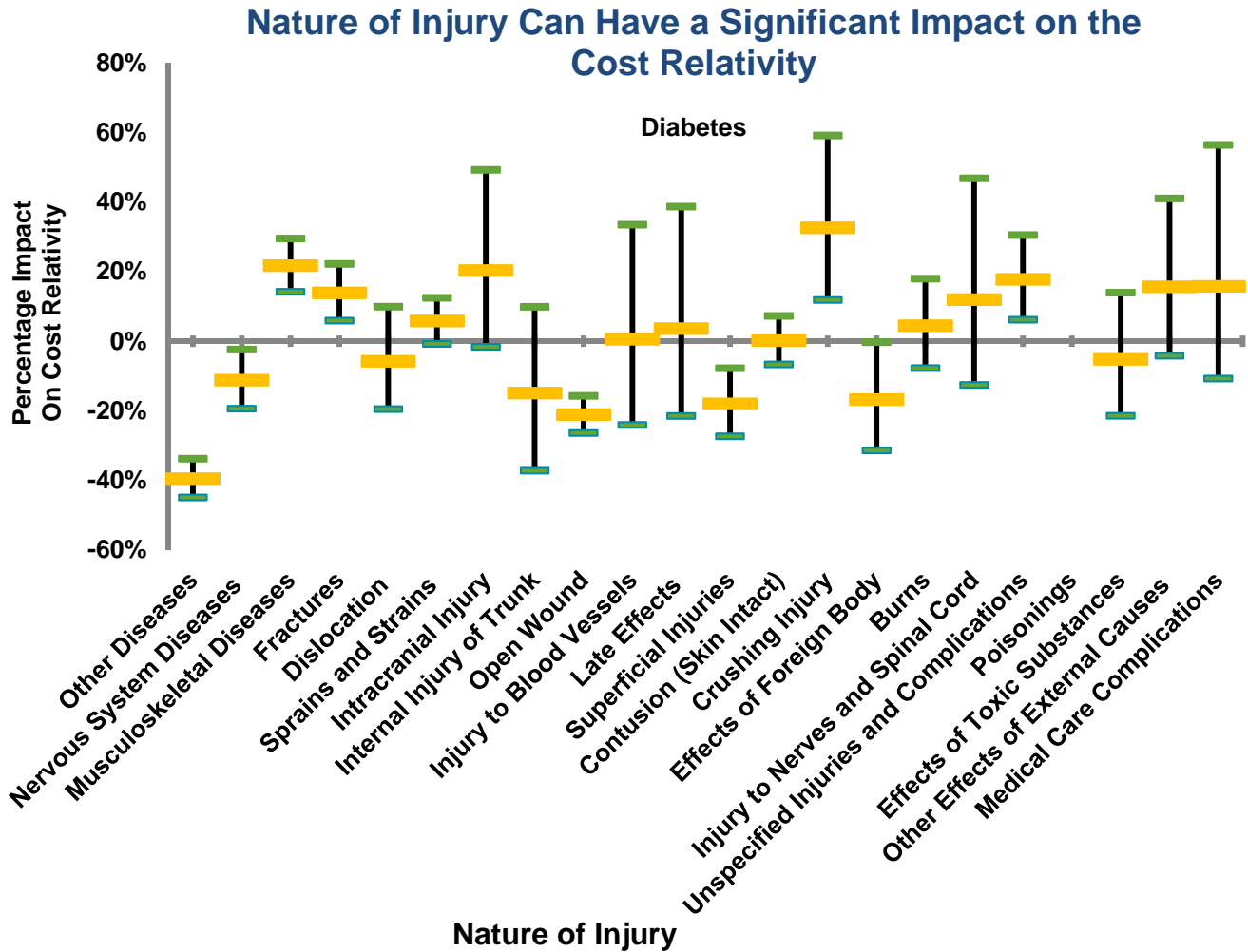
One feature of multilevel models is their ability to quantify the relative influence of each factor (e.g., state, industry, nature of injury). Exhibit 13 displays the estimated variance parameter for all factors modeled as random effects. Larger values indicate a higher variation among the different levels of the factor. The factor with the highest variation among its levels is nature of injury. In other words, nature of injury can describe more of the observed differences in the cost relativity of a claim with a comorbidity diagnosis and its match than can be described by industry, injury year, or state.



Results shown are for the 36-month evaluation  
 Results are estimated from a Bayesian multilevel model  
 Analysis based on sample data provided by carriers for all US states and DC except CA, DE, MA, MN, ND, NJ, NY, OH, PA, WA, WV, and WY

**Exhibit 13**

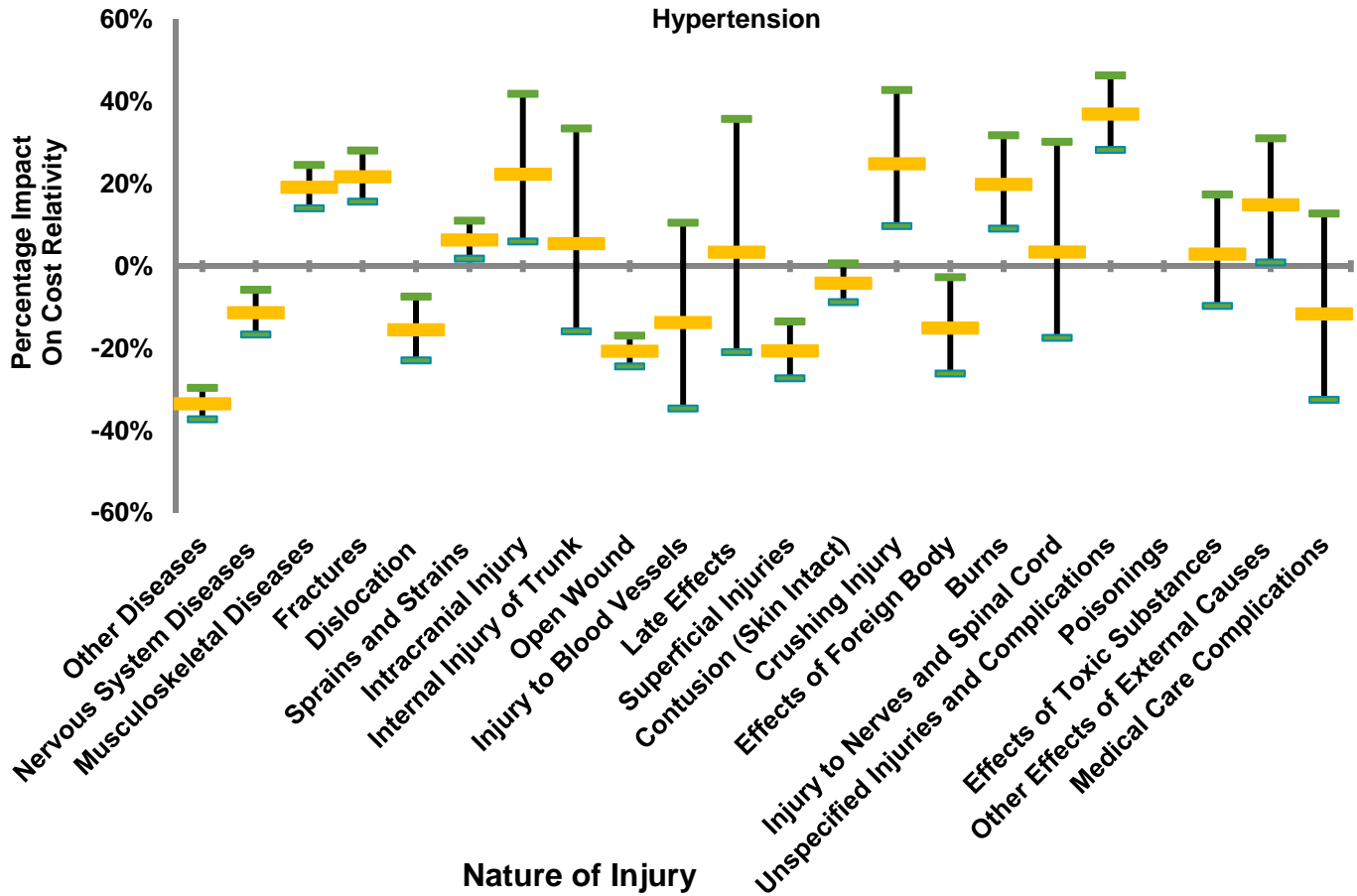
Exhibits 14 (Diabetes), 15 (Hypertension), and 16 (Chronic Pulmonary) display the relationship each nature of injury has with the paid medical cost relativities between claims with a comorbidity diagnosis and their matches. For instance, Exhibit 14 shows that, for claims with a diabetes diagnosis, claim-pairs with a Crushing Injury have a cost relativity that is 33% higher than otherwise comparable claim-pairs with a Contusion (Skin Intact). Similarly, a claim-pair with an Open Wound would have (on average) a 21% smaller cost relativity when compared to a claim-pair with a Contusion (Skin Intact).



Injury Years 1998 through 2006 at the 36-month evaluation  
 Results are estimated from a Bayesian multilevel model; the bands represent 80% credible intervals  
 There were no observations for Poisonings  
 Analysis based on sample data provided by carriers for all US states and DC except CA, DE, MA, MN, ND, NJ, NY, OH, PA, WA, WV, and WY

**Exhibit 14**

## Nature of Injury Can Have a Significant Impact on the Cost Relativity



Injury Years 1998 through 2006 at the 36-month evaluation

Results are estimated from a Bayesian multilevel model; the bands represent 80% credible intervals

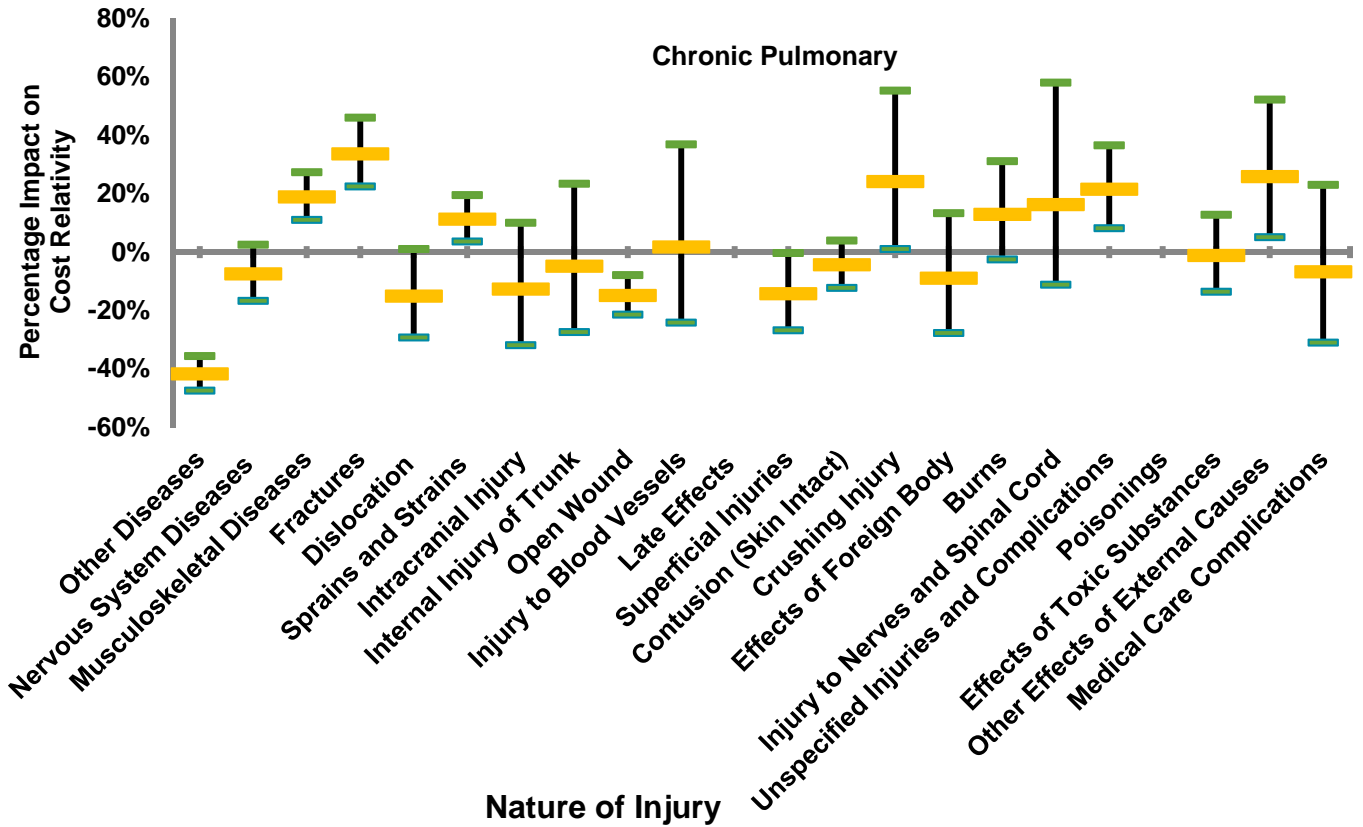
There were no observations for Poisonings

Analysis based on sample data provided by carriers for all US states and DC except CA, DE, MA, MN, ND, NJ, NY, OH, PA, WA, WV, and WY

**Exhibit 15**



## Nature of Injury Can Have a Significant Impact on the Cost Relativity

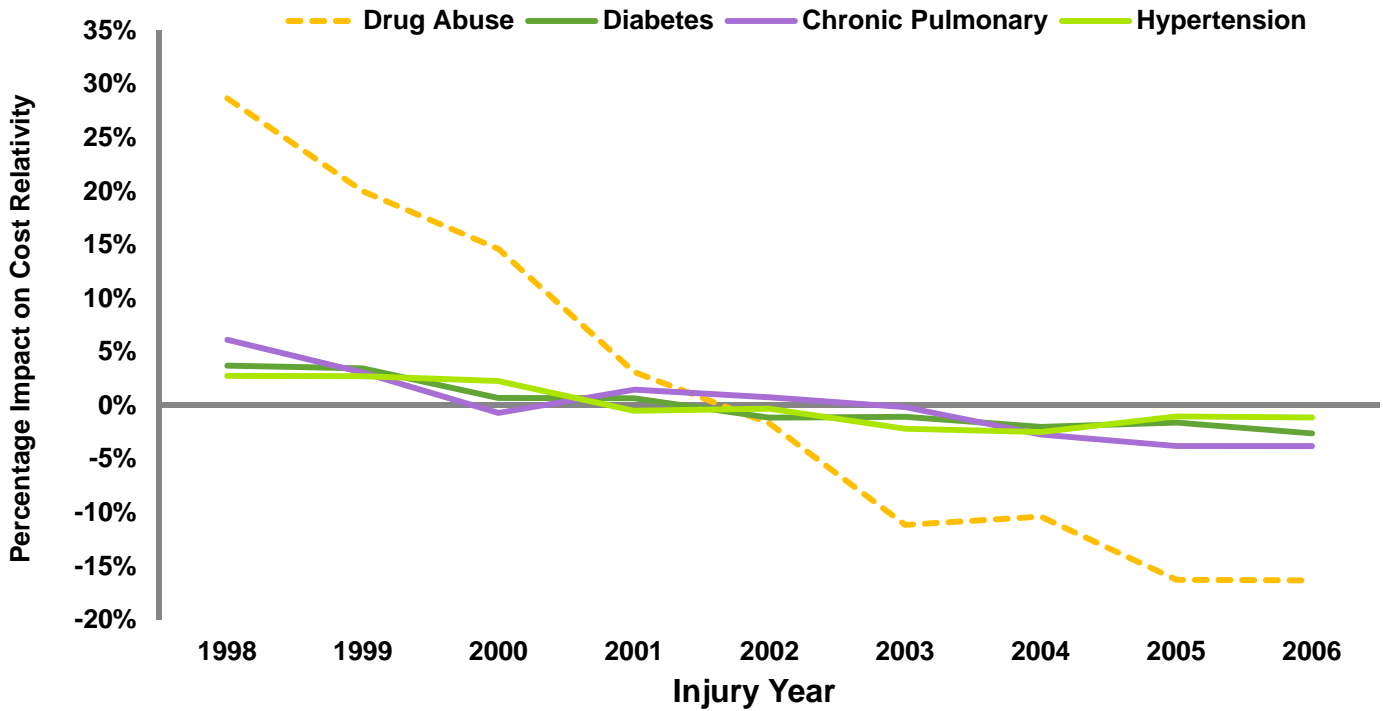


Injury Years 1998 through 2006 at the 36-month evaluation  
 Results are estimated from a Bayesian multilevel model; the bands represent 80% credible intervals  
 There were no observations for Poisonings of Late Effects  
 Analysis based on sample data provided by carriers for all US states and DC except CA, DE, MA, MN, ND, NJ, NY, OH, PA, WA, WV, and WY

Exhibit 16

Exhibit 17 shows the relationship between Injury Year and the cost relativity between claims with comorbidity diagnoses and their matches. For most comorbidities, there is very little change in the relation of the cost relativity from year to year, with Drug Abuse being the notable exception. For this comorbidity, the cost relativity for claimants injured in 2006 is 35% lower than for those injured in 1998.

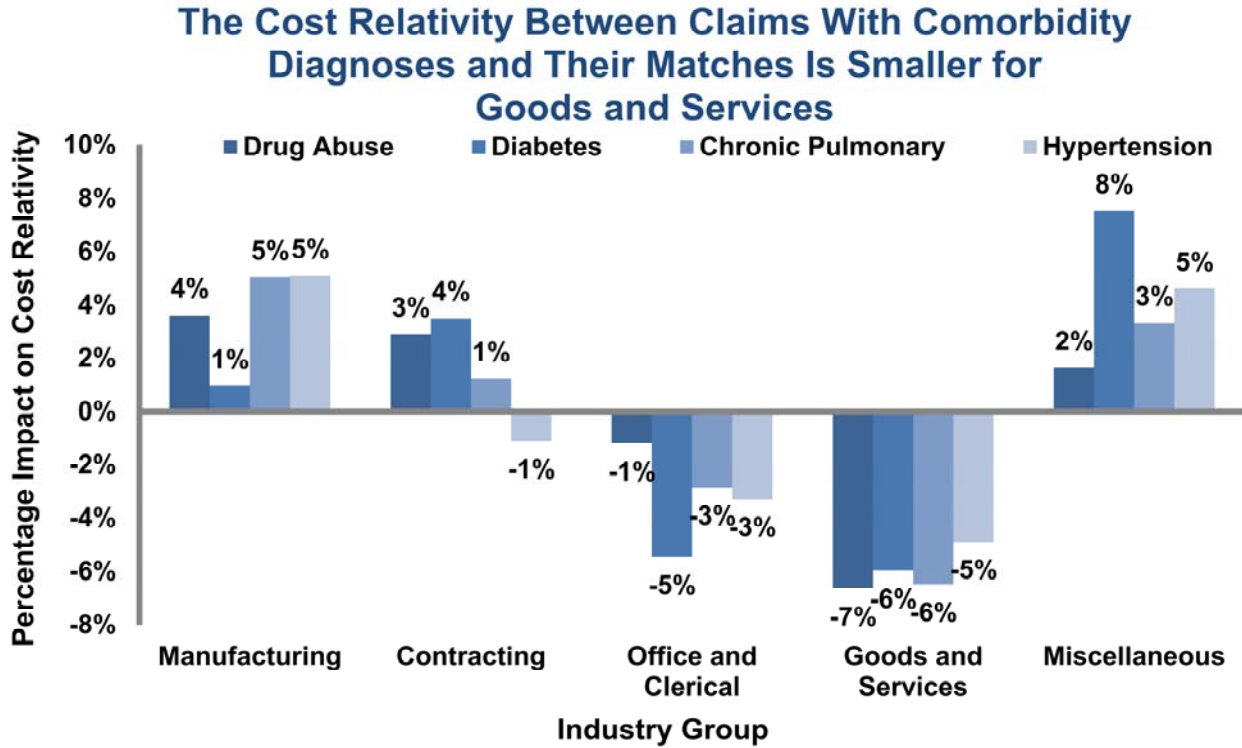
### The Cost Relativity Between Claims With Comorbidity Diagnoses and Their Matches Is Generally on the Decline



Results shown are for the 36-month evaluation  
 Results are estimated from a Bayesian multilevel model  
 Analysis based on sample data provided by carriers for all US states and DC except CA, DE, MA, MN, ND, NJ, NY, OH, PA, WA, WV, and WY

Exhibit 17

The industry from which a claim originates can be significantly related to its indemnity benefit duration. A construction worker sustaining a broken leg may be out of work for months. Conversely, if the claimant were an office worker, the claimant might return after only a few days. Analogously, one might expect to find a relation between Industry Group<sup>5</sup> and the cost relativity between claims with comorbidity diagnoses to their matches. Exhibit 18 shows that claims originating from the Goods and Services industry generally have a smaller cost relativity between matched claim-pairs than those originating in the Manufacturing industry.

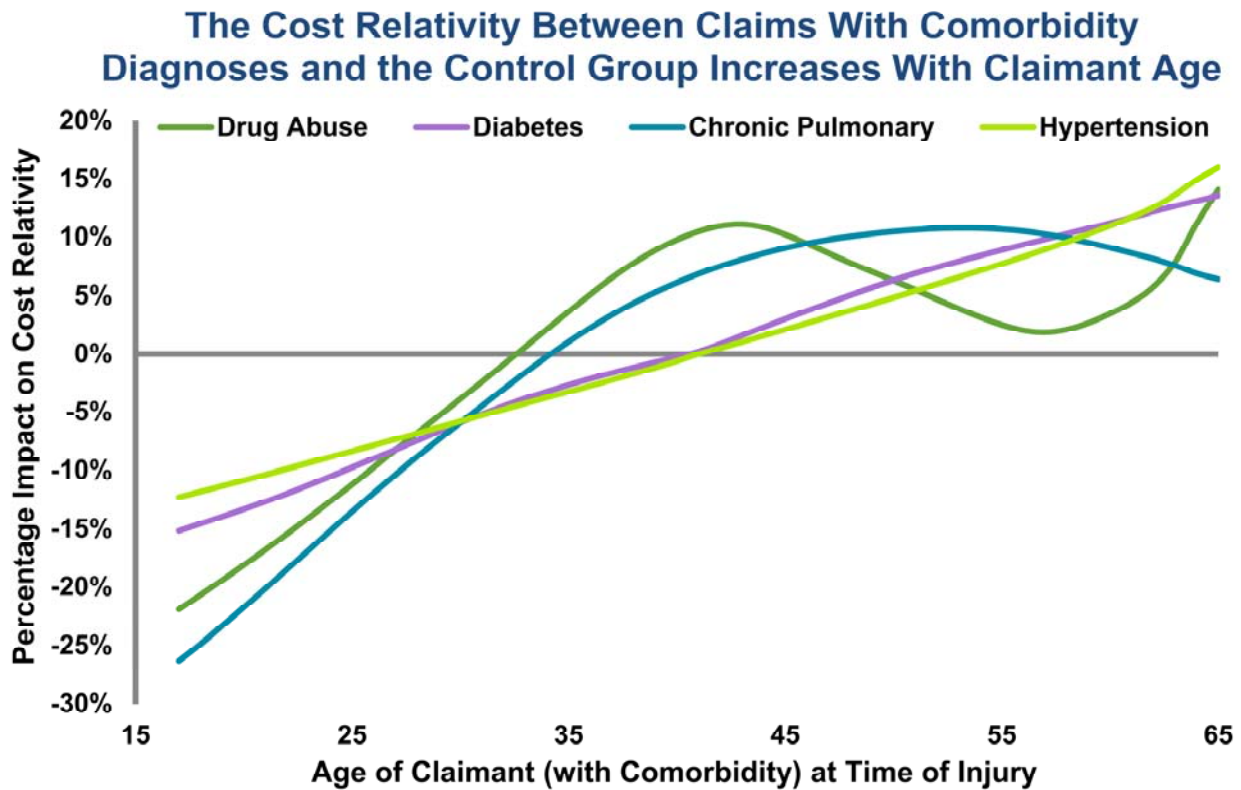


Results shown are for the 36-month evaluation  
 Results are estimated from a Bayesian multilevel model  
 Analysis based on sample data provided by carriers for all US states and DC except CA, DE, MA, MN, ND, NJ, NY, OH, PA, WA, WV, and WY

**Exhibit 18**

<sup>5</sup> NCCI groups class codes into *Industry Groups*.

Time to heal (as measured by either days away from work or average medical severity) generally increases with claimant age at time of injury [10]. Exhibit 19 shows that the cost relativity between claims with comorbidity diagnoses and their matches also increases with age. This is of particular interest because the presence of a recorded comorbidity diagnosis and claimant age at time of injury are positively correlated (Exhibit 4). Thus, the effect of age and the presence of a recorded comorbidity diagnosis likely impact claim costs simultaneously. Older claimants tend to have (1) higher medical costs and (2) higher cost relativities between claims with comorbidity diagnoses and otherwise comparable claims than do younger claimants. Alternatively, since older claimants are more likely to receive a comorbidity diagnosis (Exhibit 4), the increase of claim costs with age could be attributed to the change in mix of claims with and those without a comorbidity diagnosis. Since age is not matched exactly, some of the effect shown in this exhibit might be due to inexact matching. See Appendix 4 and 5 for details.



Results shown are for the 36-month evaluation

The impact of age is assumed to follow a linear spline which is estimated using reversible-jump Markov chain Monte Carlo

Results are estimated from a Bayesian multilevel model

Analysis based on sample data provided by carriers for all US states and DC except CA, DE, MA, MN, ND, NJ, NY, OH, PA, WA, WV, and WY

**Exhibit 19**

## CLOSING REMARKS

The share of claims with a comorbidity diagnosis has been rising over the past several years, and the cost of claims with a comorbidity diagnosis is about twice the costs of comparable claims without such comorbidity diagnoses.

Future research may address questions such as:

- To what degree does legislation impact state differences?
- Does the recording of comorbidity diagnoses continue throughout the life of a claim?
- What types of treatments are associated with recorded comorbidity diagnoses?
- How prevalent are tobacco and alcohol abuse in the Drug Abuse category?

NCCI will continue to monitor and report on these and other important issues that affect the workers compensation industry.

## CREDITS

Barry Lipton, John Robertson, and Chun Shyong of Actuarial and Economic Services contributed to this study.

## APPENDICES

## Appendix 1—Mappings Between Comorbidities and ICD9 Codes

| Comorbidity                  | ICD9 Codes                 |
|------------------------------|----------------------------|
| Cancer*                      | 140–200, 203–208           |
| Cerebrovascular Disease*     | 430–433, 435               |
| Chronic Pulmonary*           | 491–493                    |
| Dementia*                    | 290, 291, 294              |
| Diabetes*                    | 250                        |
| Drug Abuse*                  | 304, 305                   |
| HIV                          | 042                        |
| Heart Disease*               | 398, 402, 410, 411, 428    |
| Hemiplegia*                  | 342, 434, 436, 437         |
| Hypertension                 | 401                        |
| Liver Disease*               | 070, 570–573               |
| Renal Disease*               | 403, 404, 580–586          |
| Obesity                      | 278                        |
| Peripheral Vascular Disease* | 440–447                    |
| Pregnancy                    | 630–679, 760–779, V22, V23 |
| Ulcer Disease*               | 531–534                    |

\* Categories originate from [2]

## Appendix 2—CDC Estimates

“The Behavioral Risk Factor Surveillance System (BRFSS) is the world’s largest, on-going telephone health survey system, tracking health conditions and risk behaviors in the United States yearly since 1984. Currently, data are collected monthly in all 50 states, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, and Guam.”

Source: [cdc.gov/brfss/index.htm](http://cdc.gov/brfss/index.htm).

Survey questions can change slightly from year to year.

### Hypertension

Hypertension estimates come from the BRFSS and cover various states, DC, and territories. The number of states (and territories) varies from 53 to 54 over the time period displayed. Numbers shown indicate the percentage of adults who have been told they have high blood pressure.

### Obesity

Obesity estimates come from the BRFSS and cover various states, DC, and territories. The number of states (and territories) varies from 52 to 54 over the time period displayed. Numbers shown represent the share of respondents with a BMI between 30.0 and 99.8. Each respondent’s BMI was calculated from his or her disclosed height and weight.

### Diabetes

Numbers represent estimates of the “percent of the U.S. population with diagnosed diabetes by using data from the National Health Interview Survey (NHIS) of the National Center for Health Statistics (NCHS), Centers for Disease Control and Prevention (CDC). Conducted continuously since 1957, the NHIS is a health survey of the civilian, noninstitutionalized, household population of the United States. The survey provides information on the health of the United States population, including information on the prevalence and incidence of disease, the extent of disability, and the use of health care services.”

“... all sampled adults are asked whether a health professional had ever told them they had diabetes. To exclude gestational diabetes, women were asked whether they had been told they had diabetes other than during pregnancy. Also, parents of sampled children were asked whether their child had diabetes. Three-year averages were used to improve the precision of the annual estimates.”

Source: [cdc.gov/diabetes/statistics/prev/national/figage.htm](http://cdc.gov/diabetes/statistics/prev/national/figage.htm).

### Appendix 3—Nature of Injury

A nature of injury is assigned to each claimant based on the claimant’s primary ICD9 code according to the following table. The ICD9 to nature of injury mapping is identical to the one used in “Reserving in the Age of Obesity” [1]. ICD9 codes not covered in the table are conditions that are typically not related to workplace injuries and illnesses.

The logic for deriving a claimant’s primary ICD9 is described in Appendix 5.

| Category                               | ICD9 Codes              | Description  |
|--|-------------------------|--|
| Other Diseases                         | 001-289.9 and 390-629.9 | Diseases other than diseases of the musculoskeletal system and connective tissue and diseases of the nervous system and sense organs |
| Nervous System Diseases                | 320-389.9               | Diseases of the nervous system and sense organs  |
| Musculoskeletal Diseases               | 710-739.9               | Diseases of the musculoskeletal system and connective tissue   |
| Fractures                              | 800-829.1               | Fractures  |
| Dislocation                            | 830-839.9               | Dislocation  |
| Sprains and Strains                    | 840-848.9               | Sprains and strains of joints and adjacent muscles   |
| Intracranial Injury                    | 850-854.1               | Intracranial injury, excluding those with skull fracture   |
| Internal Injury of Trunk               | 860-869.1               | Internal injury of thorax, abdomen, and pelvis   |
| Open Wound                             | 870-897.7               | Open wound   |
| Injury to Blood Vessels                | 900-904.9               | Injury to blood vessels  |
| Late Effects                           | 905-909.9               | Late effects of injuries, poisonings, toxic effects, and other external causes   |
| Superficial Injuries                   | 910-919.9               | Superficial injury   |
| Contusion, Skin Intact                 | 920-924.9               | Contusion with intact skin surface   |
| Crushing Injury                        | 925-929.9               | Crushing injury  |
| Foreign Body Entering Orifice          | 930-939.9               | Effects of foreign body entering through orifice   |
| Burns                                  | 940-949.5               | Burns  |
| Injury to Nerves and Spinal Cord       | 950-957.9               | Injury to nerves and spinal cord   |
| Unspecified Injuries and Complications | 958-959.9               | Certain traumatic complications and unspecified injuries   |
| Poisonings                             | 960-979.9               | Poisoning by drugs, medicinal and biological substances  |
| Effects of Toxic Substances            | 980-989.9               | Toxic effects of substances chiefly nonmedicinal as to source  |
| Other Effects of External Causes       | 990-995.94              | Other and unspecified effects of external causes   |
| Medical Care Complications             | 996-999.9               | Complications of surgical and medical care, not elsewhere classified   |



## Appendix 4—Multilevel Model

The same multilevel model is estimated for each comorbidity. Each comorbidity is analyzed separately without regard to interaction among multiple comorbidities. The model used is identical to the one used in Laws and Schmid [1], who provide a more in-depth discussion.

The dependent variable is the natural logarithm of the ratio of paid medical costs for the claim with a comorbidity diagnosis to its match.

The model is semi-parametric. A linear spline measures the impact of age; the number of knots and their locations are both estimated endogenously.

All other independent variables—Gender, State, NCCI Industry Group, Injury Group, and Year—are discrete.

## Appendix 5—Matching Algorithm Details

### Implications of Matching by Industry Group

Because of the need to match by Industry Group, the matched-pairs analysis is restricted to the 39 jurisdictions for which we had industry group mappings (and sufficient data history) at the time of the study. The jurisdictions used are AK, AL, AR, AZ, CO, CT, DC, FL, GA, HI, IA, ID, IL, IN, KS, KY, LA, MD, ME, MI, MO, MS, MT, NC, NE, NH, NM, NV, OK, OR, RI, SC, SD, TN, TX, UT, VA, VT, and WI.

### Primary ICD9 Code

The logic for the derivation of a claimant's primary ICD9 code was developed by Schmid, Laws, and Montero in [9] and is outlined below.

The primary ICD9 code of a given claim is the first ICD9 code associated with reported medical transactions (with a valid date of service) based on the following order of priority:

- (1) Paid amount must be greater than zero
- (2) Provider Group must be one of the following four:
  - 01 (Physician), 04 (Hospital, Ambulatory Surgical Center, X-Ray, Lab), 05 (Clinic), 07 (Non-Medical)
  - When no such transaction exists, transactions from all other providers are considered:
  - 02 (Chiropractor), 03 (Therapist), 06 (Pharmacies and Durable Medical Equipment Center), 08 (Other)
- (3) Transactions are selected from the first service date, subject to data cleansing considerations
- (4) From the ICD9 codes resulting from steps 1 through 3, the ICD9 codes associated with the highest paid amount over the (heretofore recorded) life of the claim are selected
 

The paid amount of a transaction is assigned in full to any ICD9 code associated with the transaction
- (5) If there are ties after applying the mentioned criteria, an ICD9 code is randomly selected from the set of tied codes

**Immortal Time Bias**

The presence of the immortal time bias in studies such as this is discussed in Schmid, Laws, and Montero [9].

Suppose there are two types of claims, simple and complex, and that preexisting conditions, such as comorbidities, do not impact the likelihood that a claim will be simple or complex. Thus, the distribution of preexisting conditions is the same between the two types.

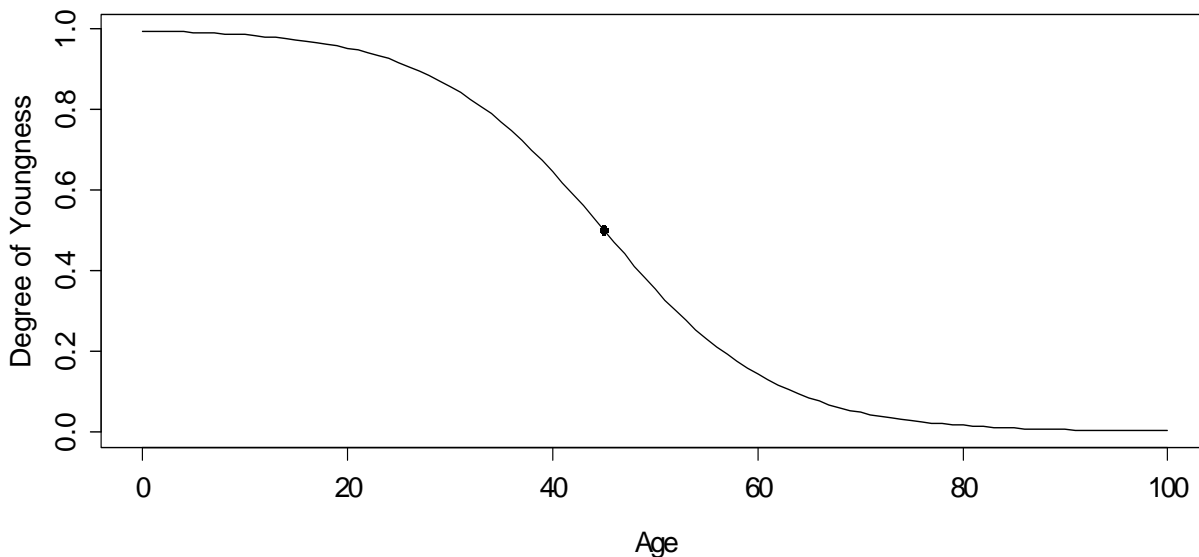
Suppose, as the name implies, complex claims have many more transactions than simple claims. This study is only able to identify claimants with comorbidities if they generate a transaction through the workers compensation system with an associated ICD9 code. If a claimant receives more treatments, there is a higher chance that the presence of any preexisting conditions will complicate at least one of the treatments and be indicated on the corresponding transaction. Thus, more claimants involved in complex claims are identified as having a comorbidity even though the presence or absence of the comorbidity does not impact the likelihood that the claim will be a complex claim. Such a selection process detracts from the relevance of any findings related to cost impact.

The approach used to mitigating the impact of the immortal time bias as well as an analysis of its performance is also outlined in Schmid, Laws, and Montero [9]. In order for a claimant without a comorbidity diagnosis to be an eligible match for a claimant with a comorbidity diagnosis, the claimant without a comorbidity diagnosis must have at least one medical transaction occurring after (measured relative to each claim’s respective injury date) the first comorbidity diagnosis on the other claim.

**Degree of Youngness**

First, the set of potential matches, all claimants sharing exactly the same State of Jurisdiction, Injury Year, Gender, NCCI Industry Group, and first three digits of each claim’s primary ICD9 code, is identified. From this set, the claim with the closest degree of youngness (as shown in Exhibit 20) is chosen as the match.

**Degree of Youngness Curve**



**Exhibit 20**

Multiple claims from the set of potential matches with the same age sometimes exist. To address this, the model is estimated 10 times on 10 different data sets. In each data set, the final match is chosen randomly. Results shown are a summary of the different estimates.

See Laws and Schmid [1] or Schmid, Laws, and Montero [9] for a more detailed discussion.

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