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Indemnity Benefit Duration and Obesity

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Overview

- Objective
- Modeling Duration
- Previous Research
- The Data
- Findings
- Conclusion
- Appendix

2013, *eForum, forthcoming,* http://www.casact.org/pubs/forum/
The paper is available at https://www.ncci.com/nccimain/IndustryInformation/ResearchOutlook/Pages/IndemnityBenefitDuration-Obesity.aspx

Objective

- Measure the indemnity benefit duration of claims with obesity diagnoses relative to otherwise similar claims
- Research design
  - Use a matched-pairs methodology that compares "obese" claims to "non-obese" claims
    - Descriptive approach (Kaplan-Meier estimator)
    - Statistical approach (Bayesian semi-parametric Weibull proportional hazard model)

Findings

- The application of a statistical framework for the measurement of indemnity duration was pioneered
- The indemnity duration for a claim categorized as “obese” is 5 times as long as an otherwise comparable claim

Statistical Modeling of Duration

- The duration of claims may be censored
- Censoring occurs when the duration is only partially known
  - Interval-Censored
    - The duration falls into a given interval
    - Example: Claims that did not breach the waiting period
  - Right-Censored
    - The duration is only known to be greater than a certain value
    - Example: Claims with ongoing indemnity payments

Statistical Modeling of Duration

- Any given set of claim durations may exhibit two mutually exclusive types of censored claims, alongside uncensored claims
- Statistical models have been developed that are capable of handling both interval-censored and right-censored data (*)
- Advantages of statistical modeling
  - The effect of covariates (such as obesity) on the average (mean) duration can be quantified
  - The model accounts for the possibility that a lengthening of duration causes more claims to breach the waiting period

* See the appendix for computer code that handles both interval-censoring and right-censoring

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 Woiszwillo, 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

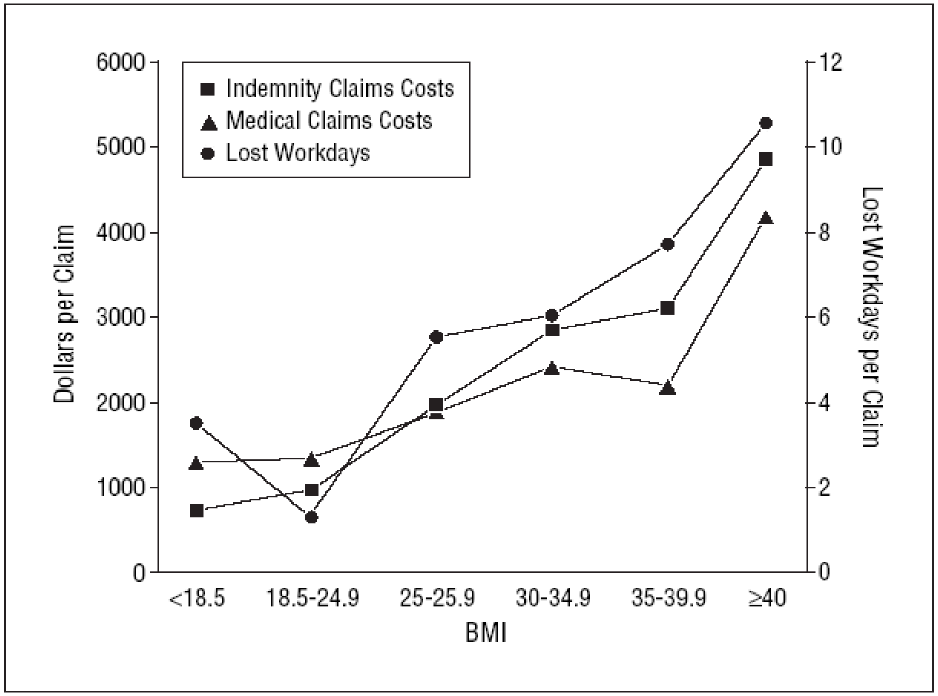


Figure 1. Mean indemnity claims costs, medical claims costs, and number of lost workdays per claim by body mass index (BMI) category. Body mass index is calculated as weight in kilograms divided by height in meters squared.

- 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

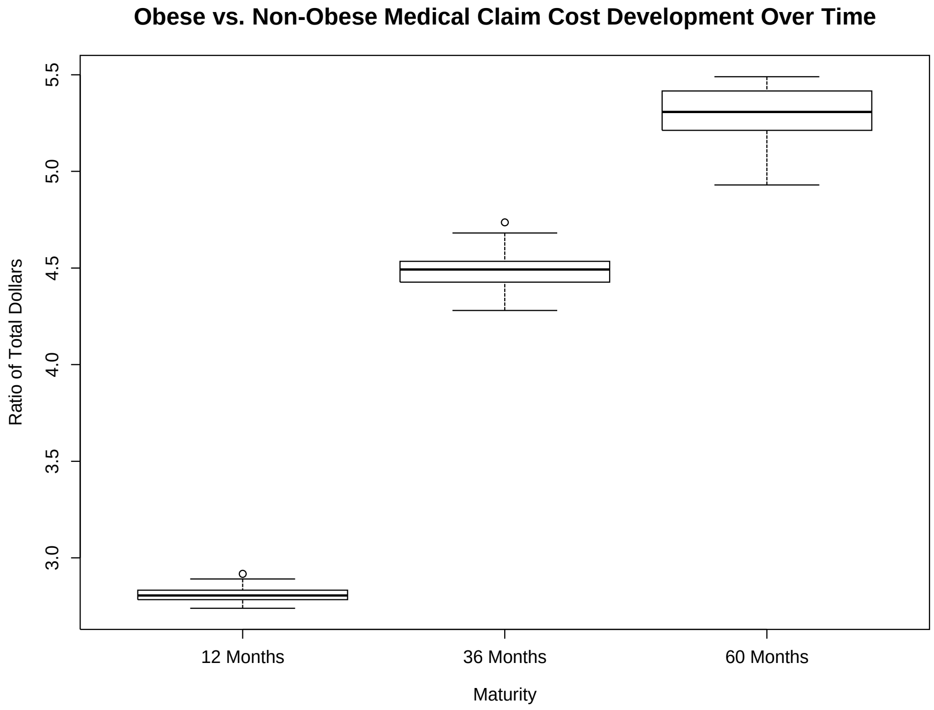
Source: Østbye, Truls, John M. Dement, and Katrina M. Krause (2007) “Obesity and Workers’ Compensation: Results from the Duke Health and Safety Surveillance System,” *Archives of Internal Medicine* **167**, 766-773

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 medial 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

- In 2010, 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

Related Research
NCCI

- In 2012, NCCI expanded its 2010 study to
  - look at additional indicators of comorbidity and
  - provide additional information related to these diagnoses
- This study found that
  - Claims with a comorbidity diagnosis have about twice the medical costs of otherwise comparable claims
  - The share of workers compensation claims with a comorbidity diagnosis nearly tripled from Accident Year 2000 to Accident Year 2009, growing from a share of 2.4% to 6.6%

Source: https://www.ncci.com/Documents/AIS-2012-Barry-Lipton_Comorbidities.pdf

The Data

- We use a claims data set provided by insurance carriers
  - The data set covers injury years 1998-2008
  - Payment 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 payment 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

- For claims with indemnity payment 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)
    - When no 180-day transaction-free interval can be established, the claim is considered right-censored

* Re-opening are not accounted for

Indemnity Benefit Duration

- Duration is implemented as a calendar-time concept
- Duration Concept I
  - Aggregation of disability days for which indemnity payment transactions indicate the claimant was compensated
    - If more than 20 percent of the payment transactions associated with a given claim are missing “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” (*)
    - Payment transaction dates substitute for missing “through-dates” (*)

* Most indemnity payment transactions record several dates. Two such dates are the “from-date” and the “through-date.” These dates record the period of time for which the claimant is being compensated.

Matched Pairs

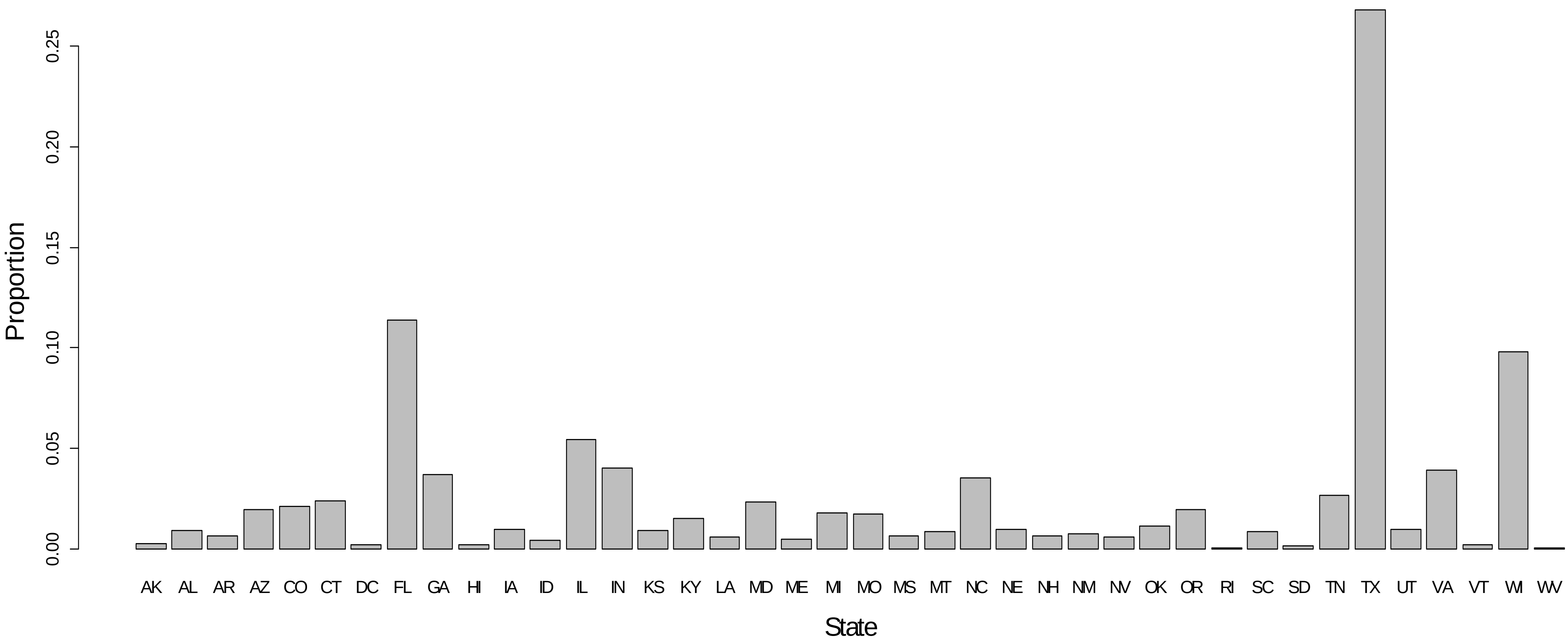
- We form matched pairs
  - An “obese” claim is paired with a “non-obese” claim, using the claim characteristics itemized below
    - Injury year
    - State
    - Gender
    - NCCI industry group (*)
    - Primary ICD9 code (at the three-digit level)
    - Age (proximity matching)

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

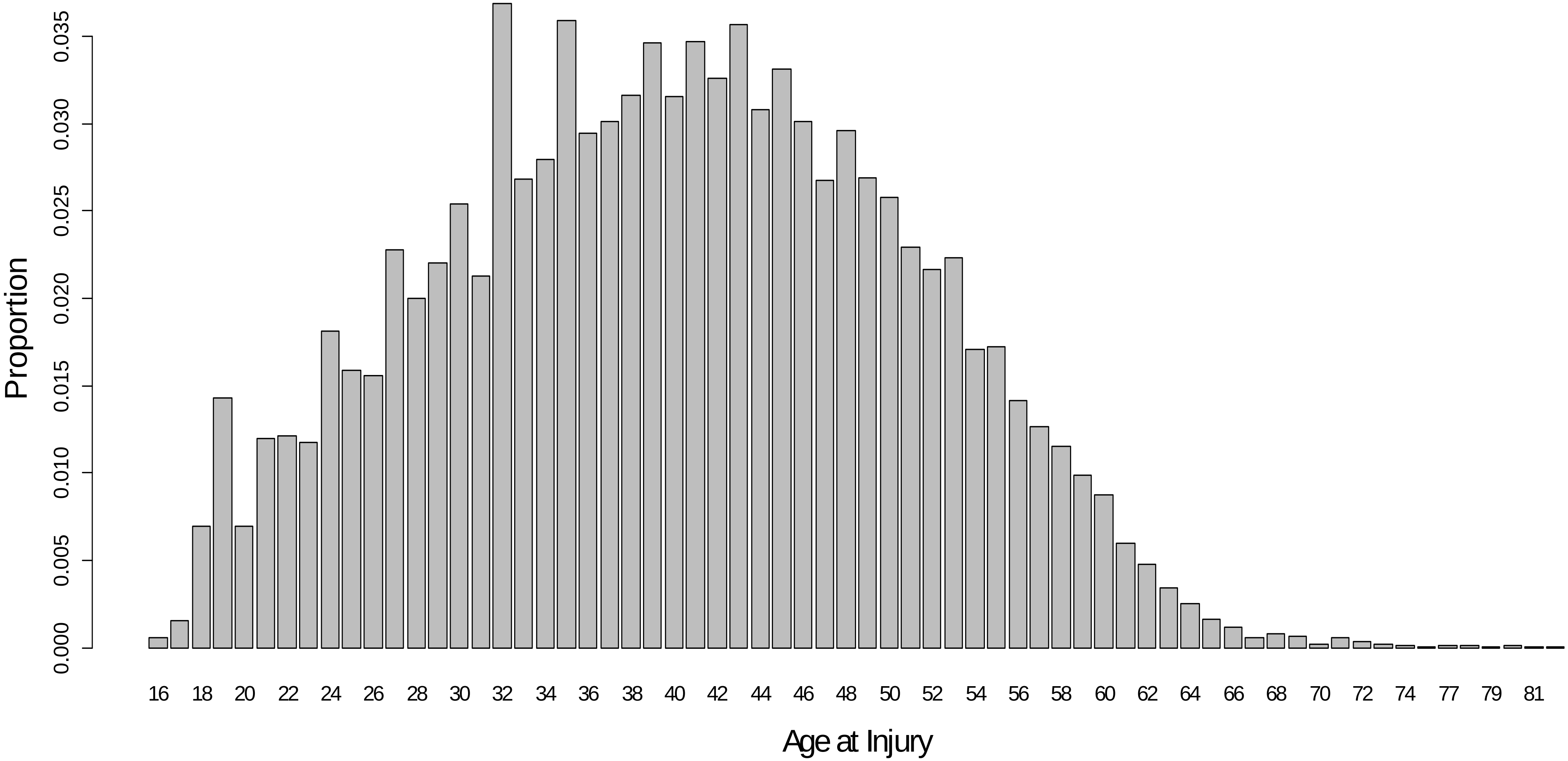
Immortal Time Bias

- 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

Descriptive Statistics
Matched Pairs



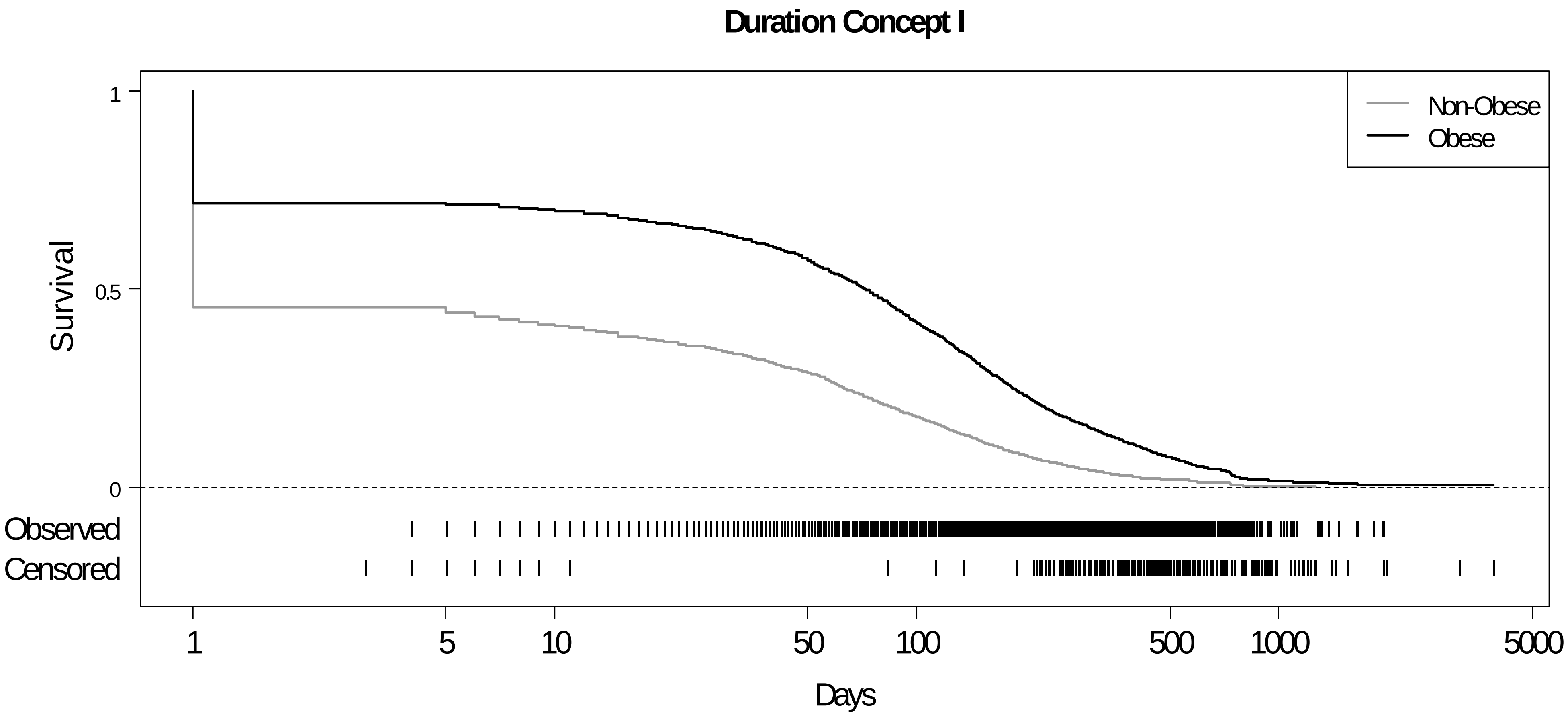
Descriptive Statistics
Claims Included in Matched Pairs



Kaplan-Meier Estimator

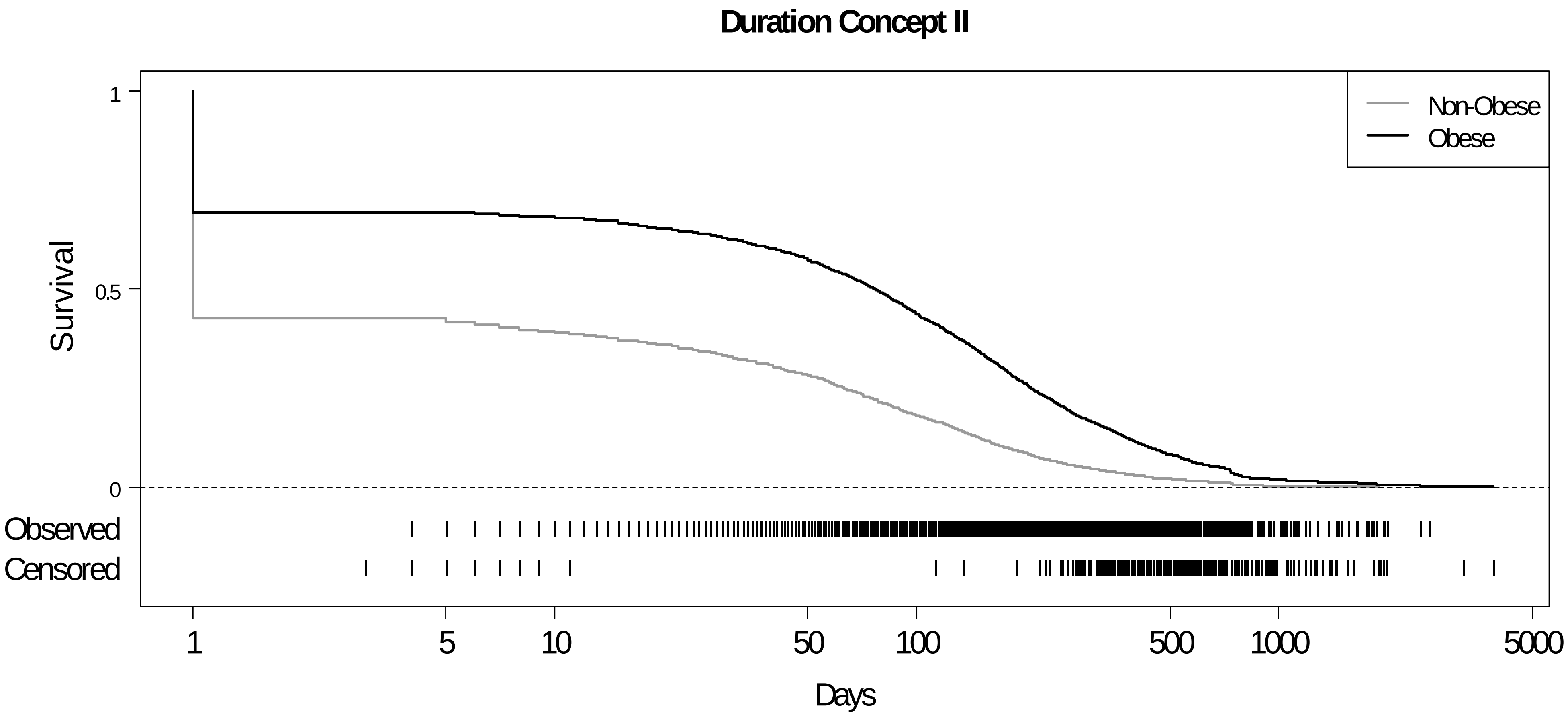
- A survival curve is a graph that depicts the survival experience of individuals
- The Kaplan-Meier estimator is a simple way of computing such a survival curve
  - The percentage of individuals surviving is displayed on the time line (calendar time since injury)
  - The Kaplan-Meier estimator, as implemented,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

Kaplan-Meier Estimator
Duration Concept I



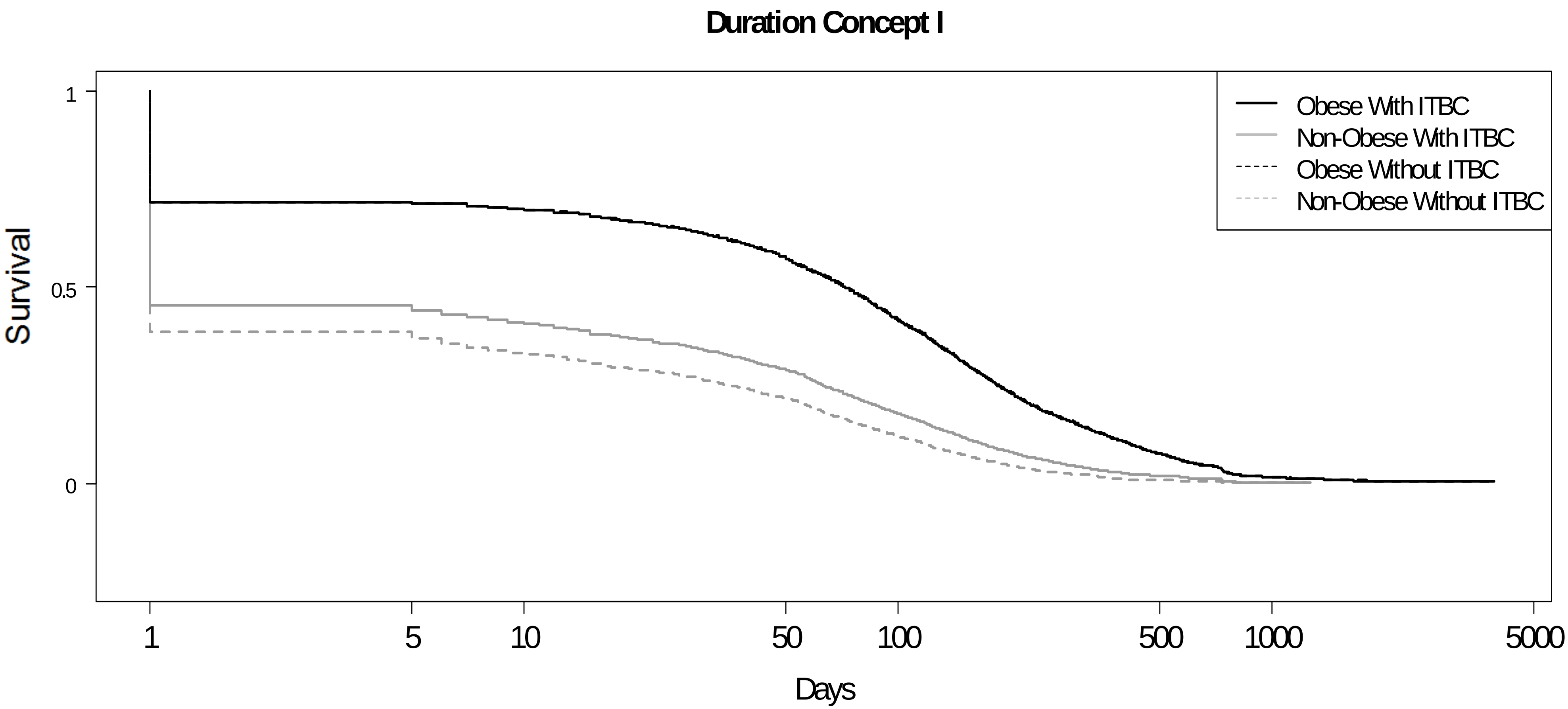
"Observed": non-censored; "censored": interval-censored (whisker at right bound) or right-censored

Kaplan-Meier Estimator
Duration Concept II



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

Immortal Time Bias
Duration Concept I



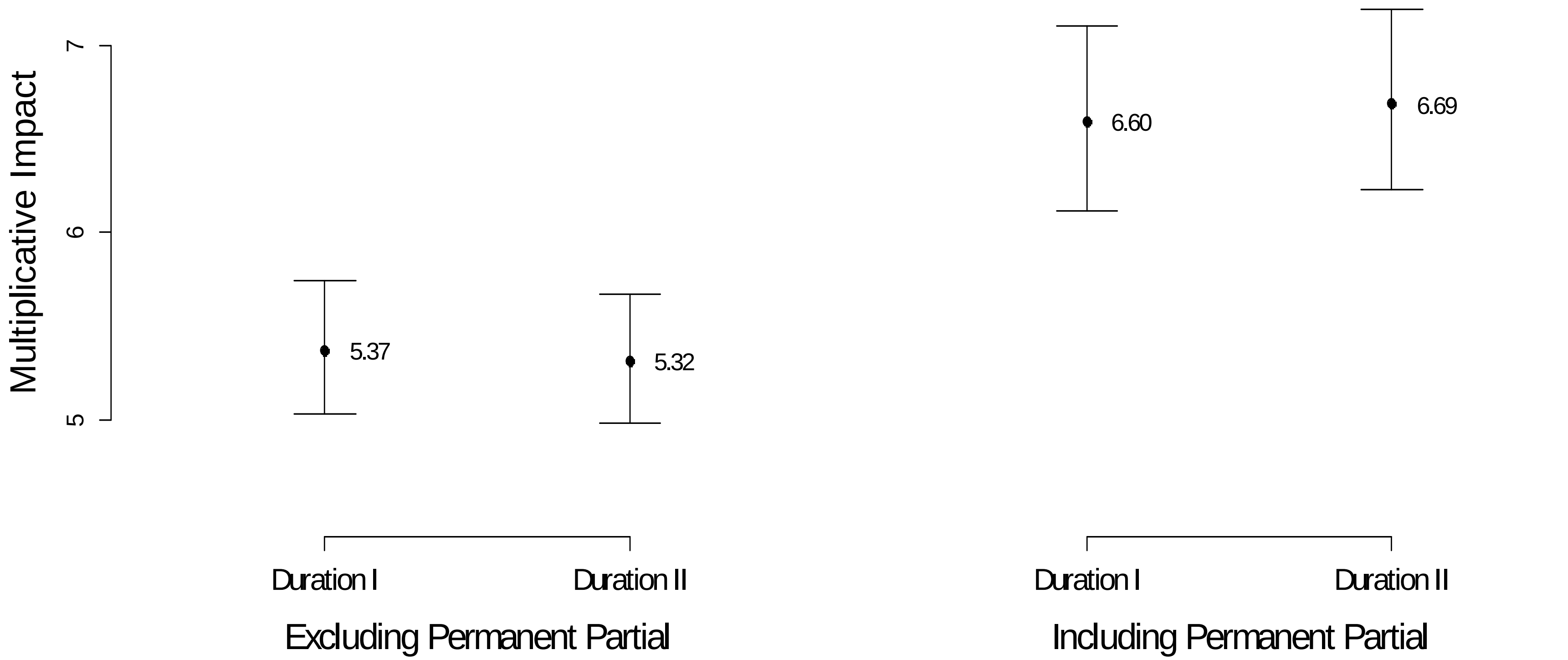
The displayed estimated survival curve for obese claims with immortal time bias correction (ITBC, for short) is indistinguishable from the one without this correction

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 absorbing the influence of proximity matching

* 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

Multiplicative Effect of Obesity on Duration



A multiplicative impact of x means that, for the set of obese claimants, the mean (and median) claim duration is x times as long as it is for the set of non-obese claimants

The displayed credible intervals comprise 80 percent of the posterior probability

Conclusion

- Obesity contributes in important ways to indemnity benefit duration
  - The duration of a claim with an obesity diagnosis is more than five times as long as the duration of a claim without such a diagnosis
  - 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 claimants categorized as obese in the data set is considerably smaller than in the U.S. population, thus suggesting that (1) many of the claimants categorized as obese are of the highest BMI category and (2) many of the claimants categorized as non-obese 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 ICD-9 code of a given claim is the first ICD-9 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 and DME Center), 08 (Other)
3) Transactions are selected from the first service date, subject to data cleansing considerations
4) From the ICD-9 codes resulting from steps 1 through 3, the ICD-9 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 ICD-9 code associated with the transaction
5) If there are ties after applying the mentioned criteria, an ICD-9 code is randomly selected from the set of tied codes

ASC: Ambulatory Surgical Center
DME: Durable Medical Equipment

Appendix
Determining the Median Duration

- Assume that an obese claim has multiple matching non-obese claims
- First, sort the matching claims by duration
- In the event 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
- In the event 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
  - The data generation process for benefit duration is the same for all claims
  - 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, π, 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 π
      (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 π
      (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 suggests that the proposed immortal time bias correction makes up most of the difference between the two categories

Appendix

JAGS Code (Proportional Hazard Model)

```
## Defining is.censored (from JAGS Manual)
## X ~ dinterval(failure.time, waiting.period.or.last.observed)
## Left Censored X = 0
## Right Censored X = 1
## Not Censored X = NA
model
{
for(i.obs in 1:n.obs){
   failure.time[i.obs] ~ dweib(r,mu[i.obs])
   is.censored[i.obs] ~ dinterval(failure.time[i.obs], waiting.period.or.last.observed[i.obs])

    mu[i.obs] <- exp(alpha[is.obese[i.obs]+1] + f[i.obs])

    f[i.obs] <- age[i.obs] * beta[1] +
        (age[i.obs] >= knot[1])*(age[i.obs] - knot[1])*b[1] +
            (age[i.obs] >= knot[2])*(age[i.obs] - knot[2])*b[2] +
                (age[i.obs] >= knot[3])*(age[i.obs] - knot[3])*b[3] +
                    (age[i.obs] >= knot[4])*(age[i.obs] - knot[4])*b[4] +
                        (age[i.obs] >= knot[5])*(age[i.obs] - knot[5])*b[5]

    median[i.obs] <- (log(2) * 1/mu[i.obs])^(1/r)
}

##Spline
##Random regression coefficients corresponding to the truncated polynomial functions
for(i.knot in 1:n.knots){
    b[i.knot] ~ dnorm(0, tau.b)
}

##Fixed regression coefficient corresponding to the 'plus' functions
beta ~ dnorm(0,1.0E-2)

##Priors
r ~ dexp(1)
alpha[1] ~ dnorm(0,0.01) ##Not Obese
alpha[2] ~ dnorm(0,0.01) ##Obese

tau.b ~ dgamma(1.0E-3,1.0E-3)
sigma.b <- 1/sqrt(tau.b)

obese.control <- alpha[2] - alpha[1]
}
```