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# Indemnity Benefit Duration and Obesity

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# Overview

- Objective
- Previous Research
- The Data
- Non-Parametric and Semi-Parametric Models
- Conclusion
- Appendix

# Objective

- Measure the effect of obesity on indemnity benefit duration
- Approach
  - Use a matched-pairs methodology that compares “obese” claims to “non-obese” claims
    - Use a Kaplan-Meier estimator to discern the impact of obesity (non-parametric approach)
    - Estimate a Bayesian semi-parametric Weibull proportional hazard model

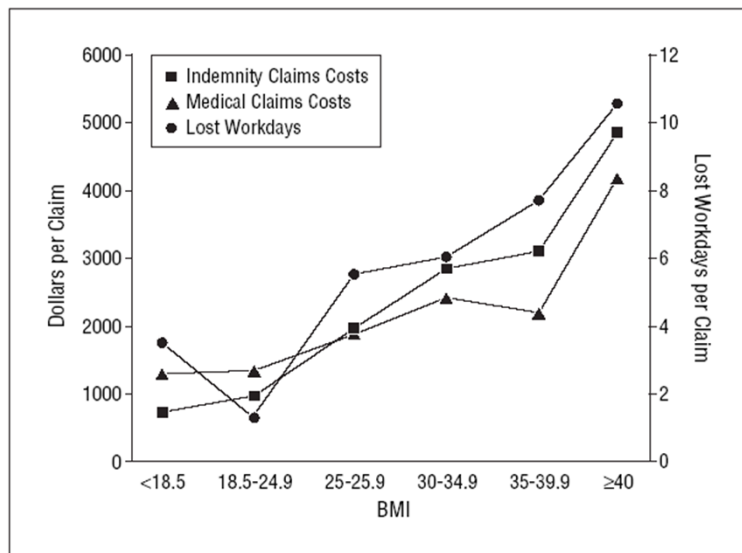
# Previous Research

- Studies by Duke University (2007), Johns Hopkins University (2007/2008), and NCCI (2010) show that obesity contributes to the cost of workers compensation
- On the other hand, a recent study by the Liberty Mutual Research Institute for Safety (2012) finds no effect of obesity on recovery and return to work following onset of work-related low back pain (\*)

\* Shaw, William S., Torill H. Tveito, Mary Jane Woiszwilllo, and Glenn Pransky, "The Effect of Body Mass Index on Recovery and Return to Work Following Onset of Work-Related Low Back Pain," *Journal of Occupational and Environmental Medicine*, 2012, forthcoming

# Previous Research

## Duke University



**Figure 1.** Mean indemnity claims costs, medical claims costs, and number of lost workdays per claim by body mass index (BMI) category. Body mass index is calculated as weight in kilograms divided by height in meters squared.

- Duke University studied a cohort of 11,728 own health care and university employees over the period 1/1/1997 through 12/31/2004
- Claimants in the highest obesity category (category III) lost 13 times more days from work injury or work-related illness as employees within the ideal body mass index (BMI 18.5-24.9); in part, this is due to the obese workers being twice as likely to sustain a workplace injury

Source: Østbye, Truls, John M. Dement, and Katrina M. Krause (2007) "Obesity and Workers' Compensation: Results from the Duke Health and Safety Surveillance System," *Archives of Internal Medicine* **167**, 766-773

# Previous Research

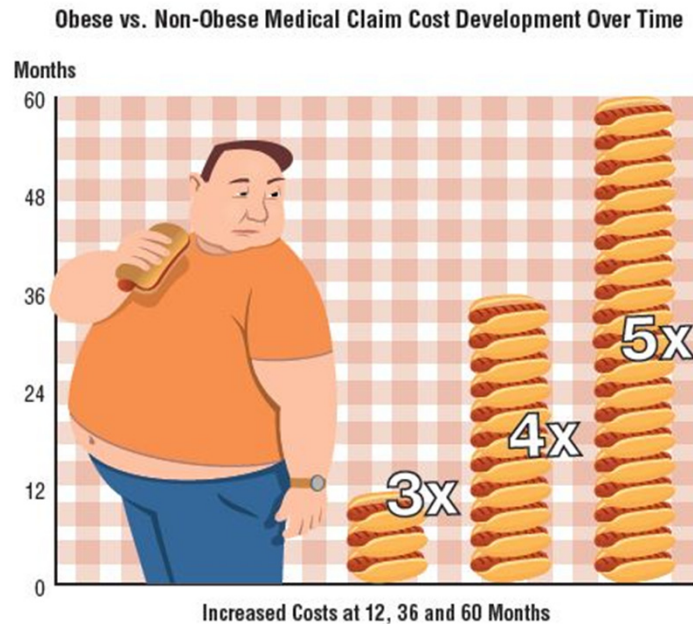
## Johns Hopkins University

- Johns Hopkins University studied a cohort of 7,690 hourly employees of a large, multi-site U.S. aluminum manufacturing company over the period 1/1/2002 through 12/31/2004—approximately 85 percent of injured workers were classified as overweight or obese
- The odds of injury in the highest obesity category (category III) as compared with the ideal BMI category (18.5-24.9) were 2.21:1 (after adjusting for confounders, such as sex, age, education, physical demands of the job, time since hire, time in the job, and so on)
- Injuries to the leg or knee were especially prevalent among members in obesity category III

Source: Pollack, Keshia M., Gary S. Sorock, Martin D. Slade, Linda Cantley, Kanta Sircar, Oyebode Taiwo, and Mark R. Cullen (2007/2008) "Association between Body Mass Index and Acute Traumatic Workplace Injury in Hourly Manufacturing Employees" (with discussion), *American Journal of Epidemiology* **166**, 204-211 & **167**, 123-124

# Previous Research

## NCCI



NCCI research shows that cumulative medical payments for obese claims continued to grow at a faster pace than non-obese claims, with significantly increased costs at 12, 36, and 60 months

- NCCI studied medical claims provided by carriers over injury years 1997 through 2006 in 36 states
- Matching obese to non-obese claims with maturities of 12, 36, and 60 months
- The study shows that, in the aggregate, obese claims are 2.8 times more expensive than non-obese claims at the 12-month maturity; this cost difference climbs to a factor of 4.5 at the three-year maturity and to 5.3 at the five-year maturity, possibly due to differences in duration between obese and non-obese claims

Source: <http://www.ncci.com/documents/research-age-of-obesity.pdf>



# The Data

- We use a claims data set provided by insurance carriers
  - The data set covers injury years 1998-2008
  - Transaction dates are through 12/31/2009
    - The data is evaluated as of 6/30/2010, thus allowing for a reporting lag of six months
  - The data set comprises 40 U.S. states
    - 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, WI, WV
  - Claimants that are 15 years of age or younger are excluded

# Obese Flag

- A claim is categorized as “obese” if (and only if) for any diagnostic field (other than the primary one) on any medical transaction that occurs within 12 months after injury, the first three digits of the ICD9 code equal 278
  - ICD9 278: Overweight, obesity, and other hyperalimentation

# Indemnity Benefit Duration

- We calculate indemnity benefit duration (duration, for short) based on recorded indemnity transactions
  - For the purpose of this study, we count the waiting period toward the indemnity benefit duration even where the retroactive period has not been reached
- The transactions cover payment categories Temporary Total and Permanent Total
  - Any claims with transactions in the Fatal category are excluded
  - In a sensitivity analysis, we count transactions in the Permanent Partial category toward duration
- If the claim has no indemnity transaction data, it is assumed that this claim has not breached the waiting period

# Indemnity Benefit Duration

- The duration of indemnity benefits may be censored
- Censoring occurs when the duration is only partially known
  - Interval-Censored
    - The duration falls into a given interval, as is the case with a claim that does not breach the waiting period
  - Right-Censored
    - The duration is only known to be greater than a certain value

# Indemnity Benefit Duration

- Duration is implemented as a calendar-time concept
- Duration Concept I
  - Aggregation of compensated time intervals
    - If more than 20 percent of the transactions associated with a given claim miss the “from-date” and “through-date” information, then the claim is categorized as right-censored at the waiting period
- Duration Concept II
  - Time interval between injury date and most recent “through-date”
    - Transaction dates substitute for missing “through-dates”
- Duration Concept II is our preferred approach

# Indemnity Benefit Duration

- For claims with indemnity transactions, benefit duration is established by means of the concept of dormancy
  - Only transactions prior to the date of dormancy are considered
- The date of dormancy is the first (\*) transaction date that is not followed by another transaction within 180 days
  - The latest date for which such a transaction-free time interval can be established is 180 days prior to 12/31/2009 (which is the latest transaction date considered in this study)
    - Claims for which no 180-day transaction-free interval can be established are categorized as right-censored

\* No re-opening is considered

# Indemnity Benefit Duration

- For claims without indemnity transactions, it is assumed that the claim did not breach the waiting period
- Such claims are treated as interval-censored on the waiting period

# Matched Pairs

- We form matched pairs
  - An “obese” claim is paired up with a “non-obese” claim, using the claim characteristics itemized below
    - Injury year
    - State
    - Gender
    - NCCI industry group (\*)
    - Primary ICD9 code (at the three-digit level)

\* NCCI industry groups consist of Manufacturing, Contracting, Office and Clerical, Goods and Services, and Miscellaneous

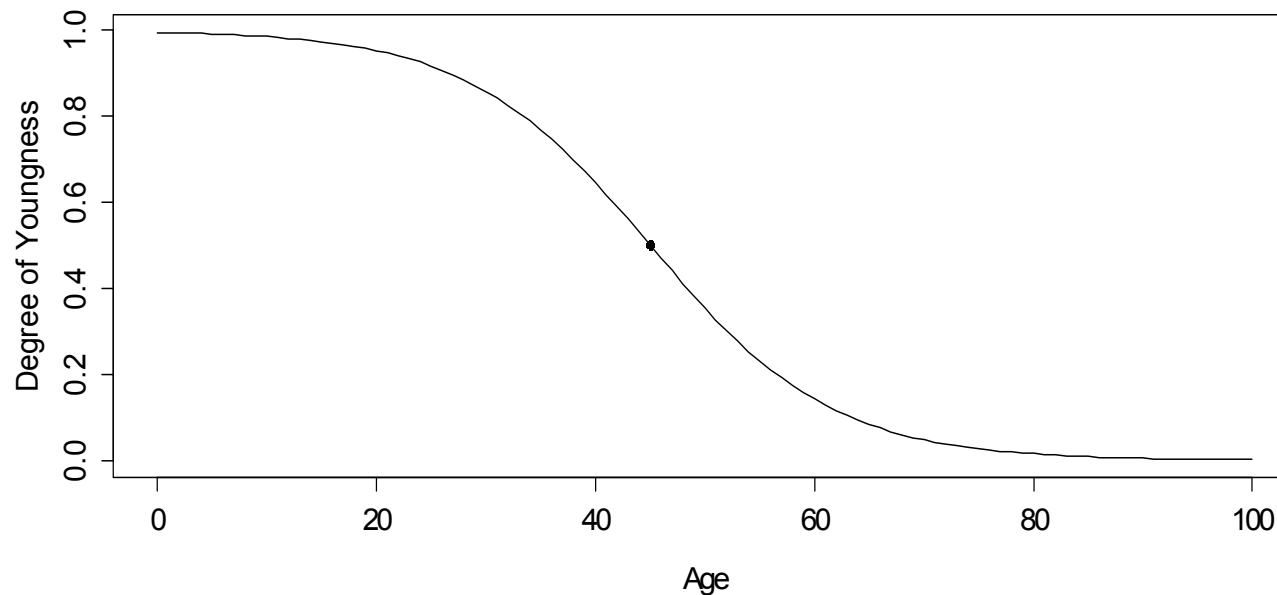


# Immortal Time Bias

- As mentioned, a claim is categorized as “obese” if this claim acquires the ICD9 code 278 within the first 12 months of inception
  - Allowing for a 12-month time period for acquiring the obesity flag favors long-duration claims for inclusion in the obese category, thus introducing a survivor selection bias that is known as immortal time bias
- In order to correct for the immortal time bias, it is stipulated that a non-obese claim be a potential match for a given obese claim only if this non-obese claim had at least one medical transaction past the time span it took the obese claim to acquire the ICD9 code 278
  - See the appendix for a simulation of the immortal time bias correction

# Proximity Matching for Age

- Claims are proximity-matched by degree of youngness



The inflection point of the displayed sigmoid function is at age 45

# Matching-Toward-the-Center Problem

- On the age time line, younger claimants have more neighbors to the right than to the left, and older claimants have more neighbors to the left than to the right
  - Hence, a young obese claimant is more likely to be paired with a non-obese claimant that is older
  - Conversely, an old obese claimant is more likely to be paired with a non-obese claimant that is younger
- As a result, if duration increases with age and the effect of age is not controlled for, then the effect of obesity may be overstated for old claimants and understated for young claimants

# Matching-Toward-the-Center Problem

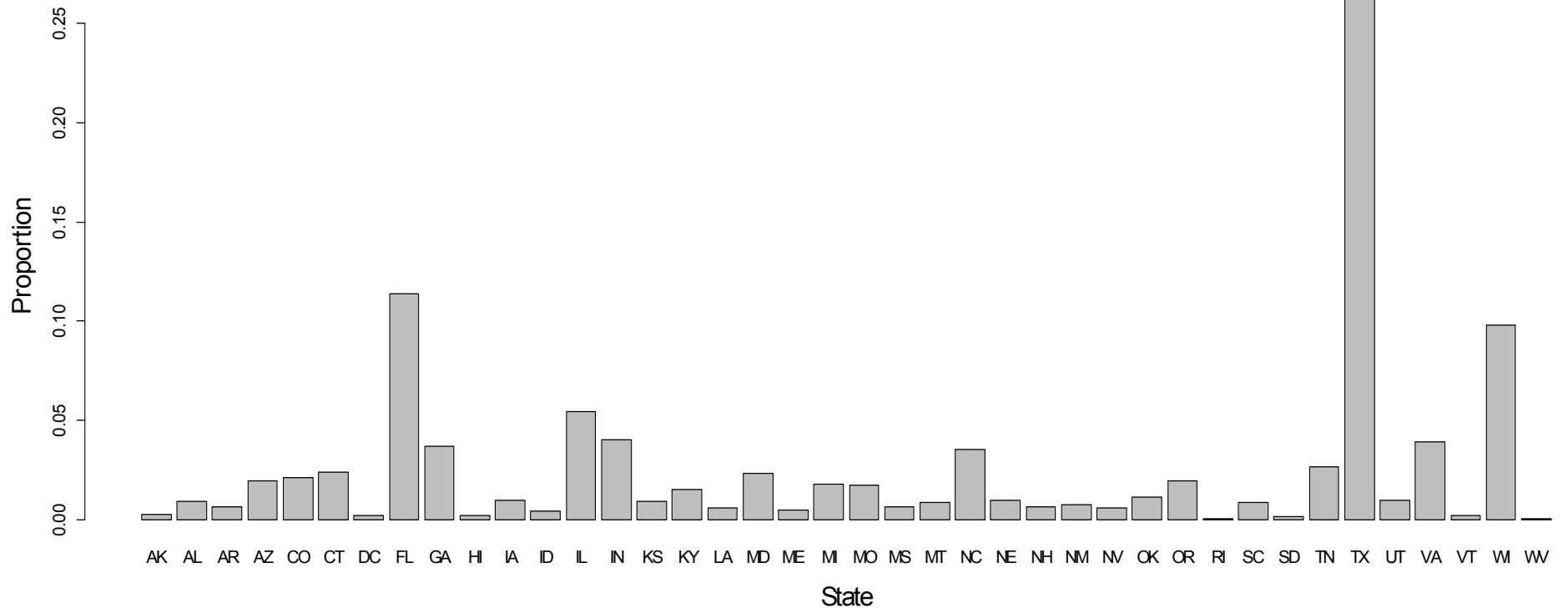
- In the Kaplan-Meier approach, we do not control for age
  - Thus, the measured effect of obesity on duration may be compromised by the matching-toward-the-center effect
- The proportional hazard model controls for age and, thus, there is no matching-toward-the-center effect embedded in the measured impact of obesity
  - In a semi-parametric approach, a linear spline (with knots at ages 25, 35, ..., 65) controls for the effect of age on indemnity duration

# Multiple Matches

- There may be more than one non-obese claim that matches a given obese claim
  - This set of matching claims may differ by indemnity duration and by the type of censoring (interval-censored, non-censored, and right-censored)
  - Within the set of matching claims, the median indemnity duration is chosen
    - See the appendix for details on the algorithm for determining the median duration while accounting for the type of censoring

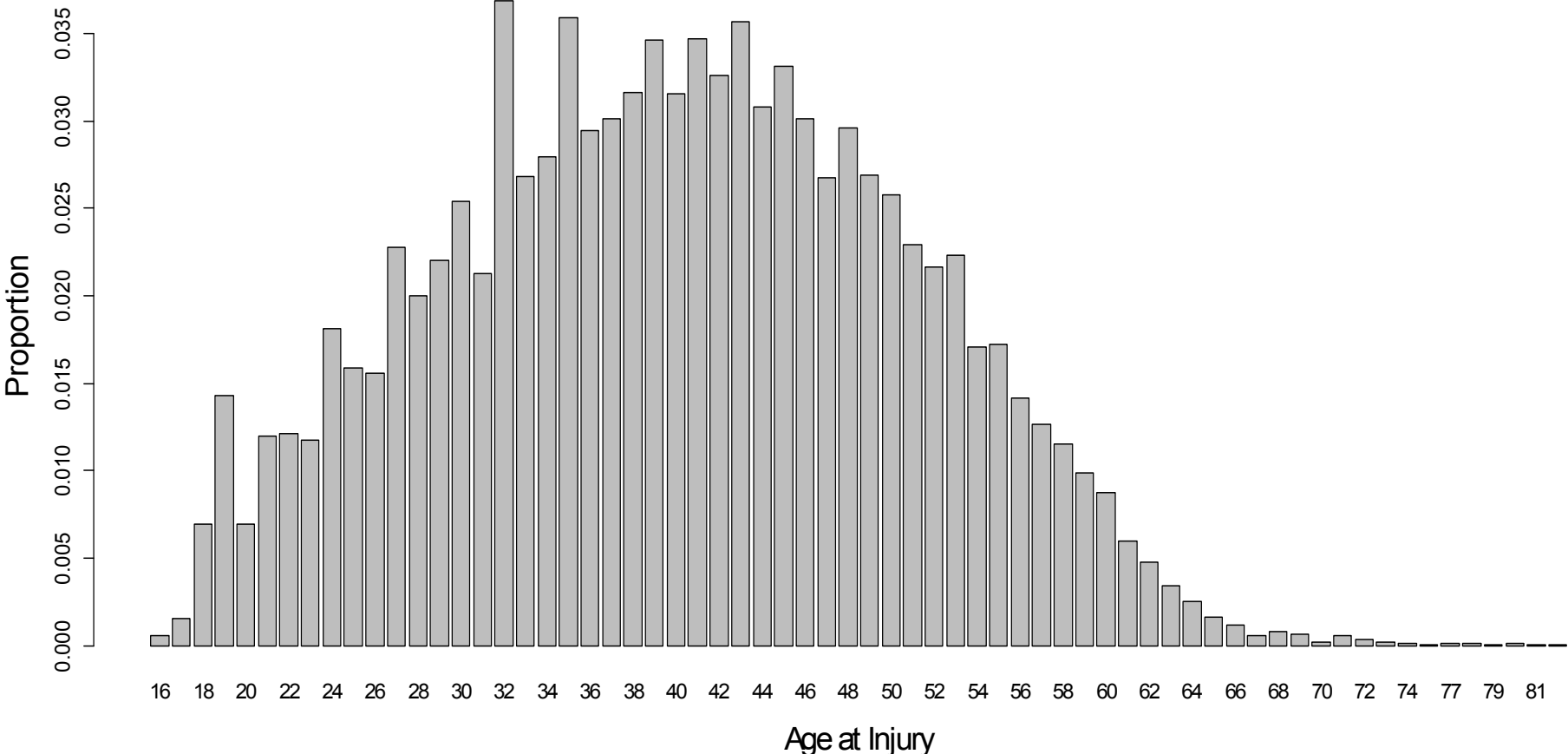
# Descriptive Statistics

## Matched Pairs



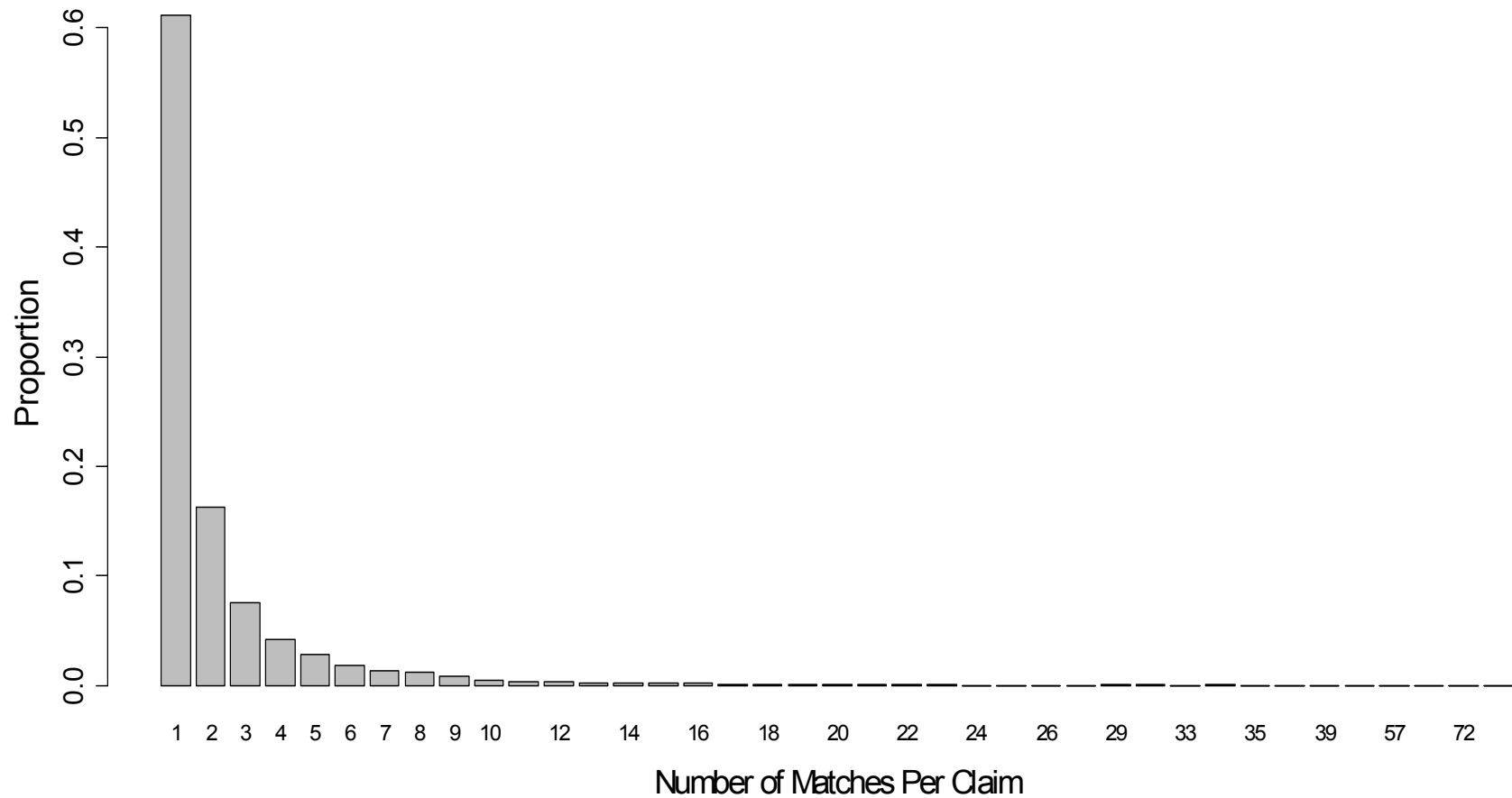
# Descriptive Statistics

## Claims Included in Matched Pairs



# Descriptive Statistics

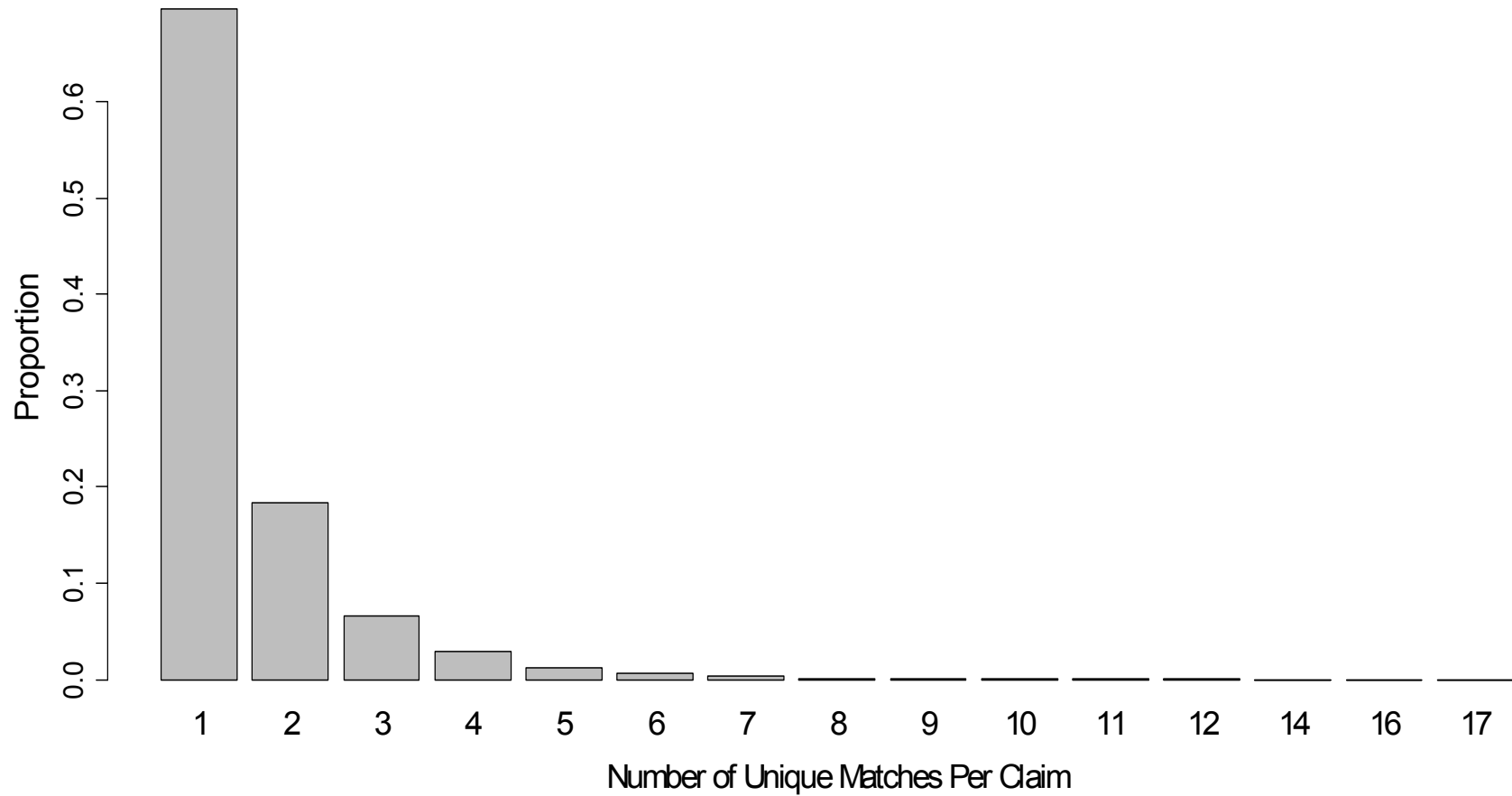
## Multiple Matches





# Descriptive Statistics

## Unique Durations in Multiple Matches

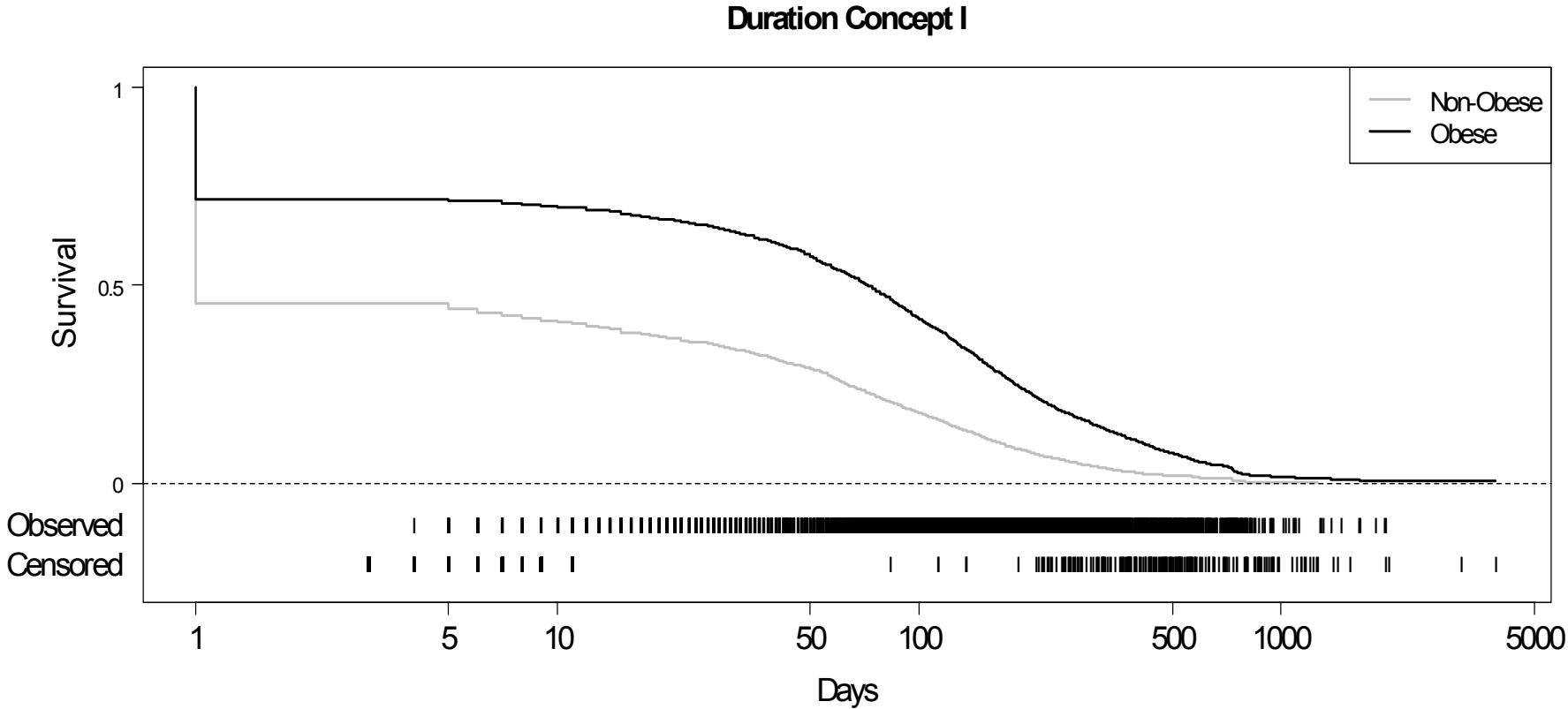


# Kaplan-Meier Estimator

- A survival curve is a graph that depicts the survival experience of individuals
- The Kaplan-Meier estimator is a simple way of computing such a survival curve
  - The percentage of individuals surviving is displayed on the time line (calendar time since injury)
  - The Kaplan-Meier estimator, as implemented, handles interval-censored and right-censored data

# Kaplan-Meier Estimator

## Duration Concept I

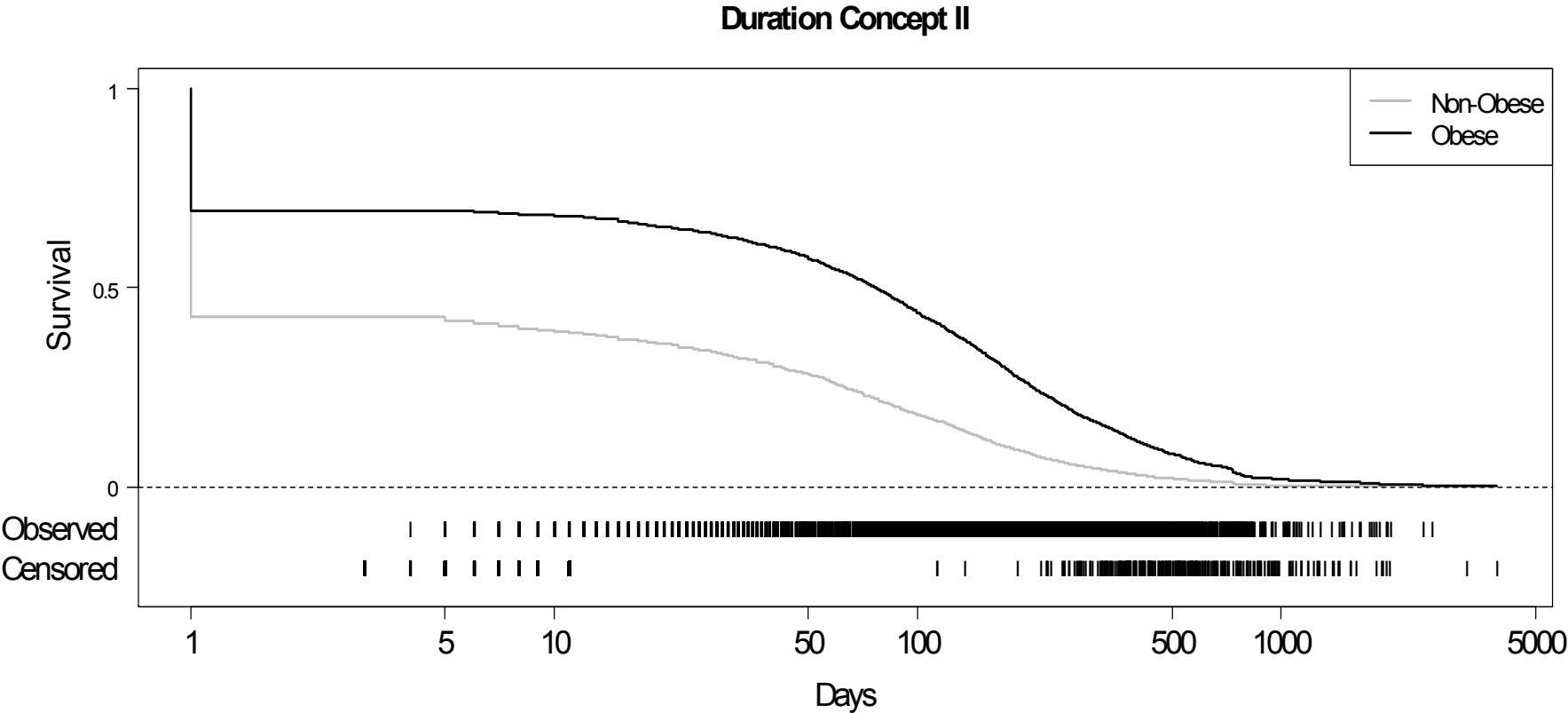


“Observed”: non-censored; “censored”: interval-censored (whisker at right bound) or right-censored



# Kaplan-Meier Estimator

## Duration Concept II



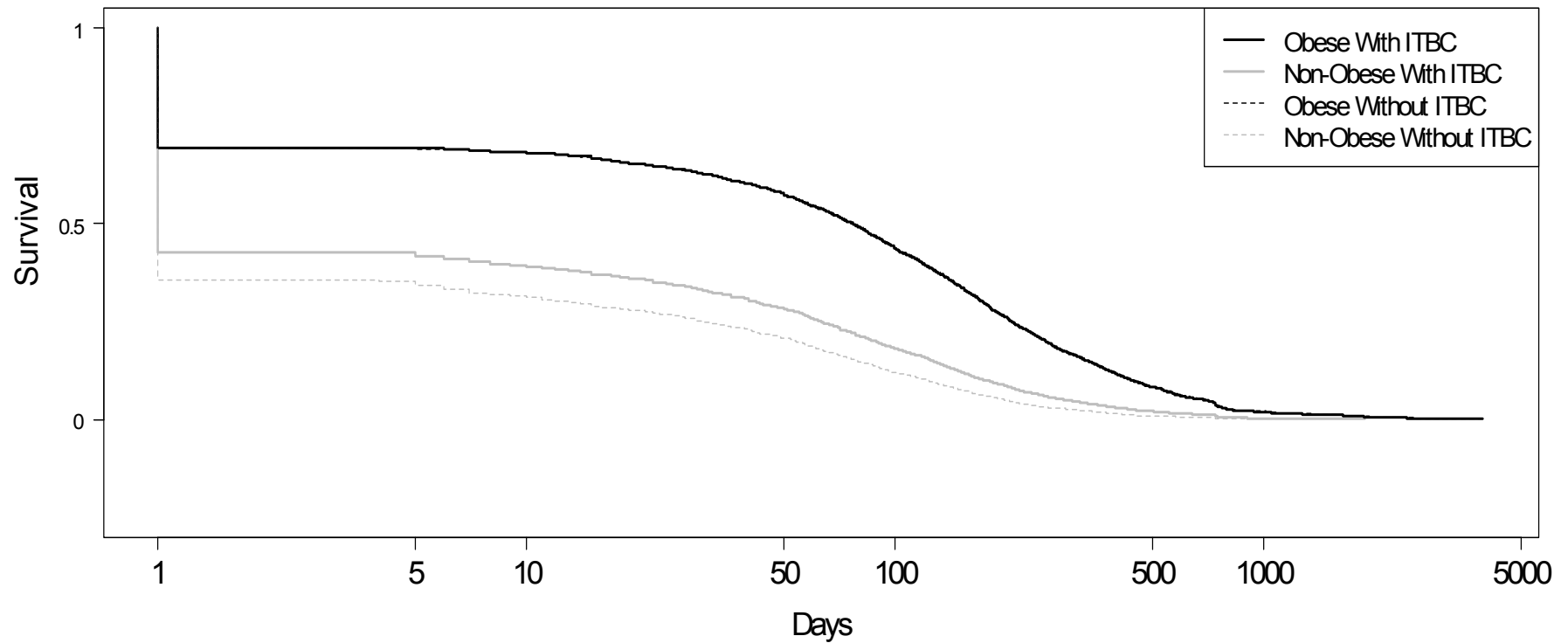
“Observed”: non-censored; “censored”: interval-censored (whisker at right bound) or right-censored



# Immortal Time Bias

## Duration Concept II

Duration Concept II



The displayed estimated survival curve for obese claims with immortal time bias correction (ITBC, for short) is indistinguishable from the one without this correction

# Weibull Proportional Hazard Model

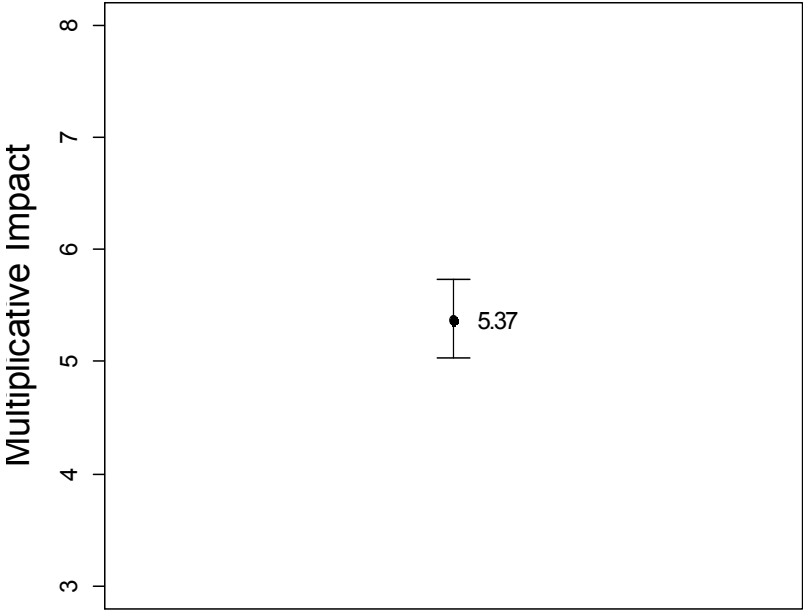
- The hazard manifests itself in the outcome “indemnity benefits ending”
  - A proportional hazard model implies that the hazard in one group (e.g., the obese) is, on the time line (calendar time since injury), a constant proportion of the hazard in the other group (e.g., the non-obese) (\*)
  - The baseline hazard as a function of time follows a Weibull distribution (\*\*)
  - As specified, the model accommodates interval-censoring and right-censoring
- The Weibull proportional hazard model is semi-parametric
  - Obesity is the only covariate in the parametric component
  - Age is the only covariate in the non-parametric component, and serves the purpose of controlling for the matching-toward-the-center effect

\* This proportion is known as the hazard ratio

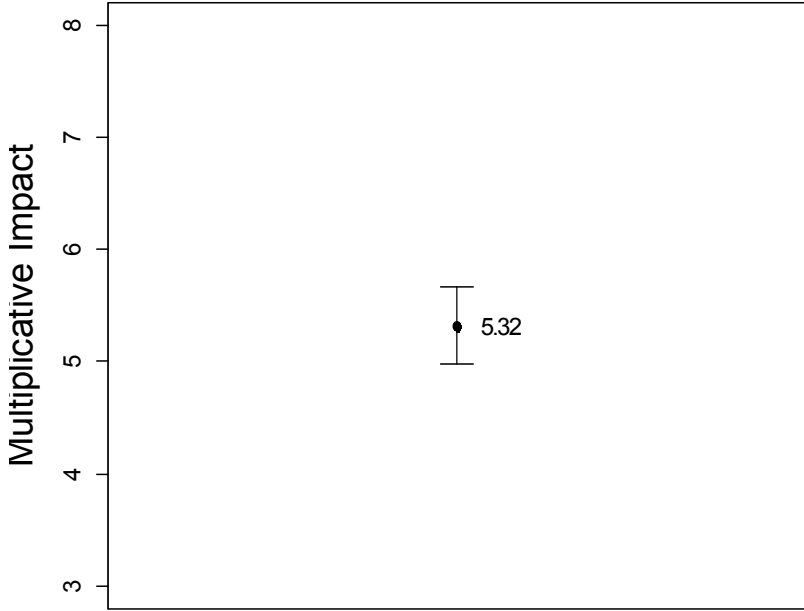
\*\* The Weibull distribution is the only distribution where the measured effect can be interpreted within a proportional hazard framework and, alternatively, within an accelerated failure time (AFT) framework

# Effect of Obesity on Mean Duration

Duration I



Duration II



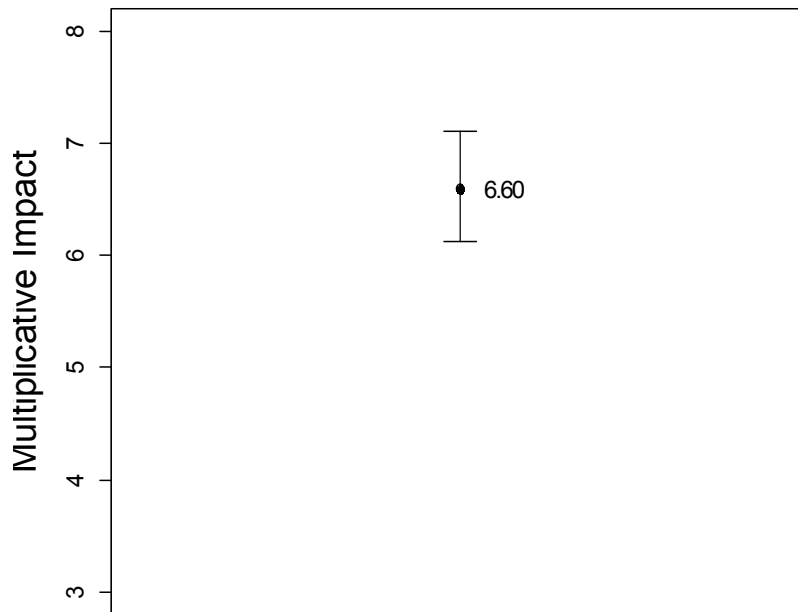
A multiplicative impact of  $x$  means that, for the obese, the mean claim duration is  $x$  times as long as it is for the non-obese  
The displayed credible interval comprises 90 percent of the posterior probability



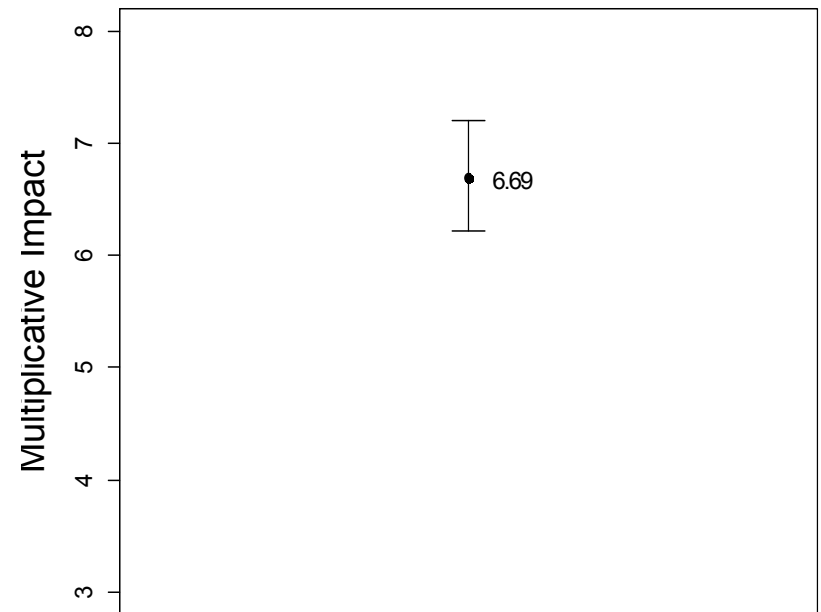
# Sensitivity Analysis

Transactions in the Permanent Partial Category are Counted Toward Duration

**Duration I**



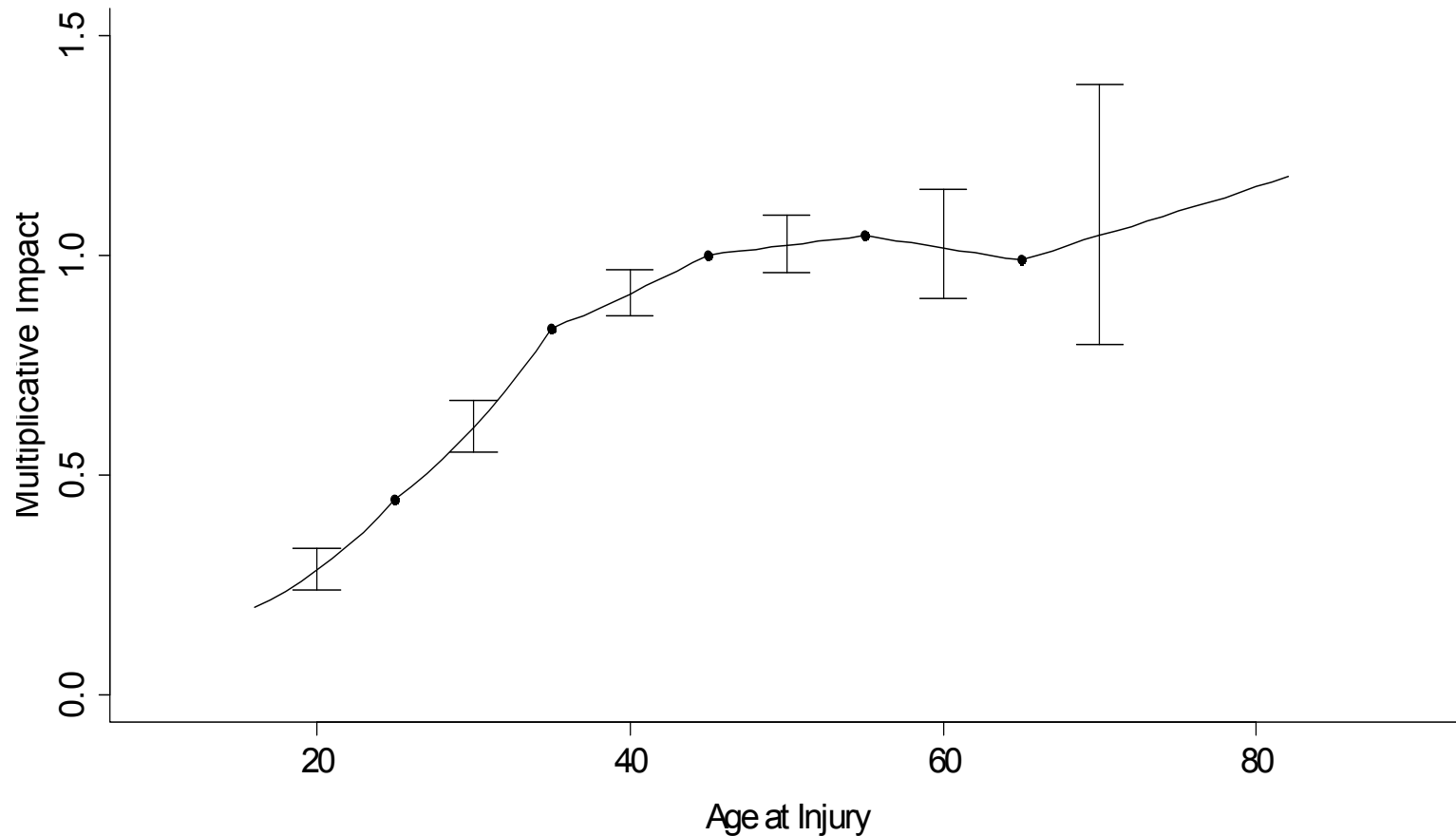
**Duration II**



A multiplicative impact of  $x$  means that, for the obese, the mean claim duration is  $x$  times as long as it is for the non-obese  
The displayed credible interval comprises 90 percent of the posterior probability



# Effect of Age on Mean Duration



A multiplicative impact of  $x$  means that for the displayed age, the mean claim duration is  $x$  times as long as it is for a 45-year old claimant  
The displayed credible interval comprises 90 percent of the posterior probability

# Conclusion

- Obesity contributes in important ways to indemnity benefit duration
  - The duration of an obese claimant is about six times as long as the duration of a non-obese claimant
  - The magnitude of the effect agrees with previous research at Duke University
- The estimated effect of obesity may reflect an upper bound
  - The proportion of obese claims in the data set is considerably smaller than in the U.S. population, thus suggesting that (1) many of the obese claimants are of the highest BMI category and (2) many of the non-obese claimants are in fact obese—whereas the former causes an overestimation of the effect of obesity, the latter causes an underestimation
  - For some claims, the arrival of medical complications may be causal to the claimant being coded as obese—such cases pose a problem of “self-selection”

# Appendix

## Primary ICD9 Code Logic

- The primary ICD9 code of a given claim is the first ICD9 code associated with reported medical transactions (using a valid service date) 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, ASC, 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 & DME), 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

# Appendix

## Determining the Median Duration

- Assume that an obese claim has multiple matching non-obese claims
- First, sort the matching claims by duration
- Assume that the number of matching claims is odd
  - Identify all claims that have the same duration as the central value
  - If more than one such claim exists, choose among these claims based on the following hierarchy, listed in descending order:  
right-censored, non-censored, interval-censored
- Assume that the number of matching claims is even
  - Identify the two central values
  - Identify all claims with a duration that equals the longest duration of these two values
  - If more than one such claim exists, choose among these claims based on the following hierarchy, listed in descending order:  
right-censored, non-censored, interval-censored

# Appendix

## Immortal Time Bias Correction

- A Monte-Carlo simulation was conducted to investigate the validity of the immortal time bias correction described earlier
- The simulation maintains the primary features of the underlying data generation process under the assumptions that
  1. The data generation process for benefit duration is the same for all claims
  2. The probability of acquiring a 278 ICD9 code is governed solely by the duration of a claim
- The simulation assumes that
  - Claims only generate ICD9 codes while they are open
  - Claims are only considered open over their indemnity benefit duration
  - There is a fixed probability,  $\pi$ , that on any day that a claim is open it will produce a 278 ICD9 code
  - The acquiring of a 278 ICD9 on day  $x$  is independent of the acquiring of a 278 on day  $y$ , provided  $x \neq y$
- In this simulation, the parameters were calibrated to reflect important characteristics of the data and of the estimated statistical model

# Appendix

## Immortal Time Bias Correction

- The algorithm generates pairs of obese and non-obese claims as follows
  1. Draw the indemnity benefit duration and the time to the first 278 ICD9 code for a claim classified as obese
    - a) Randomly generate an indemnity benefit duration from a Weibull distribution and round up to the next integer
    - b) Randomly draw the time to the first 278 ICD9 code from a geometric distribution with parameter  $\pi$   
(Note: This step b is independent of step a)
    - c) If the time to the first 278 ICD9 code is greater than the minimum of the drawn indemnity benefit duration or 1 year, then reject the draw and return to step 1
      - Otherwise, accept the draw and proceed to step 2
  2. Draw a suitable non-obese claim to pair with the obese claim generated in step 1)
    - a) Randomly generate an indemnity benefit duration from a Weibull distribution and round up to the next integer
    - b) Randomly draw the time to the first 278 ICD9 code from a geometric distribution with parameter  $\pi$   
(Note: This step b is independent of step a)
    - c) If the time to the first 278 ICD9 code is less than the minimum of the drawn indemnity benefit duration or 1 year, then reject the draw and return to step 2
      - Otherwise, accept the draw and return the obese non-obese pair

# Appendix

## Immortal Time Bias Correction

- Under the aforementioned simulation
  - The average duration for claims flagged as obese is 98.5 days
  - The average duration for claims flagged as non-obese is 98.2 days
- Conducting the simulation without the immortal time bias correction is equivalent to all generated claims passing step 2c
- Without the immortal time bias correction
  - The average duration for claims flagged as obese is 98.5 days
  - The average duration for claims flagged as non-obese is 9.5 days
- The result suggest that the proposed immortal time bias correction makes up most of the difference between the two categories