CrittersFull

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# Censored data problem

We observed an experiment where 32 animals were each exposed to 50 critters in a closed environment for 24 hours, after which all the critters were exterminated and the animals cleaned.

The 32 animals were in 4 groups of 8, where each group received a different treatment.

The questions are: which treatments are equivalent? If any are not equivalent, how much better or worse are they?

# Data structure

library(tidyverse)

"ticks.csv" |> read.csv() -> d

# Simple Model for counts after 24h

$$y\_{ij}∼Binomial\left(n=50,p\_{ij}\right)$$

$$p\_{ij}∼Beta\left(a\_{j},b\_{j}\right)$$

$$μ\_{j}=\frac{a\_{j}}{a\_{j}+b\_{j}}$$

### Alternatively

$$logit\left(p\_{ij}\right)=β\_{i}+μ\_{j}$$

$$β\_{i}∼N\left(0,τ\right)$$

# Model for individual ticks

lifetime of each tick is $w\_{i}$

$$log\left(w\_{ij}\right)∼N\left(μ\_{j}+β\_{i},σ\_{j}\right)$$

$$β\_{i}∼N\left(0,τ\right)$$

## Implementation

library(rstan)
options(mc.cores = 3)

lower <- d$LOWERLOG
lower[is.na(lower)] <- log(0.001)
upper <- d$UPPERLOG
upper[is.na(upper)] <- log(2400)

data {
 int n;
 real low[n];
 real upp[n];
 int tr[n];
 int ntreat;
 int subj[n];
 int nsubj;
}
parameters {
 real mu[ntreat];
 real beta[nsubj];
 real<lower=0> sigma[ntreat];
 real<lower=0> tau;
}
model {
 for (i in 1:n) {
 target += log\_diff\_exp(normal\_lcdf(upp[i] | mu[tr[i]] + beta[subj[i]], sigma[tr[i]]), normal\_lcdf(low[i] | mu[tr[i]] + beta[subj[i]], sigma[tr[i]]) );
 }
 beta ~ normal(0, tau);
 tau ~ gamma(0.001,0.001);
 sigma ~ gamma(0.001,0.001);
}

stan\_data <- list(n = nrow(d), low = lower, upp = upper, tr = d$GROUPN, ntreat = max(d$GROUPN), subj = d$IDNO, nsubj = max(d$IDNO))
censored |> sampling(stan\_data, iter = 4000, cores = 3) -> results1

results1 |> extract() -> sims1
sims1$mu |> boxplot(xlab = 'Treatment Number', ylab = 'Log Lifetime', col = 2:5)



## Discussion

We can see that the control treatment has the longest expected lifetime (worst results) and that the first non-control treatment has the shortest expected lifetime.

Even though Treatment 4 had the same number of critters die over 24 hours, they died much slower than those of Treatment 2.

effectiveness <- 1 - exp(sims1$mu - sims1$mu[,1])
par(mar = c(4.5, 6, 0.5, 0.5))
effectiveness |> boxplot(xlab = 'Treatment Number', ylab = 'Effectiveness', col = 2:5)



rel\_eff <- effectiveness[,3:4]/effectiveness[,2]
prob90 <- colMeans(rel\_eff > 0.9)

The probability that Treatment 3 is at least 90% as effective as Treatment 4 is about 0.01% and the probability that Treatment 3 is at least 90% as effective as Treatment 4 is about 6.19%.