Piecewise Regression QPoisson Error on Real Data using STAN Directly

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Goal

- Fit two piece quasipoisson to data

Recap

Set up

Install libraries

```
# install packages user might not have by replacing FALSE with TRUE

## load libraries
library(stats)
library(MASS) # provides negative binomial fitting:  glm.nb
library(ggplot2)
library(ggpubr)
library(grid)
library(gridExtra)
library(GGally)
library(broom)
library(tidyverse)
library(viridisLite)
library(cmdstanr)
library(rstan)
options(mc.cores = (parallel::detectCores()-2))
rstan_options(auto_write = TRUE)
library(loo)


## options(ggplot2.continuous.colour="viridis",
##         ggplot2.discrete.colour="viridis",
##         ggplot2.scale_fill_discrete = scale_fill_viridis_d,
##         ggplot2.scale_fill_continuous = scale_fill_viridis_c)

library(reshape2)
```

```
library(lme4)
library(latex2exp)
```

Load Data

```
load(file.path("input", "data.processing_2022-12-15.Rda"),
     verbose = TRUE)
```

```
## Loading objects:
##   motif_data
##   motif_data_40C
##   motif_stats
##   motif_stats_40C
##   bird_bill_data
```

```
motif_data
```

```
## # A tibble: 146 x 28
##    male  round trial_round motif~1 motif~2 temp_~3 humid~4 chamber date  counter
##    <fct> <dbl>       <dbl>   <int>   <dbl>   <dbl>   <dbl> <fct>   <chr> <chr>
##  1 T229      1           1       0 0          45.8      NA 6       02/1~ KIM
##  2 T229      1           2      24 0.0131     42.3      NA 6       02/1~ KIM
##  3 T229      1           3     114 0.0622     40.7      NA 6       02/1~ KIM
##  4 T229      1           4     198 0.108      26.2      NA 6       02/1~ KIM
##  5 T229      1           5     315 0.172      34.9      NA 6       02/2~ KIM
##  6 T231      1           1      57 0.0431     42.8      NA 2       02/1~ RAS
##  7 T231      1           2       7 0.00529    45.0      NA 2       02/1~ RAS
##  8 T231      1           3      86 0.0650     41.1      NA 2       02/1~ KIM
##  9 T231      1           4      24 0.0181     27.2      NA 2       02/1~ RAS
## 10 T231      1           5     215 0.162      36.5      NA 2       02/2~ RAS
## # ... with 136 more rows, 18 more variables: test_order <int>,
## #   temp_target <dbl>, temp_median <dbl>, humdity_mean <dbl>, motif_rate <dbl>,
## #   mass <dbl>, n_obs_completed <lgl>, motif_count_plus_1 <int>,
## #   log_motif_count_plus_1 <dbl>, temp <dbl>, n_obs_round <int>, n_obs <int>,
## #   trial <int>, motif_prop_round <dbl>, weights <dbl>, svp <dbl>, vpd <dbl>,
## #   vpd_offset <dbl>, and abbreviated variable names 1: motif_count,
## #   2: motif_prop, 3: temp_mean, 4: humidity_mean
```

Examine Data

Create Working Dataset

```
filter_data <- TRUE

if(filter_data) {
  males_filtered_disp <- motif_stats_40C %>%
    filter(dispersion < 50) %>%
```

```
    pull(male)

  males_filtered_mean <- motif_stats %>%
    filter(mean > 10) %>% # changing from 10 to 40 removes previous male 7 (T258)
    pull(male)

  male_vector <- intersect(males_filtered_mean, males_filtered_disp)
} else {
  male_vector <- motif_data %>% select(male) %>% distinct()
}

data_ind <- motif_data %>%
    filter(male %in% male_vector) %>%
    mutate(male = droplevels(male)) %>%
    mutate(index = as.integer(male)) %>%
    mutate(male = as.character(male)) %>%
    arrange(index) %>%
    select(male, index, motif_count, temp, round, trial_round, date, counter) %>%
  ##    left_join(index_shape, by = "index") %>%
  mutate()

stats_ind <- motif_stats %>%
    filter(male %in% male_vector)


data_ind <- data_ind %>% filter(temp < 38) %>%
    group_by(male) %>% mutate(y0_simple.est = mean(motif_count), phi_ind = var(motif_count)/y0_simple.es
    ungroup()

summary(data_ind)
```

```
##      male                index          motif_count         temp
##  Length:38          Min.   : 1.000   Min.   :  0.0   Min.   :25.71
##  Class :character   1st Qu.: 3.000   1st Qu.: 52.5   1st Qu.:29.51
##  Mode  :character   Median : 5.500   Median : 89.0   Median :33.52
##                     Mean   : 5.579   Mean   :112.9   Mean   :31.88
##                     3rd Qu.: 8.000   3rd Qu.:167.2   3rd Qu.:34.34
##                     Max.   :11.000   Max.   :425.0   Max.   :37.64
##      round        trial_round        date              counter
##  Min.   :1.000   Min.   :1.000   Length:38          Length:38
##  1st Qu.:1.000   1st Qu.:2.000   Class :character   Class :character
##  Median :3.000   Median :3.000   Mode  :character   Mode  :character
##  Mean   :2.211   Mean   :3.105
##  3rd Qu.:3.000   3rd Qu.:4.000
##  Max.   :3.000   Max.   :6.000
##  y0_simple.est       phi_ind
##  Min.   : 24.00   Min.   :  0.142
##  1st Qu.: 64.33   1st Qu.:  6.955
##  Median : 93.20   Median : 12.986
##  Mean   :112.89   Mean   : 33.913
##  3rd Qu.:166.38   3rd Qu.: 48.000
##  Max.   :246.25   Max.   :128.361
```

```
summary_stats <- data_ind %>% ungroup() %>%  summarize(y0_bar = mean(y0_simple.est), y0_sd = sd(y0_simpl

n_male <- length(unique(data_ind$male))
```

Set Up Data

```
data <- data_ind
motif_count <- data %>% pull(motif_count)
temp <- data %>% pull(temp)
N <- length(temp)
index <- data %>% pull(index)
## parameters to be printed

pars <- c("t0", "y0")
pars_full <- c(pars, "lp__")
```

Fit Models

QPoisson

```
iter <- 15000
tmax <- 46
t0max <- tmax - 0.5;
t0min <- 20;
## values to use for model predictions
tp = seq(25, tmax, length.out = 100)
n_cores <- 4
n_chains <- n_cores

##y0_grouping <- map_int(data$male, ~ if_else(. %in% y0_group[[1]], 1, 2))
model <- "qpoi"
stan_file <- "two.piece_qpoisson_2.0.stan"
## For debugging
## cmodel <- cmdstan_model(stan_file = stan_file)

stan_model(file = stan_file,
           verbose = TRUE)
```

```
##
## TRANSLATING MODEL '' FROM Stan CODE TO C++ CODE NOW.
```

```
## Define groups

flags <- c("separate", "grouping_1", "pooled")
flags_x <- flags
flags_y <- flags
fit_tbl <- crossing(model = model,
                    x0 = flags_x, y0 = flags_y,
```

```
                    desc = "NA_character",
                    y0_group_list = list(NA),
                    x0_group_list = list(NA),
                    fit = list(NA),
                    llik = list(NA),
                    r_eff = list(NA),
                    loo = list(NA)
                    )



for(x_flag in flags_x) {
    for(y_flag in flags_y) {

        desc <- paste0(model, ": ", x_flag, ", ", y_flag)
        curr_row <- which(fit_tbl$x0 == x_flag & fit_tbl$y0 == y_flag)

        fit_tbl[ curr_row, ]$desc <- desc
        print(desc)

        x0_group_list <- list()
        y0_group_list <- list()

        switch(x_flag,
               separate = {
                   x0_group_list <- data$male %>% unique() %>% as.list()
               },
               grouping_1 = {
                   ## set up groupings based on 2022-12-20 analysis
                   ## Using male ID's instead index to make code more robust
                   x0_group_list[[1]] <- c("T235", "T237", "T244", "T247", "T257", "T260")
                   x0_group_list[[2]] <- c("T234", "T236", "T243", "T246", "T258")
               },
               pooled = {
                   x0_group_list[[1]] <- data$male
               }
               )

        switch(y_flag,
               separate = {
                   y0_group_list <- data$male %>% unique() %>% as.list()
               },
               grouping_1 = {
                   ## set up groupings based on 2022-12-20 analysis
                   ## Using male ID's instead index to make code more robust
                   y0_group_list[[1]] <- c("T234", "T243", "T244", "T246", "T258", "T260")
                   y0_group_list[[2]] <- c("T235", "T236", "T237", "T247", "T257")
               },
               pooled = {
                   y0_group_list[[1]] <- data$male
               }
               )
```

```
        fit_tbl[ curr_row, ]$x0_group_list[[1]] <- x0_group_list

        fit_tbl[ curr_row, ]$y0_group_list[[1]] <- y0_group_list

        ## Convert lists to a vector of concatenated strings
        ## This will simplify mapping male to an x0/y0 index
        x0_group <-lapply(x0_group_list, paste, collapse = " ") %>% unlist()
        y0_group <-lapply(y0_group_list, paste, collapse = " ") %>% unlist()

        x0_index <- sapply(as.character(data$male), function(x) str_which(x0_group, x))
        y0_index <- sapply(as.character(data$male), function(x) str_which(y0_group, x))

        fit <- stan(file = stan_file,
                    model_name = desc,
                    data=list(x = temp,
                              y = motif_count,
                              N = N,
                              X = length(x0_group),
                              Y = length(y0_group),
                              NB = 1,
                              xx = x0_index,
                              yy = y0_index,
                              nbb = rep(1,N),
                              xmax = tmax,
                              x0_min = t0min,
                              x0_max = t0max,
                              y_xmax = 0,
                              y0_min = 10,
                              sd_y0_prior = 200,
                              alpha_theta_prior = 10,
                              ##tp = tp,
                              ## max threshold value.
                              ## having it too close to xmax *sometimes* leads to sampling
                              ## near xmax, but with lower lp and very high E13) b0 values
                              y_xmax = 0),
                    cores = n_cores,
                    chains = n_chains,
                    iter = iter,
                    warmup = floor(iter/2),
                    verbose = TRUE)

        print(fit)

        fit_tbl[ curr_row, ]$fit <- list(fit)

    }
}
```

```
## [1] "qpoi: separate, separate"
##
## TRANSLATING MODEL 'qpoi: separate, separate' FROM Stan CODE TO C++ CODE NOW.
##
## CHECKING DATA AND PREPROCESSING FOR MODEL 'anon_model' NOW.
```

```
##
## COMPILING MODEL 'anon_model' NOW.
##
## STARTING SAMPLER FOR MODEL 'anon_model' NOW.
## Inference for Stan model: anon_model.
## 4 chains, each with iter=15000; warmup=7500; thin=1;
## post-warmup draws per chain=7500, total post-warmup draws=30000.
##
##                mean se_mean    sd    2.5%     25%     50%     75%   97.5% n_eff
## y0[1]         56.61    0.10 11.97   37.04   48.74   55.38   62.78   84.54 13833
## y0[2]        285.37    0.35 40.74  210.34  256.48  284.08  313.21  366.64 13693
## y0[3]        180.57    0.13 18.56  146.34  167.90  179.98  192.34  218.79 19314
## y0[4]        198.48    0.47 50.21  119.81  159.40  191.46  233.29  306.10 11304
## y0[5]         68.90    0.33 16.44   45.72   58.17   65.79   75.44  113.04  2533
## y0[6]         92.02    0.21 21.94   59.78   76.14   88.06  103.77  145.13 11024
## y0[7]         16.33    0.03  5.38   10.19   12.25   14.97   18.95   29.97 25813
## y0[8]        172.27    0.32 35.01  108.86  146.12  172.02  197.39  239.70 12147
## y0[9]        218.74    0.65 60.28  137.49  173.79  201.83  255.74  358.67  8479
## y0[10]        49.84    0.14 16.34   24.34   38.71   47.63   58.34   89.77 13058
## y0[11]       106.43    0.30 33.87   53.75   78.91  103.25  130.74  176.67 12699
## x0[1]         37.84    0.05  5.34   23.10   34.97   38.49   42.00   45.13 12290
## x0[2]         23.95    0.02  2.44   20.17   21.90   23.85   25.74   28.92 11785
## x0[3]         38.62    0.03  4.16   30.93   35.34   38.74   42.15   45.17 14391
## x0[4]         29.09    0.07  6.77   20.39   23.66   27.58   32.85   44.19  9365
## x0[5]         37.64    0.19  7.01   21.13   36.75   39.84   42.66   45.19  1412
## x0[6]         31.47    0.06  6.00   20.70   27.97   31.18   34.43   44.19  9811
## x0[7]         36.21    0.05  6.41   21.24   32.69   37.15   41.33   45.07 18585
## x0[8]         26.18    0.05  4.72   20.25   22.58   25.36   28.66   39.64  9118
## x0[9]         32.60    0.08  7.42   20.66   26.07   32.62   39.06   44.83  8090
## x0[10]        35.02    0.07  7.13   20.83   30.26   36.23   40.87   45.03 11903
## x0[11]        28.90    0.06  6.46   20.34   23.54   27.67   33.10   43.78 10203
## theta[1]       7.17    0.00  0.61    6.05    6.75    7.14    7.56    8.44 17969
## log_lik[1]    -4.41    0.00  0.68   -6.16   -4.71   -4.24   -3.91   -3.66 18765
## log_lik[2]    -4.07    0.00  0.28   -4.90   -4.13   -3.97   -3.90   -3.82 13439
## log_lik[3]    -4.96    0.00  0.66   -6.63   -5.30   -4.82   -4.47   -4.11 18351
## log_lik[4]    -4.01    0.00  0.29   -4.81   -4.08   -3.91   -3.83   -3.75 20542
## log_lik[5]   -31.59    0.03  4.60  -40.99  -34.62  -31.44  -28.40  -23.07 27969
## log_lik[6]    -6.32    0.01  1.03   -8.83   -6.88   -6.13   -5.56   -4.91 24973
## log_lik[7]   -16.39    0.01  2.38  -21.40  -17.92  -16.28  -14.73  -12.07 32520
## log_lik[8]    -6.42    0.00  0.85   -8.34   -6.93   -6.32   -5.80   -5.07 31887
## log_lik[9]    -4.74    0.00  0.33   -5.65   -4.81   -4.62   -4.55   -4.47 15936
## log_lik[10]   -5.73    0.01  0.88   -7.84   -6.21   -5.57   -5.07   -4.48 21971
## log_lik[11]   -4.84    0.00  0.33   -5.73   -4.97   -4.72   -4.60   -4.50 16902
## log_lik[12]   -4.93    0.00  0.41   -6.03   -5.10   -4.81   -4.64   -4.52 17931
## log_lik[13]   -4.67    0.00  0.55   -6.24   -4.80   -4.46   -4.33   -4.24 18573
## log_lik[14]   -4.90    0.00  0.54   -6.42   -5.05   -4.69   -4.55   -4.45 16047
## log_lik[15]  -19.30    0.06  3.85  -27.06  -21.92  -19.25  -16.56  -12.10  4247
## log_lik[16]   -4.84    0.01  0.57   -6.23   -5.16   -4.73   -4.39   -4.14  5681
## log_lik[17]  -19.14    0.07  3.27  -26.41  -21.16  -18.58  -16.75  -13.98  2262
## log_lik[18]   -5.23    0.01  0.71   -6.92   -5.63   -5.10   -4.70   -4.24  6520
## log_lik[19]   -4.09    0.00  0.23   -4.72   -4.14   -4.01   -3.96   -3.88  8402
## log_lik[20]   -4.66    0.00  0.73   -6.48   -5.05   -4.50   -4.12   -3.76 23799
## log_lik[21]   -5.16    0.01  1.10   -7.90   -5.73   -4.88   -4.31   -3.91 14697
## log_lik[22]   -4.08    0.00  0.23   -4.71   -4.16   -4.01   -3.94   -3.86 13254
```

```
## log_lik[23]   -5.00    0.00  0.56   -6.34   -5.32   -4.91   -4.58   -4.24 24906
## log_lik[24]   -5.76    0.01  0.87   -7.77   -6.27   -5.62   -5.11   -4.48 16721
## log_lik[25]   -5.16    0.01  1.70   -9.49   -6.01   -4.75   -3.88   -3.11 25524
## log_lik[26]   -6.91    0.01  1.09   -9.17   -7.61   -6.94   -6.17   -4.77 15851
## log_lik[27]   -4.55    0.01  0.57   -6.16   -4.73   -4.41   -4.18   -3.97 12929
## log_lik[28]   -4.73    0.00  0.43   -6.05   -4.80   -4.57   -4.48   -4.40 11523
## log_lik[29]   -4.67    0.00  0.34   -5.54   -4.85   -4.59   -4.41   -4.26 26354
## log_lik[30]   -4.38    0.00  0.17   -4.87   -4.42   -4.33   -4.27   -4.20 17322
## log_lik[31]   -4.42    0.00  0.18   -4.90   -4.46   -4.36   -4.31   -4.24 16706
## log_lik[32]   -4.78    0.00  0.42   -5.96   -4.87   -4.62   -4.52   -4.44 17310
## log_lik[33]   -4.76    0.00  0.41   -5.92   -4.87   -4.61   -4.51   -4.42 15067
## log_lik[34]   -5.73    0.01  1.16   -8.48   -6.40   -5.51   -4.85   -4.14 18098
## log_lik[35]   -4.96    0.01  1.30   -8.20   -5.62   -4.66   -3.97   -3.42 27405
## log_lik[36]   -4.01    0.00  0.38   -5.12   -4.05   -3.88   -3.80   -3.73 14055
## log_lik[37]   -4.26    0.00  0.28   -5.05   -4.33   -4.15   -4.08   -4.00 15261
## log_lik[38]   -4.30    0.00  0.33   -5.22   -4.39   -4.18   -4.10   -4.02 20061
## b0            -8.15    0.10 10.17  -30.44   -7.14   -6.13   -5.33   -4.03 10817
## phi           13.39    0.02  2.93    8.15   11.31   13.23   15.30   19.46 19016
## mu            81.82    0.12 16.07   52.30   70.50   81.31   92.43  114.72 19341
## val1          14.64    0.00  0.00   14.64   14.64   14.64   14.64   14.64     2
## val2          17.10    0.06  6.46    2.22   12.90   18.33   22.46   25.66 10203
## lp__        -262.85    0.05  4.16 -271.88 -265.48 -262.51 -259.89 -255.71  7246
##             Rhat
## y0[1]       1.00
## y0[2]       1.00
## y0[3]       1.00
## y0[4]       1.00
## y0[5]       1.00
## y0[6]       1.00
## y0[7]       1.00
## y0[8]       1.00
## y0[9]       1.00
## y0[10]      1.00
## y0[11]      1.00
## x0[1]       1.00
## x0[2]       1.00
## x0[3]       1.00
## x0[4]       1.00
## x0[5]       1.01
## x0[6]       1.00
## x0[7]       1.00
## x0[8]       1.00
## x0[9]       1.00
## x0[10]      1.00
## x0[11]      1.00
## theta[1]    1.00
## log_lik[1]  1.00
## log_lik[2]  1.00
## log_lik[3]  1.00
## log_lik[4]  1.00
## log_lik[5]  1.00
## log_lik[6]  1.00
## log_lik[7]  1.00
## log_lik[8]  1.00
```

```
## log_lik[9]  1.00
## log_lik[10] 1.00
## log_lik[11] 1.00
## log_lik[12] 1.00
## log_lik[13] 1.00
## log_lik[14] 1.00
## log_lik[15] 1.00
## log_lik[16] 1.00
## log_lik[17] 1.00
## log_lik[18] 1.00
## log_lik[19] 1.00
## log_lik[20] 1.00
## log_lik[21] 1.00
## log_lik[22] 1.00
## log_lik[23] 1.00
## log_lik[24] 1.00
## log_lik[25] 1.00
## log_lik[26] 1.00
## log_lik[27] 1.00
## log_lik[28] 1.00
## log_lik[29] 1.00
## log_lik[30] 1.00
## log_lik[31] 1.00
## log_lik[32] 1.00
## log_lik[33] 1.00
## log_lik[34] 1.00
## log_lik[35] 1.00
## log_lik[36] 1.00
## log_lik[37] 1.00
## log_lik[38] 1.00
## b0          1.00
## phi         1.00
## mu          1.00
## val1        1.00
## val2        1.00
## lp__        1.00
##
## Samples were drawn using NUTS(diag_e) at Fri Jan 20 17:17:10 2023.
## For each parameter, n_eff is a crude measure of effective sample size,
## and Rhat is the potential scale reduction factor on split chains (at
## convergence, Rhat=1).
## [1] "qpoi: separate, grouping_1"
##
## TRANSLATING MODEL 'qpoi: separate, grouping_1' FROM Stan CODE TO C++ CODE NOW.
##
## CHECKING DATA AND PREPROCESSING FOR MODEL 'anon_model' NOW.
##
## COMPILING MODEL 'anon_model' NOW.
##
## STARTING SAMPLER FOR MODEL 'anon_model' NOW.
## Inference for Stan model: anon_model.
## 4 chains, each with iter=15000; warmup=7500; thin=1;
## post-warmup draws per chain=7500, total post-warmup draws=30000.
##
```

```
##                mean se_mean    sd    2.5%     25%     50%     75%   97.5% n_eff
## y0[1]         56.89    0.04  5.12   47.33   53.39   56.69   60.24   67.38 16062
## y0[2]        196.63    0.12 14.31  169.99  186.88  196.10  205.74  226.15 14450
## x0[1]         38.39    0.03  4.59   28.17   35.31   38.70   42.17   45.15 20797
## x0[2]         27.99    0.02  1.89   24.18   26.65   28.05   29.43   31.14 15762
## x0[3]         38.16    0.03  4.49   29.72   34.61   38.33   41.98   45.16 16716
## x0[4]         28.28    0.05  5.25   20.87   24.82   27.37   30.16   43.07 10353
## x0[5]         40.28    0.04  3.90   28.94   38.43   40.75   43.11   45.26  8888
## x0[6]         38.62    0.03  4.14   30.70   35.32   38.76   42.15   45.16 17545
## x0[7]         27.24    0.11  7.96   20.08   20.95   22.77   33.61   44.27  5399
## x0[8]         23.27    0.02  2.11   20.19   21.58   23.00   24.66   27.93 15926
## x0[9]         35.75    0.04  5.66   25.36   31.23   35.65   40.60   44.97 15985
## x0[10]        34.49    0.05  7.17   20.90   28.61   35.43   40.53   45.00 17375
## x0[11]        37.97    0.03  4.46   29.35   34.62   37.98   41.71   45.12 17430
## theta[1]       7.66    0.00  0.62    6.51    7.22    7.63    8.06    8.94 22366
## log_lik[1]    -4.34    0.00  0.30   -5.04   -4.51   -4.29   -4.12   -3.87 17052
## log_lik[2]    -4.01    0.00  0.22   -4.74   -4.01   -3.95   -3.91   -3.85 17779
## log_lik[3]    -4.77    0.00  0.46   -6.17   -4.89   -4.66   -4.49   -4.25 19109
## log_lik[4]    -3.96    0.00  0.13   -4.29   -4.02   -3.93   -3.88   -3.80 16736
## log_lik[5]   -24.43    0.02  3.66  -32.07  -26.83  -24.25  -21.83  -17.90 23155
## log_lik[6]    -9.30    0.01  1.04  -11.49   -9.97   -9.25   -8.58   -7.41 16412
## log_lik[7]   -19.25    0.02  2.41  -24.15  -20.86  -19.14  -17.54  -14.86 24544
## log_lik[8]    -7.78    0.01  1.01   -9.89   -8.45   -7.71   -7.05   -6.01 23445
## log_lik[9]    -4.68    0.00  0.26   -5.40   -4.69   -4.61   -4.56   -4.49 18286
## log_lik[10]   -6.40    0.01  0.80   -8.21   -6.87   -6.30   -5.83   -5.12 14723
## log_lik[11]   -4.65    0.00  0.11   -4.96   -4.69   -4.63   -4.58   -4.52 14953
## log_lik[12]   -4.73    0.00  0.27   -5.45   -4.76   -4.65   -4.60   -4.53 18832
## log_lik[13]   -4.79    0.01  0.75   -6.99   -4.81   -4.45   -4.35   -4.27  8742
## log_lik[14]   -4.75    0.00  0.31   -5.63   -4.82   -4.62   -4.55   -4.48 12484
## log_lik[15]  -17.10    0.02  2.26  -21.19  -18.52  -17.23  -15.88  -11.51 10341
## log_lik[16]   -5.26    0.00  0.34   -5.99   -5.47   -5.23   -5.01   -4.65 16369
## log_lik[17]  -18.60    0.02  2.10  -24.58  -19.44  -18.29  -17.28  -15.55  8536
## log_lik[18]   -5.46    0.00  0.50   -6.78   -5.66   -5.39   -5.14   -4.76 11065
## log_lik[19]   -4.04    0.00  0.09   -4.27   -4.08   -4.02   -3.98   -3.91 16281
## log_lik[20]   -4.07    0.00  0.23   -4.62   -4.21   -4.04   -3.90   -3.74 21608
## log_lik[21]   -3.96    0.00  0.06   -4.11   -3.99   -3.95   -3.92   -3.86 15370
## log_lik[22]   -4.10    0.00  0.25   -4.85   -4.13   -4.00   -3.95   -3.89 28503
## log_lik[23]   -5.96    0.00  0.48   -7.03   -6.23   -5.91   -5.63   -5.15 18568
## log_lik[24]   -7.91    0.00  0.62   -9.20   -8.31   -7.89   -7.47   -6.74 17441
## log_lik[25]  -15.64    0.02  2.00  -19.79  -16.98  -15.53  -14.20  -12.06 12293
## log_lik[26]   -4.50    0.01  0.47   -5.28   -4.88   -4.60   -3.96   -3.84  5202
## log_lik[27]   -4.49    0.00  0.34   -5.34   -4.65   -4.42   -4.25   -4.06 32628
## log_lik[28]   -4.56    0.00  0.12   -4.88   -4.60   -4.53   -4.49   -4.42 14697
## log_lik[29]   -4.63    0.00  0.23   -5.16   -4.77   -4.59   -4.45   -4.31 19727
## log_lik[30]   -4.39    0.00  0.16   -4.84   -4.42   -4.35   -4.30   -4.24 27979
## log_lik[31]   -4.43    0.00  0.16   -4.88   -4.46   -4.38   -4.34   -4.27 27298
## log_lik[32]   -4.66    0.00  0.20   -5.18   -4.72   -4.60   -4.54   -4.47 17428
## log_lik[33]   -4.79    0.00  0.36   -5.83   -4.88   -4.67   -4.56   -4.46 17283
## log_lik[34]   -5.09    0.01  0.86   -7.14   -5.57   -4.72   -4.48   -4.22 13013
## log_lik[35]   -5.48    0.01  0.80   -7.02   -6.01   -5.51   -4.96   -3.93 15740
## log_lik[36]   -3.98    0.00  0.18   -4.46   -4.05   -3.93   -3.86   -3.77 15905
## log_lik[37]   -4.62    0.00  0.33   -5.50   -4.75   -4.56   -4.40   -4.19 20619
## log_lik[38]   -4.65    0.00  0.27   -5.24   -4.79   -4.61   -4.46   -4.23 17564
## b0           -12.91    0.17 15.74  -64.69  -13.18   -7.03   -5.01   -3.42  8710
```

```
## phi            8.56    0.01  1.16    6.42    7.77    8.51    9.29   10.99 18771
## mu            56.46    0.04  5.34   46.16   52.99   56.39   59.94   67.08 17013
## val1          14.64    0.00  0.00   14.64   14.64   14.64   14.64   14.64     2
## val2           8.03    0.03  4.46    0.88    4.29    8.02   11.38   16.65 17430
## lp__        -312.85    0.04  3.26 -320.03 -314.82 -312.51 -310.49 -307.50  8387
##             Rhat
## y0[1]          1
## y0[2]          1
## x0[1]          1
## x0[2]          1
## x0[3]          1
## x0[4]          1
## x0[5]          1
## x0[6]          1
## x0[7]          1
## x0[8]          1
## x0[9]          1
## x0[10]         1
## x0[11]         1
## theta[1]       1
## log_lik[1]     1
## log_lik[2]     1
## log_lik[3]     1
## log_lik[4]     1
## log_lik[5]     1
## log_lik[6]     1
## log_lik[7]     1
## log_lik[8]     1
## log_lik[9]     1
## log_lik[10]    1
## log_lik[11]    1
## log_lik[12]    1
## log_lik[13]    1
## log_lik[14]    1
## log_lik[15]    1
## log_lik[16]    1
## log_lik[17]    1
## log_lik[18]    1
## log_lik[19]    1
## log_lik[20]    1
## log_lik[21]    1
## log_lik[22]    1
## log_lik[23]    1
## log_lik[24]    1
## log_lik[25]    1
## log_lik[26]    1
## log_lik[27]    1
## log_lik[28]    1
## log_lik[29]    1
## log_lik[30]    1
## log_lik[31]    1
## log_lik[32]    1
## log_lik[33]    1
## log_lik[34]    1
```

```
## log_lik[35]    1
## log_lik[36]    1
## log_lik[37]    1
## log_lik[38]    1
## b0             1
## phi            1
## mu             1
## val1           1
## val2           1
## lp__           1
##
## Samples were drawn using NUTS(diag_e) at Fri Jan 20 17:17:31 2023.
## For each parameter, n_eff is a crude measure of effective sample size,
## and Rhat is the potential scale reduction factor on split chains (at
## convergence, Rhat=1).
## [1] "qpoi: separate, pooled"
##
## TRANSLATING MODEL 'qpoi: separate, pooled' FROM Stan CODE TO C++ CODE NOW.
##
## CHECKING DATA AND PREPROCESSING FOR MODEL 'anon_model' NOW.
##
## COMPILING MODEL 'anon_model' NOW.
##
## STARTING SAMPLER FOR MODEL 'anon_model' NOW.
## Inference for Stan model: anon_model.
## 4 chains, each with iter=15000; warmup=7500; thin=1;
## post-warmup draws per chain=7500, total post-warmup draws=30000.
##
##                mean se_mean    sd    2.5%     25%     50%     75%   97.5% n_eff
## y0[1]        123.37    0.07  8.08  107.73  117.91  123.24  128.79  139.34 12977
## x0[1]         21.75    0.01  1.62   20.06   20.60   21.34   22.47   25.58 21423
## x0[2]         31.44    0.06  3.48   26.62   29.73   30.78   31.92   42.78  3495
## x0[3]         39.18    0.03  3.67   32.81   36.13   39.21   42.31   45.18 13943
## x0[4]         36.92    0.04  5.07   27.44   32.95   37.03   41.16   45.05 18443
## x0[5]         22.12    0.02  1.81   20.07   20.76   21.69   23.04   26.38  9499
## x0[6]         24.86    0.03  3.41   20.23   22.08   24.18   27.34   31.95 14561
## x0[7]         20.89    0.01  1.01   20.02   20.27   20.63   21.21   23.10 12309
## x0[8]         33.19    0.05  4.83   25.92   29.86   32.12   35.33   44.33  8236
## x0[9]         38.66    0.03  4.07   31.05   35.42   38.77   42.11   45.16 16019
## x0[10]        22.09    0.02  2.18   20.06   20.67   21.54   22.90   26.65 14067
## x0[11]        25.27    0.03  3.26   20.28   22.74   24.99   27.41   32.12 16915
## theta[1]       9.39    0.01  0.69    8.12    8.91    9.37    9.84   10.81 18948
## log_lik[1]    -7.25    0.01  0.84   -9.19   -7.73   -7.15   -6.66   -5.88 19788
## log_lik[2]    -4.07    0.00  0.08   -4.22   -4.10   -4.06   -4.02   -3.96 16798
## log_lik[3]    -4.64    0.00  0.18   -5.02   -4.76   -4.64   -4.52   -4.31 18443
## log_lik[4]    -5.04    0.00  0.44   -6.08   -5.25   -4.97   -4.74   -4.41 21405
## log_lik[5]   -14.58    0.03  2.63  -20.56  -16.11  -14.29  -12.76  -10.10  7628
## log_lik[6]   -14.58    0.01  1.07  -16.77  -15.29  -14.55  -13.85  -12.60 16673
## log_lik[7]   -22.85    0.01  1.85  -26.90  -24.01  -22.72  -21.57  -19.57 21071
## log_lik[8]    -9.92    0.01  1.21  -12.38  -10.70   -9.92   -9.10   -7.64 10402
## log_lik[9]    -6.27    0.00  0.47   -7.32   -6.52   -6.22   -5.96   -5.53 15059
## log_lik[10]   -4.50    0.00  0.08   -4.70   -4.54   -4.49   -4.45   -4.40 11337
## log_lik[11]   -6.70    0.00  0.45   -7.65   -6.99   -6.67   -6.38   -5.89 13588
## log_lik[12]   -6.86    0.00  0.49   -7.91   -7.16   -6.83   -6.52   -6.01 14147
```

```
## log_lik[13]   -4.53    0.00  0.23   -5.26   -4.52   -4.46   -4.42   -4.36 21916
## log_lik[14]   -5.93    0.00  0.41   -6.83   -6.15   -5.89   -5.65   -5.28 14375
## log_lik[15]  -15.60    0.02  1.68  -19.23  -16.57  -15.45  -14.48  -12.78 10621
## log_lik[16]   -4.36    0.00  0.12   -4.70   -4.39   -4.32   -4.28   -4.23 26372
## log_lik[17]  -18.07    0.01  1.22  -20.44  -18.86  -18.07  -17.29  -15.72 12921
## log_lik[18]   -5.02    0.00  0.26   -5.53   -5.19   -5.02   -4.85   -4.51 20540
## log_lik[19]   -4.66    0.00  0.34   -5.54   -4.81   -4.59   -4.42   -4.21 23823
## log_lik[20]   -4.49    0.00  0.60   -6.13   -4.68   -4.28   -4.09   -3.92 23582
## log_lik[21]   -6.12    0.01  0.76   -7.71   -6.64   -6.06   -5.54   -4.88 22050
## log_lik[22]   -4.16    0.00  0.14   -4.43   -4.22   -4.14   -4.08   -4.01 11552
## log_lik[23]   -4.93    0.00  0.38   -5.66   -5.22   -4.94   -4.61   -4.33 17651
## log_lik[24]   -5.08    0.00  0.42   -5.93   -5.40   -5.07   -4.71   -4.46 17305
## log_lik[25]  -26.70    0.02  2.39  -31.58  -28.26  -26.63  -25.06  -22.26 14144
## log_lik[26]   -4.02    0.00  0.11   -4.18   -4.05   -4.01   -3.98   -3.92  6725
## log_lik[27]   -4.85    0.01  0.79   -6.65   -5.40   -4.50   -4.21   -4.08  8604
## log_lik[28]   -5.30    0.00  0.28   -5.92   -5.46   -5.27   -5.10   -4.84 12777
## log_lik[29]   -4.75    0.00  0.39   -5.75   -4.96   -4.60   -4.45   -4.38 27373
## log_lik[30]   -4.46    0.00  0.12   -4.80   -4.49   -4.43   -4.40   -4.34 18891
## log_lik[31]   -4.50    0.00  0.13   -4.87   -4.52   -4.46   -4.43   -4.37 19264
## log_lik[32]   -5.78    0.00  0.36   -6.56   -6.00   -5.75   -5.53   -5.18 13520
## log_lik[33]   -5.62    0.00  0.46   -6.85   -5.81   -5.54   -5.33   -5.01 18284
## log_lik[34]   -4.39    0.00  0.15   -4.71   -4.48   -4.38   -4.29   -4.18 14846
## log_lik[35]   -8.68    0.01  1.19  -11.58   -9.29   -8.52   -7.88   -6.86 19841
## log_lik[36]   -4.02    0.00  0.27   -4.55   -4.02   -3.96   -3.92   -3.86 13368
## log_lik[37]   -4.31    0.00  0.16   -4.70   -4.36   -4.26   -4.21   -4.14 11251
## log_lik[38]   -4.36    0.00  0.25   -5.11   -4.39   -4.27   -4.21   -4.15 30198
## b0            -6.18    0.03  3.12   -8.61   -6.63   -5.90   -5.34   -4.65 12258
## phi           10.62    0.01  1.82    7.70    9.28   10.39   11.74   14.68 22553
## mu            88.56    0.09 13.49   68.12   78.21   86.41   96.99  119.20 24541
## val1          14.64    0.00  0.00   14.64   14.64   14.64   14.64   14.64     2
## val2          20.73    0.03  3.26   13.88   18.59   21.01   23.26   25.72 16915
## lp__        -360.13    0.04  3.24 -367.48 -362.10 -359.76 -357.77 -354.95  5508
##             Rhat
## y0[1]          1
## x0[1]          1
## x0[2]          1
## x0[3]          1
## x0[4]          1
## x0[5]          1
## x0[6]          1
## x0[7]          1
## x0[8]          1
## x0[9]          1
## x0[10]         1
## x0[11]         1
## theta[1]       1
## log_lik[1]     1
## log_lik[2]     1
## log_lik[3]     1
## log_lik[4]     1
## log_lik[5]     1
## log_lik[6]     1
## log_lik[7]     1
## log_lik[8]     1
```

```
## log_lik[9]     1
## log_lik[10]    1
## log_lik[11]    1
## log_lik[12]    1
## log_lik[13]    1
## log_lik[14]    1
## log_lik[15]    1
## log_lik[16]    1
## log_lik[17]    1
## log_lik[18]    1
## log_lik[19]    1
## log_lik[20]    1
## log_lik[21]    1
## log_lik[22]    1
## log_lik[23]    1
## log_lik[24]    1
## log_lik[25]    1
## log_lik[26]    1
## log_lik[27]    1
## log_lik[28]    1
## log_lik[29]    1
## log_lik[30]    1
## log_lik[31]    1
## log_lik[32]    1
## log_lik[33]    1
## log_lik[34]    1
## log_lik[35]    1
## log_lik[36]    1
## log_lik[37]    1
## log_lik[38]    1
## b0             1
## phi            1
## mu             1
## val1           1
## val2           1
## lp__           1
##
## Samples were drawn using NUTS(diag_e) at Fri Jan 20 17:17:50 2023.
## For each parameter, n_eff is a crude measure of effective sample size,
## and Rhat is the potential scale reduction factor on split chains (at
## convergence, Rhat=1).
## [1] "qpoi: grouping_1, separate"
##
## TRANSLATING MODEL 'qpoi: grouping_1, separate' FROM Stan CODE TO C++ CODE NOW.
##
## CHECKING DATA AND PREPROCESSING FOR MODEL 'anon_model' NOW.
##
## COMPILING MODEL 'anon_model' NOW.
##
## STARTING SAMPLER FOR MODEL 'anon_model' NOW.
## Inference for Stan model: anon_model.
## 4 chains, each with iter=15000; warmup=7500; thin=1;
## post-warmup draws per chain=7500, total post-warmup draws=30000.
##
```

```
##                mean se_mean    sd    2.5%     25%     50%     75%   97.5% n_eff
## y0[1]         54.23    0.06  9.50   36.70   47.62   53.86   60.45   73.76 24316
## y0[2]        292.74    0.40 40.37  215.96  264.39  292.43  320.65  372.16 10108
## y0[3]        179.40    0.11 17.32  146.86  167.50  179.02  190.88  214.14 24454
## y0[4]        237.40    0.39 42.34  159.18  207.77  235.85  265.69  323.54 12054
## y0[5]         63.48    0.07 10.00   44.26   56.49   63.30   70.04   83.55 22343
## y0[6]        120.87    0.19 20.25   84.03  106.46  119.93  134.30  162.78 11433
## y0[7]         16.25    0.03  5.16   10.22   12.27   14.98   18.94   29.32 27714
## y0[8]        191.32    0.28 28.15  137.61  171.39  191.32  210.64  246.84 10437
## y0[9]        293.98    0.45 50.39  200.83  258.62  292.23  327.95  397.16 12276
## y0[10]        45.21    0.08 12.05   23.75   36.68   44.49   52.96   70.41 24522
## y0[11]       132.68    0.23 27.26   83.56  113.47  131.32  150.50  189.93 13946
## x0[1]         23.35    0.03  2.36   20.13   21.38   22.98   24.95   28.58  6774
## x0[2]         41.09    0.02  2.62   36.40   38.97   41.16   43.31   45.28 15240
## theta[1]       7.08    0.00  0.61    5.97    6.66    7.06    7.48    8.35 22137
## log_lik[1]    -4.30    0.00  0.56   -5.70   -4.58   -4.16   -3.87   -3.65 28021
## log_lik[2]    -4.00    0.00  0.18   -4.50   -4.04   -3.94   -3.88   -3.81 11710
## log_lik[3]    -4.85    0.00  0.58   -6.25   -5.17   -4.74   -4.42   -4.09 18323
## log_lik[4]    -3.98    0.00  0.25   -4.67   -4.05   -3.89   -3.82   -3.75 21239
## log_lik[5]   -31.84    0.03  4.65  -41.31  -34.91  -31.69  -28.61  -23.20 29763
## log_lik[6]    -6.29    0.01  1.01   -8.72   -6.85   -6.11   -5.54   -4.90 24899
## log_lik[7]   -16.55    0.01  2.40  -21.57  -18.10  -16.42  -14.87  -12.20 35811
## log_lik[8]    -6.44    0.00  0.86   -8.39   -6.95   -6.34   -5.83   -5.09 34471
## log_lik[9]    -4.68    0.00  0.23   -5.31   -4.74   -4.60   -4.53   -4.46 15653
## log_lik[10]   -5.68    0.01  0.82   -7.61   -6.15   -5.55   -5.06   -4.49 25035
## log_lik[11]   -4.84    0.00  0.33   -5.72   -4.97   -4.73   -4.60   -4.50 18641
## log_lik[12]   -4.89    0.00  0.37   -5.85   -5.06   -4.78   -4.63   -4.51 19313
## log_lik[13]   -4.52    0.00  0.34   -5.49   -4.60   -4.40   -4.31   -4.23 19851
## log_lik[14]   -4.79    0.00  0.43   -6.00   -4.89   -4.63   -4.53   -4.44 15124
## log_lik[15]  -20.50    0.02  3.50  -27.61  -22.80  -20.42  -18.10  -13.84 21254
## log_lik[16]   -4.95    0.00  0.57   -6.35   -5.27   -4.84   -4.52   -4.18 18203
## log_lik[17]  -17.92    0.01  2.27  -22.71  -19.36  -17.82  -16.33  -13.81 23516
## log_lik[18]   -5.06    0.00  0.61   -6.52   -5.40   -4.95   -4.61   -4.21 18513
## log_lik[19]   -4.05    0.00  0.17   -4.54   -4.10   -4.00   -3.95   -3.88 12905
## log_lik[20]   -4.20    0.00  0.39   -5.17   -4.40   -4.11   -3.90   -3.71 33323
## log_lik[21]   -6.19    0.01  1.20   -8.96   -6.89   -6.02   -5.30   -4.34 30524
## log_lik[22]   -4.12    0.00  0.22   -4.69   -4.22   -4.06   -3.96   -3.87 23577
## log_lik[23]   -5.32    0.00  0.59   -6.69   -5.67   -5.23   -4.88   -4.40 29233
## log_lik[24]   -5.54    0.00  0.71   -7.19   -5.95   -5.43   -5.01   -4.48 28780
## log_lik[25]   -5.25    0.01  1.68   -9.44   -6.14   -4.84   -3.96   -3.23 27130
## log_lik[26]   -6.59    0.01  0.90   -8.00   -7.32   -6.69   -5.95   -4.68 21260
## log_lik[27]   -4.42    0.00  0.36   -5.31   -4.61   -4.34   -4.15   -3.96 35879
## log_lik[28]   -4.59    0.00  0.22   -5.21   -4.65   -4.52   -4.46   -4.38 14632
## log_lik[29]   -4.72    0.00  0.35   -5.59   -4.90   -4.64   -4.45   -4.27 27213
## log_lik[30]   -4.36    0.00  0.16   -4.81   -4.41   -4.32   -4.27   -4.20 17758
## log_lik[31]   -4.40    0.00  0.17   -4.87   -4.45   -4.35   -4.30   -4.23 16897
## log_lik[32]   -4.81    0.00  0.46   -6.13   -4.92   -4.64   -4.53   -4.43 21463
## log_lik[33]   -4.82    0.00  0.46   -6.10   -4.97   -4.65   -4.51   -4.42 18762
## log_lik[34]   -5.49    0.01  1.05   -8.04   -6.06   -5.28   -4.69   -4.11 16032
## log_lik[35]   -4.87    0.01  1.23   -7.91   -5.51   -4.59   -3.92   -3.41 30641
## log_lik[36]   -3.90    0.00  0.19   -4.42   -3.95   -3.84   -3.79   -3.72 16827
## log_lik[37]   -4.24    0.00  0.28   -5.03   -4.31   -4.15   -4.07   -4.00 13184
## log_lik[38]   -4.29    0.00  0.33   -5.24   -4.37   -4.17   -4.09   -4.01 18584
## b0            -5.86    0.01  1.03   -8.00   -6.53   -5.83   -5.14   -3.94 29608
```

```
## phi           14.23    0.02  2.83    9.08   12.24   14.09   16.07   20.13 26719
## mu            85.75    0.09 15.14   57.64   75.30   85.31   95.55  117.13 29607
## val1          14.64    0.00  0.00   14.64   14.64   14.64   14.64   14.64     2
## val2          22.65    0.03  2.36   17.42   21.05   23.02   24.62   25.87  6774
## lp__        -271.90    0.03  2.87 -278.39 -273.60 -271.55 -269.82 -267.34 10117
##             Rhat
## y0[1]          1
## y0[2]          1
## y0[3]          1
## y0[4]          1
## y0[5]          1
## y0[6]          1
## y0[7]          1
## y0[8]          1
## y0[9]          1
## y0[10]         1
## y0[11]         1
## x0[1]          1
## x0[2]          1
## theta[1]       1
## log_lik[1]     1
## log_lik[2]     1
## log_lik[3]     1
## log_lik[4]     1
## log_lik[5]     1
## log_lik[6]     1
## log_lik[7]     1
## log_lik[8]     1
## log_lik[9]     1
## log_lik[10]    1
## log_lik[11]    1
## log_lik[12]    1
## log_lik[13]    1
## log_lik[14]    1
## log_lik[15]    1
## log_lik[16]    1
## log_lik[17]    1
## log_lik[18]    1
## log_lik[19]    1
## log_lik[20]    1
## log_lik[21]    1
## log_lik[22]    1
## log_lik[23]    1
## log_lik[24]    1
## log_lik[25]    1
## log_lik[26]    1
## log_lik[27]    1
## log_lik[28]    1
## log_lik[29]    1
## log_lik[30]    1
## log_lik[31]    1
## log_lik[32]    1
## log_lik[33]    1
## log_lik[34]    1
```

```
## log_lik[35]    1
## log_lik[36]    1
## log_lik[37]    1
## log_lik[38]    1
## b0             1
## phi            1
## mu             1
## val1           1
## val2           1
## lp__           1
##
## Samples were drawn using NUTS(diag_e) at Fri Jan 20 17:18:08 2023.
## For each parameter, n_eff is a crude measure of effective sample size,
## and Rhat is the potential scale reduction factor on split chains (at
## convergence, Rhat=1).
## [1] "qpoi: grouping_1, grouping_1"
##
## TRANSLATING MODEL 'qpoi: grouping_1, grouping_1' FROM Stan CODE TO C++ CODE NOW.
##
## CHECKING DATA AND PREPROCESSING FOR MODEL 'anon_model' NOW.
##
## COMPILING MODEL 'anon_model' NOW.
##
## STARTING SAMPLER FOR MODEL 'anon_model' NOW.
## Inference for Stan model: anon_model.
## 4 chains, each with iter=15000; warmup=7500; thin=1;
## post-warmup draws per chain=7500, total post-warmup draws=30000.
##
##                mean se_mean    sd    2.5%     25%     50%     75%   97.5% n_eff
## y0[1]         58.06    0.04  5.05   48.45   54.65   57.94   61.35   68.29 16998
## y0[2]        178.07    0.11 12.36  155.36  169.61  177.56  186.03  203.86 12022
## x0[1]         29.76    0.01  1.21   26.96   29.07   29.89   30.58   31.86 10773
## x0[2]         40.97    0.02  2.72   35.95   38.81   41.05   43.24   45.28 13803
## theta[1]       7.95    0.00  0.63    6.80    7.51    7.92    8.36    9.24 17551
## log_lik[1]    -4.39    0.00  0.30   -5.07   -4.57   -4.36   -4.18   -3.92 17378
## log_lik[2]    -3.97    0.00  0.07   -4.13   -3.99   -3.96   -3.92   -3.87 15138
## log_lik[3]    -4.58    0.00  0.22   -5.08   -4.71   -4.55   -4.42   -4.22 16378
## log_lik[4]    -4.00    0.00  0.13   -4.33   -4.07   -3.97   -3.91   -3.83 17481
## log_lik[5]   -23.67    0.02  2.39  -28.59  -25.23  -23.61  -22.02  -19.12 22899
## log_lik[6]   -10.45    0.01  1.07  -12.63  -11.15  -10.42   -9.72   -8.42 12856
## log_lik[7]   -18.81    0.01  1.61  -22.12  -19.87  -18.76  -17.68  -15.81 23759
## log_lik[8]    -7.65    0.00  0.62   -8.94   -8.05   -7.62   -7.21   -6.51 30095
## log_lik[9]    -4.68    0.00  0.14   -5.04   -4.73   -4.64   -4.59   -4.52 15248
## log_lik[10]   -5.47    0.00  0.51   -6.67   -5.76   -5.39   -5.09   -4.69 11627
## log_lik[11]   -4.84    0.00  0.21   -5.34   -4.95   -4.79   -4.68   -4.57 14206
## log_lik[12]   -4.89    0.00  0.23   -5.44   -5.02   -4.85   -4.72   -4.59 14071
## log_lik[13]   -4.48    0.00  0.14   -4.83   -4.54   -4.44   -4.38   -4.30 28542
## log_lik[14]   -4.61    0.00  0.09   -4.85   -4.64   -4.59   -4.55   -4.49 15377
## log_lik[15]  -17.35    0.01  1.78  -20.95  -18.52  -17.31  -16.15  -13.96 17001
## log_lik[16]   -5.16    0.00  0.31   -5.84   -5.36   -5.14   -4.94   -4.62 16572
## log_lik[17]  -17.50    0.01  1.44  -20.55  -18.37  -17.43  -16.52  -14.95 17570
## log_lik[18]   -5.28    0.00  0.33   -5.99   -5.48   -5.26   -5.05   -4.70 16864
## log_lik[19]   -4.04    0.00  0.08   -4.23   -4.07   -4.03   -3.99   -3.93 13655
## log_lik[20]   -3.82    0.00  0.08   -4.01   -3.85   -3.80   -3.77   -3.71 12526
```

```
## log_lik[21]   -3.98    0.00  0.06   -4.11   -4.00   -3.97   -3.94   -3.88 13435
## log_lik[22]   -4.98    0.00  0.30   -5.62   -5.17   -4.96   -4.77   -4.46 15742
## log_lik[23]   -7.05    0.00  0.56   -8.21   -7.41   -7.02   -6.66   -6.02 16741
## log_lik[24]   -7.84    0.00  0.62   -9.15   -8.23   -7.80   -7.40   -6.71 17142
## log_lik[25]  -17.37    0.01  1.77  -20.96  -18.54  -17.34  -16.17  -14.01 16832
## log_lik[26]   -3.97    0.00  0.10   -4.22   -4.01   -3.95   -3.91   -3.84 17387
## log_lik[27]   -5.66    0.00  0.48   -6.70   -5.95   -5.62   -5.32   -4.84 29464
## log_lik[28]   -4.61    0.00  0.14   -4.98   -4.66   -4.57   -4.52   -4.45 12526
## log_lik[29]   -4.38    0.00  0.08   -4.58   -4.41   -4.37   -4.33   -4.28 19024
## log_lik[30]   -5.13    0.00  0.37   -5.97   -5.35   -5.08   -4.86   -4.54 30847
## log_lik[31]   -5.16    0.00  0.37   -5.99   -5.38   -5.12   -4.90   -4.57 28538
## log_lik[32]   -4.69    0.00  0.15   -5.07   -4.77   -4.66   -4.59   -4.50 20517
## log_lik[33]   -5.28    0.00  0.31   -5.96   -5.47   -5.25   -5.06   -4.77 28574
## log_lik[34]   -4.49    0.00  0.20   -4.96   -4.61   -4.47   -4.34   -4.17 16135
## log_lik[35]   -5.90    0.00  0.62   -7.22   -6.29   -5.85   -5.47   -4.80 17046
## log_lik[36]   -4.32    0.00  0.20   -4.77   -4.44   -4.30   -4.17   -3.98 15094
## log_lik[37]   -5.32    0.00  0.37   -6.12   -5.55   -5.30   -5.06   -4.67 15814
## log_lik[38]   -4.86    0.00  0.31   -5.57   -5.05   -4.82   -4.63   -4.35 15190
## b0            -3.59    0.00  0.38   -4.37   -3.84   -3.58   -3.33   -2.87 16282
## phi            7.61    0.01  1.06    5.63    6.87    7.57    8.30    9.81 15569
## mu            52.44    0.04  5.45   41.93   48.74   52.40   56.08   63.36 16161
## val1          14.64    0.00  0.00   14.64   14.64   14.64   14.64   14.64     2
## val2          16.24    0.01  1.21   14.14   15.42   16.11   16.93   19.04 10773
## lp__        -330.55    0.02  1.77 -334.89 -331.51 -330.20 -329.25 -328.13  9236
##             Rhat
## y0[1]          1
## y0[2]          1
## x0[1]          1
## x0[2]          1
## theta[1]       1
## log_lik[1]     1
## log_lik[2]     1
## log_lik[3]     1
## log_lik[4]     1
## log_lik[5]     1
## log_lik[6]     1
## log_lik[7]     1
## log_lik[8]     1
## log_lik[9]     1
## log_lik[10]    1
## log_lik[11]    1
## log_lik[12]    1
## log_lik[13]    1
## log_lik[14]    1
## log_lik[15]    1
## log_lik[16]    1
## log_lik[17]    1
## log_lik[18]    1
## log_lik[19]    1
## log_lik[20]    1
## log_lik[21]    1
## log_lik[22]    1
## log_lik[23]    1
## log_lik[24]    1
```

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## log_lik[25]    1
## log_lik[26]    1
## log_lik[27]    1
## log_lik[28]    1
## log_lik[29]    1
## log_lik[30]    1
## log_lik[31]    1
## log_lik[32]    1
## log_lik[33]    1
## log_lik[34]    1
## log_lik[35]    1
## log_lik[36]    1
## log_lik[37]    1
## log_lik[38]    1
## b0             1
## phi            1
## mu             1
## val1           1
## val2           1
## lp__           1
##
## Samples were drawn using NUTS(diag_e) at Fri Jan 20 17:18:21 2023.
## For each parameter, n_eff is a crude measure of effective sample size,
## and Rhat is the potential scale reduction factor on split chains (at
## convergence, Rhat=1).
## [1] "qpoi: grouping_1, pooled"
##
## TRANSLATING MODEL 'qpoi: grouping_1, pooled' FROM Stan CODE TO C++ CODE NOW.
##
## CHECKING DATA AND PREPROCESSING FOR MODEL 'anon_model' NOW.
##
## COMPILING MODEL 'anon_model' NOW.
##
## STARTING SAMPLER FOR MODEL 'anon_model' NOW.
## Inference for Stan model: anon_model.
## 4 chains, each with iter=15000; warmup=7500; thin=1;
## post-warmup draws per chain=7500, total post-warmup draws=30000.
##
##                mean se_mean   sd    2.5%     25%     50%     75%   97.5% n_eff
## y0[1]        122.52    0.07 8.23  106.89  117.00  122.45  127.97  138.93 12425
## x0[1]         30.62    0.01 1.18   28.25   29.91   30.64   31.30   32.91 10861
## x0[2]         21.00    0.02 1.11   20.03   20.31   20.73   21.40   23.29  2434
## theta[1]      10.14    0.00 0.71    8.83    9.66   10.12   10.61   11.61 21147
## log_lik[1]    -6.66    0.00 0.57   -7.87   -7.02   -6.62   -6.26   -5.64 20316
## log_lik[2]    -4.12    0.00 0.07   -4.27   -4.16   -4.12   -4.08   -4.02  5596
## log_lik[3]    -4.74    0.00 0.15   -5.06   -4.84   -4.73   -4.63   -4.47 17174
## log_lik[4]    -4.80    0.00 0.26   -5.38   -4.96   -4.77   -4.61   -4.36 18825
## log_lik[5]   -13.19    0.01 1.31  -15.91  -14.04  -13.14  -12.28  -10.76 27764
## log_lik[6]   -14.01    0.01 1.02  -16.07  -14.68  -13.98  -13.31  -12.12 14777
## log_lik[7]   -21.53    0.01 1.46  -24.50  -22.49  -21.49  -20.51  -18.86 21819
## log_lik[8]    -9.79    0.00 0.67  -11.16  -10.23   -9.78   -9.33   -8.50 28457
## log_lik[9]   -11.61    0.01 0.65  -12.91  -12.04  -11.59  -11.17  -10.39 12858
## log_lik[10]   -4.96    0.00 0.19   -5.39   -5.08   -4.94   -4.82   -4.64 19015
## log_lik[11]   -8.27    0.00 0.53   -9.35   -8.62   -8.25   -7.91   -7.29 20625
```

```
## log_lik[12]  -12.07    0.01 0.70  -13.47  -12.53  -12.06  -11.60  -10.77 14713
## log_lik[13]   -4.74    0.00 0.16   -5.09   -4.83   -4.72   -4.62   -4.49 25032
## log_lik[14]   -5.91    0.00 0.34   -6.63   -6.12   -5.88   -5.67   -5.34 11534
## log_lik[15]  -13.98    0.01 1.17  -16.30  -14.73  -13.95  -13.20  -11.81  9853
## log_lik[16]   -4.34    0.00 0.05   -4.45   -4.36   -4.33   -4.31   -4.26 19110
## log_lik[17]  -17.59    0.01 1.00  -19.60  -18.24  -17.57  -16.92  -15.77  9987
## log_lik[18]   -5.17    0.00 0.20   -5.58   -5.30   -5.16   -5.03   -4.81 14920
## log_lik[19]   -4.46    0.00 0.17   -4.85   -4.56   -4.44   -4.34   -4.20 20106
## log_lik[20]   -5.63    0.00 0.44   -6.59   -5.90   -5.60   -5.33   -4.87 27220
## log_lik[21]   -6.80    0.01 0.63   -8.14   -7.20   -6.77   -6.36   -5.67 14354
## log_lik[22]   -4.23    0.00 0.11   -4.50   -4.28   -4.21   -4.15   -4.08 15399
## log_lik[23]   -4.40    0.00 0.06   -4.53   -4.42   -4.39   -4.36   -4.31 16135
## log_lik[24]   -4.54    0.00 0.08   -4.73   -4.57   -4.53   -4.49   -4.44  5982
## log_lik[25]  -25.26    0.01 2.05  -29.39  -26.62  -25.21  -23.85  -21.34 19500
## log_lik[26]   -4.05    0.00 0.06   -4.17   -4.07   -4.04   -4.01   -3.96  2694
## log_lik[27]   -4.29    0.00 0.12   -4.58   -4.35   -4.27   -4.21   -4.13 20502
## log_lik[28]   -5.31    0.00 0.27   -5.88   -5.47   -5.28   -5.12   -4.87  9911
## log_lik[29]   -4.90    0.00 0.19   -5.32   -5.02   -4.89   -4.77   -4.58 28430
## log_lik[30]   -4.47    0.00 0.06   -4.61   -4.49   -4.46   -4.43   -4.38  9641
## log_lik[31]   -4.51    0.00 0.07   -4.68   -4.54   -4.50   -4.47   -4.41  7251
## log_lik[32]   -6.04    0.00 0.34   -6.77   -6.25   -6.01   -5.80   -5.45 16193
## log_lik[33]   -6.89    0.00 0.43   -7.77   -7.17   -6.87   -6.60   -6.08 29348
## log_lik[34]   -4.49    0.00 0.12   -4.75   -4.56   -4.48   -4.40   -4.29 18960
## log_lik[35]   -7.76    0.00 0.69   -9.21   -8.20   -7.72   -7.27   -6.50 19475
## log_lik[36]   -4.34    0.00 0.18   -4.74   -4.43   -4.32   -4.21   -4.07 14610
## log_lik[37]   -4.47    0.00 0.16   -4.85   -4.55   -4.44   -4.35   -4.25 29323
## log_lik[38]   -4.95    0.00 0.27   -5.53   -5.11   -4.92   -4.76   -4.50 23376
## b0            -8.00    0.01 0.91   -9.16   -8.34   -7.97   -7.61   -6.95  4041
## phi           12.70    0.01 1.28   10.30   11.82   12.65   13.54   15.31 19316
## mu           115.44    0.05 7.29  101.27  110.57  115.48  120.29  129.63 19037
## val1          14.64    0.00 0.00   14.64   14.64   14.64   14.64   14.64     2
## val2          15.38    0.01 1.18   13.09   14.70   15.36   16.09   17.75 10861
## lp__        -382.57    0.02 1.58 -386.54 -383.32 -382.22 -381.43 -380.58  8267
##             Rhat
## y0[1]          1
## x0[1]          1
## x0[2]          1
## theta[1]       1
## log_lik[1]     1
## log_lik[2]     1
## log_lik[3]     1
## log_lik[4]     1
## log_lik[5]     1
## log_lik[6]     1
## log_lik[7]     1
## log_lik[8]     1
## log_lik[9]     1
## log_lik[10]    1
## log_lik[11]    1
## log_lik[12]    1
## log_lik[13]    1
## log_lik[14]    1
## log_lik[15]    1
## log_lik[16]    1
```

```
## log_lik[17]    1
## log_lik[18]    1
## log_lik[19]    1
## log_lik[20]    1
## log_lik[21]    1
## log_lik[22]    1
## log_lik[23]    1
## log_lik[24]    1
## log_lik[25]    1
## log_lik[26]    1
## log_lik[27]    1
## log_lik[28]    1
## log_lik[29]    1
## log_lik[30]    1
## log_lik[31]    1
## log_lik[32]    1
## log_lik[33]    1
## log_lik[34]    1
## log_lik[35]    1
## log_lik[36]    1
## log_lik[37]    1
## log_lik[38]    1
## b0             1
## phi            1
## mu             1
## val1           1
## val2           1
## lp__           1
##
## Samples were drawn using NUTS(diag_e) at Fri Jan 20 17:18:28 2023.
## For each parameter, n_eff is a crude measure of effective sample size,
## and Rhat is the potential scale reduction factor on split chains (at
## convergence, Rhat=1).
## [1] "qpoi: pooled, separate"
##
## TRANSLATING MODEL 'qpoi: pooled, separate' FROM Stan CODE TO C++ CODE NOW.
##
## CHECKING DATA AND PREPROCESSING FOR MODEL 'anon_model' NOW.
##
## COMPILING MODEL 'anon_model' NOW.
##
## STARTING SAMPLER FOR MODEL 'anon_model' NOW.
## Inference for Stan model: anon_model.
## 4 chains, each with iter=15000; warmup=7500; thin=1;
## post-warmup draws per chain=7500, total post-warmup draws=30000.
##
##                mean se_mean    sd    2.5%     25%     50%     75%   97.5% n_eff
## y0[1]         80.21    0.64 18.77   48.02   66.25   79.14   92.66  119.46   854
## y0[2]        282.59    2.43 51.03  187.12  243.27  286.52  319.87  375.21   441
## y0[3]        239.12    1.68 37.72  170.30  211.06  239.06  266.25  311.99   505
## y0[4]        229.42    2.34 51.78  137.42  190.01  229.54  265.98  330.42   491
## y0[5]         93.99    0.75 20.83   57.41   78.49   93.10  108.38  136.51   772
## y0[6]        118.75    0.97 23.94   75.73  100.70  118.36  135.70  166.03   604
## y0[7]         17.40    0.09  6.44   10.26   12.56   15.67   20.47   33.99  5705
```

```
## y0[8]        186.23    1.87 35.91  118.62  158.36  188.94  212.61  251.44   368
## y0[9]        285.05    2.68 60.40  173.23  240.38  285.57  327.95  400.13   509
## y0[10]        65.02    0.59 21.33   30.02   49.48   62.92   78.56  111.99  1287
## y0[11]       128.49    1.41 32.32   71.27  104.44  127.46  150.61  194.23   522
## x0[1]         24.13    0.21  3.66   20.10   21.07   22.68   27.53   31.21   296
## theta[1]       7.76    0.01  0.62    6.61    7.33    7.74    8.16    9.03  2839
## log_lik[1]    -5.13    0.02  0.99   -7.48   -5.68   -4.94   -4.36   -3.80  3434
## log_lik[2]    -4.53    0.01  0.43   -5.55   -4.77   -4.45   -4.20   -3.95  3416
## log_lik[3]    -5.76    0.01  0.74   -7.41   -6.21   -5.69   -5.22   -4.58  3197
## log_lik[4]    -4.14    0.01  0.36   -5.12   -4.27   -4.00   -3.89   -3.80  4356
## log_lik[5]   -29.85    0.08  4.60  -39.49  -32.86  -29.62  -26.68  -21.46  2930
## log_lik[6]    -6.64    0.05  1.28   -9.86   -7.32   -6.37   -5.69   -4.97   555
## log_lik[7]   -15.59    0.04  2.31  -20.37  -17.09  -15.47  -13.97  -11.34  4079
## log_lik[8]    -6.34    0.01  0.84   -8.24   -6.85   -6.24   -5.72   -4.99  3798
## log_lik[9]    -6.21    0.02  0.84   -8.06   -6.75   -6.14   -5.61   -4.78  1171
## log_lik[10]   -7.23    0.04  1.44  -10.52   -8.07   -7.06   -6.17   -4.97  1498
## log_lik[11]   -4.76    0.00  0.24   -5.45   -4.82   -4.68   -4.61   -4.54  5777
## log_lik[12]   -6.32    0.03  0.89   -8.28   -6.89   -6.24   -5.67   -4.81  1178
## log_lik[13]   -4.57    0.01  0.36   -5.59   -4.65   -4.44   -4.35   -4.28  5012
## log_lik[14]   -4.86    0.01  0.46   -6.12   -4.97   -4.69   -4.58   -4.49  2185
## log_lik[15]  -14.76    0.05  2.71  -20.34  -16.52  -14.65  -12.87   -9.86  2669
## log_lik[16]   -4.44    0.01  0.34   -5.39   -4.55   -4.32   -4.22   -4.13  1700
## log_lik[17]  -22.68    0.04  2.16  -27.09  -24.09  -22.60  -21.18  -18.67  2320
## log_lik[18]   -5.83    0.01  0.76   -7.53   -6.29   -5.74   -5.28   -4.62  2646
## log_lik[19]   -4.24    0.00  0.33   -5.16   -4.34   -4.12   -4.02   -3.94  5176
## log_lik[20]   -4.25    0.01  0.42   -5.31   -4.46   -4.15   -3.94   -3.76  2040
## log_lik[21]   -5.91    0.03  1.15   -8.64   -6.57   -5.73   -5.05   -4.20  1972
## log_lik[22]   -4.14    0.00  0.21   -4.69   -4.23   -4.08   -3.99   -3.91  5350
## log_lik[23]   -5.21    0.01  0.57   -6.52   -5.55   -5.13   -4.79   -4.35  2754
## log_lik[24]   -5.45    0.01  0.67   -7.02   -5.83   -5.34   -4.94   -4.46  3638
## log_lik[25]   -4.70    0.03  1.73   -9.05   -5.55   -4.28   -3.44   -2.58  4179
## log_lik[26]   -7.95    0.03  0.98   -9.56   -8.68   -8.03   -7.30   -5.83   951
## log_lik[27]   -4.45    0.01  0.36   -5.34   -4.63   -4.37   -4.18   -4.01  4970
## log_lik[28]   -4.69    0.02  0.31   -5.57   -4.75   -4.58   -4.51   -4.44   367
## log_lik[29]   -4.71    0.01  0.33   -5.57   -4.88   -4.64   -4.46   -4.31  3513
## log_lik[30]   -4.41    0.00  0.17   -4.88   -4.46   -4.36   -4.31   -4.25  6812
## log_lik[31]   -4.45    0.00  0.17   -4.93   -4.50   -4.40   -4.35   -4.28  6928
## log_lik[32]   -4.85    0.01  0.44   -6.09   -4.97   -4.68   -4.57   -4.48  7204
## log_lik[33]   -4.84    0.01  0.43   -6.04   -4.97   -4.68   -4.55   -4.47  4855
## log_lik[34]   -6.21    0.03  1.20   -9.01   -6.88   -6.05   -5.33   -4.44  2061
## log_lik[35]   -5.10    0.02  1.38   -8.57   -5.82   -4.77   -4.05   -3.46  4989
## log_lik[36]   -3.95    0.00  0.18   -4.46   -3.99   -3.89   -3.83   -3.77  6132
## log_lik[37]   -4.29    0.00  0.28   -5.06   -4.36   -4.19   -4.12   -4.05  4087
## log_lik[38]   -4.34    0.00  0.33   -5.28   -4.41   -4.22   -4.14   -4.06  6546
## b0            -5.88    0.02  1.09   -8.15   -6.58   -5.83   -5.11   -3.88  4100
## phi           12.82    0.04  2.61    8.16   11.01   12.66   14.48   18.35  4646
## mu            85.94    0.25 15.92   56.68   74.80   85.20   96.26  119.17  3922
## val1          14.64    0.00  0.00   14.64   14.64   14.64   14.64   14.64     2
## val2          21.87    0.21  3.66   14.79   18.47   23.32   24.93   25.90   296
## lp__        -283.49    0.05  2.72 -289.77 -285.07 -283.10 -281.53 -279.28  3229
##             Rhat
## y0[1]       1.00
## y0[2]       1.01
## y0[3]       1.01
```

```
## y0[4]       1.01
## y0[5]       1.00
## y0[6]       1.00
## y0[7]       1.00
## y0[8]       1.01
## y0[9]       1.01
## y0[10]      1.00
## y0[11]      1.01
## x0[1]       1.01
## theta[1]    1.00
## log_lik[1]  1.00
## log_lik[2]  1.00
## log_lik[3]  1.00
## log_lik[4]  1.00
## log_lik[5]  1.00
## log_lik[6]  1.01
## log_lik[7]  1.00
## log_lik[8]  1.00
## log_lik[9]  1.00
## log_lik[10] 1.00
## log_lik[11] 1.00
## log_lik[12] 1.00
## log_lik[13] 1.00
## log_lik[14] 1.00
## log_lik[15] 1.00
## log_lik[16] 1.00
## log_lik[17] 1.00
## log_lik[18] 1.00
## log_lik[19] 1.00
## log_lik[20] 1.00
## log_lik[21] 1.00
## log_lik[22] 1.00
## log_lik[23] 1.00
## log_lik[24] 1.00
## log_lik[25] 1.00
## log_lik[26] 1.00
## log_lik[27] 1.00
## log_lik[28] 1.01
## log_lik[29] 1.00
## log_lik[30] 1.00
## log_lik[31] 1.00
## log_lik[32] 1.00
## log_lik[33] 1.00
## log_lik[34] 1.00
## log_lik[35] 1.00
## log_lik[36] 1.00
## log_lik[37] 1.00
## log_lik[38] 1.00
## b0          1.00
## phi         1.00
## mu          1.00
## val1        1.00
## val2        1.01
## lp__        1.00
```

```
##
## Samples were drawn using NUTS(diag_e) at Fri Jan 20 17:18:41 2023.
## For each parameter, n_eff is a crude measure of effective sample size,
## and Rhat is the potential scale reduction factor on split chains (at
## convergence, Rhat=1).
## [1] "qpoi: pooled, grouping_1"
##
## TRANSLATING MODEL 'qpoi: pooled, grouping_1' FROM Stan CODE TO C++ CODE NOW.
##
## CHECKING DATA AND PREPROCESSING FOR MODEL 'anon_model' NOW.
##
## COMPILING MODEL 'anon_model' NOW.
##
## STARTING SAMPLER FOR MODEL 'anon_model' NOW.
## Inference for Stan model: anon_model.
## 4 chains, each with iter=15000; warmup=7500; thin=1;
## post-warmup draws per chain=7500, total post-warmup draws=30000.
##
##                mean se_mean    sd    2.5%     25%     50%     75%   97.5% n_eff
## y0[1]         61.47    0.12  6.90   49.18   57.00   61.19   65.42   75.66  3578
## y0[2]        174.07    0.34 17.53  144.25  163.13  173.20  183.17  209.09  2671
## x0[1]         31.68    0.11  3.45   27.48   30.19   30.99   32.02   42.87   939
## theta[1]       8.30    0.01  0.64    7.13    7.86    8.28    8.71    9.62 12196
## log_lik[1]    -4.57    0.01  0.39   -5.47   -4.80   -4.53   -4.29   -3.95  4244
## log_lik[2]    -4.25    0.00  0.19   -4.67   -4.36   -4.23   -4.11   -3.94  3342
## log_lik[3]    -5.22    0.01  0.36   -5.98   -5.45   -5.21   -4.97   -4.57  4229
## log_lik[4]    -4.09    0.00  0.17   -4.51   -4.18   -4.05   -3.96   -3.86  5456
## log_lik[5]   -24.87    0.04  2.70  -30.56  -26.58  -24.73  -23.01  -19.94  4603
## log_lik[6]   -10.64    0.03  1.32  -13.39  -11.49  -10.58   -9.75   -8.13  2533
## log_lik[7]   -18.03    0.03  1.70  -21.64  -19.11  -17.92  -16.84  -15.00  3315
## log_lik[8]    -7.03    0.01  0.59   -8.26   -7.42   -7.01   -6.62   -5.95  6996
## log_lik[9]    -5.71    0.01  0.42   -6.59   -5.97   -5.69   -5.41   -4.94  4009
## log_lik[10]   -5.30    0.01  0.58   -6.74   -5.59   -5.20   -4.88   -4.50  3591
## log_lik[11]   -4.96    0.01  0.30   -5.75   -5.11   -4.88   -4.73   -4.60  1762
## log_lik[12]   -5.82    0.00  0.41   -6.72   -6.08   -5.79   -5.52   -5.12 16608
## log_lik[13]   -4.64    0.00  0.21   -5.17   -4.75   -4.59   -4.48   -4.36  7267
## log_lik[14]   -4.67    0.00  0.15   -5.11   -4.71   -4.63   -4.58   -4.52  1646
## log_lik[15]  -13.59    0.03  1.65  -17.08  -14.65  -13.50  -12.45  -10.59  4106
## log_lik[16]   -4.99    0.01  0.34   -5.74   -5.19   -4.95   -4.75   -4.44  3097
## log_lik[17]  -21.58    0.05  1.97  -25.08  -22.87  -21.74  -20.56  -16.81  1676
## log_lik[18]   -5.89    0.00  0.43   -6.81   -6.17   -5.87   -5.58   -5.10  8684
## log_lik[19]   -4.05    0.00  0.07   -4.24   -4.08   -4.04   -4.01   -3.95  4884
## log_lik[20]   -3.84    0.00  0.10   -4.12   -3.87   -3.82   -3.79   -3.73  1693
## log_lik[21]   -4.02    0.00  0.09   -4.25   -4.05   -4.00   -3.97   -3.91 10602
## log_lik[22]   -4.59    0.01  0.28   -5.15   -4.77   -4.59   -4.42   -4.00  1898
## log_lik[23]   -6.31    0.00  0.48   -7.32   -6.62   -6.29   -5.97   -5.45 12579
## log_lik[24]   -7.31    0.01  0.61   -8.62   -7.69   -7.28   -6.89   -6.23  3654
## log_lik[25]  -17.83    0.03  2.07  -22.04  -19.17  -17.77  -16.41  -13.93  4147
## log_lik[26]   -3.95    0.00  0.07   -4.14   -3.99   -3.94   -3.91   -3.85 12705
## log_lik[27]   -6.28    0.03  1.04   -9.46   -6.50   -6.02   -5.65   -5.08  1016
## log_lik[28]   -4.62    0.00  0.15   -5.03   -4.66   -4.58   -4.53   -4.47  9627
## log_lik[29]   -4.50    0.00  0.18   -5.00   -4.55   -4.44   -4.39   -4.32  1826
## log_lik[30]   -5.33    0.01  0.41   -6.25   -5.59   -5.29   -5.03   -4.65  6639
## log_lik[31]   -5.26    0.01  0.42   -6.17   -5.52   -5.23   -4.96   -4.56  3591
```

```
## log_lik[32]   -4.67    0.00  0.14   -5.06   -4.73   -4.63   -4.58   -4.51  2284
## log_lik[33]   -5.02    0.00  0.27   -5.63   -5.19   -5.00   -4.83   -4.60  6053
## log_lik[34]   -4.86    0.00  0.29   -5.50   -5.03   -4.83   -4.65   -4.37 11905
## log_lik[35]   -6.11    0.01  0.72   -7.62   -6.57   -6.07   -5.60   -4.81  4025
## log_lik[36]   -4.10    0.00  0.15   -4.45   -4.19   -4.08   -3.99   -3.86  5753
## log_lik[37]   -4.87    0.00  0.29   -5.52   -5.06   -4.85   -4.66   -4.38 11020
## log_lik[38]   -4.58    0.00  0.23   -5.12   -4.72   -4.55   -4.41   -4.22  5665
## b0            -5.27    0.14  6.10  -17.16   -4.48   -4.14   -3.85   -3.33  1987
## phi            8.05    0.01  1.06    6.08    7.31    8.00    8.74   10.24  7824
## mu            58.28    0.07  5.58   47.59   54.47   58.20   61.98   69.41  6109
## val1          14.64    0.00  0.00   14.64   14.64   14.64   14.64   14.64     2
## val2          14.32    0.11  3.45    3.13   13.98   15.01   15.81   18.52   939
## lp__        -338.34    0.05  1.97 -343.33 -339.27 -337.77 -336.90 -336.00  1581
##             Rhat
## y0[1]          1
## y0[2]          1
## x0[1]          1
## theta[1]       1
## log_lik[1]     1
## log_lik[2]     1
## log_lik[3]     1
## log_lik[4]     1
## log_lik[5]     1
## log_lik[6]     1
## log_lik[7]     1
## log_lik[8]     1
## log_lik[9]     1
## log_lik[10]    1
## log_lik[11]    1
## log_lik[12]    1
## log_lik[13]    1
## log_lik[14]    1
## log_lik[15]    1
## log_lik[16]    1
## log_lik[17]    1
## log_lik[18]    1
## log_lik[19]    1
## log_lik[20]    1
## log_lik[21]    1
## log_lik[22]    1
## log_lik[23]    1
## log_lik[24]    1
## log_lik[25]    1
## log_lik[26]    1
## log_lik[27]    1
## log_lik[28]    1
## log_lik[29]    1
## log_lik[30]    1
## log_lik[31]    1
## log_lik[32]    1
## log_lik[33]    1
## log_lik[34]    1
## log_lik[35]    1
## log_lik[36]    1
```

```
## log_lik[37]    1
## log_lik[38]    1
## b0             1
## phi            1
## mu             1
## val1           1
## val2           1
## lp__           1
##
## Samples were drawn using NUTS(diag_e) at Fri Jan 20 17:18:55 2023.
## For each parameter, n_eff is a crude measure of effective sample size,
## and Rhat is the potential scale reduction factor on split chains (at
## convergence, Rhat=1).
## [1] "qpoi: pooled, pooled"
##
## TRANSLATING MODEL 'qpoi: pooled, pooled' FROM Stan CODE TO C++ CODE NOW.
##
## CHECKING DATA AND PREPROCESSING FOR MODEL 'anon_model' NOW.
##
## COMPILING MODEL 'anon_model' NOW.
##
## STARTING SAMPLER FOR MODEL 'anon_model' NOW.
## Inference for Stan model: anon_model.
## 4 chains, each with iter=15000; warmup=7500; thin=1;
## post-warmup draws per chain=7500, total post-warmup draws=30000.
##
##                mean se_mean    sd    2.5%     25%     50%     75%   97.5% n_eff
## y0[1]         95.96    0.12  7.76   81.59   90.76   95.83  100.87  110.89  3884
## x0[1]         33.34    0.07  3.22   30.09   31.60   32.49   33.48   43.39  2423
## theta[1]      10.49    0.01  0.72    9.15    9.99   10.46   10.95   11.98 10048
## log_lik[1]    -6.89    0.01  0.70   -8.36   -7.33   -6.86   -6.39   -5.65  5047
## log_lik[2]    -4.31    0.00  0.23   -4.95   -4.36   -4.24   -4.16   -4.07  3180
## log_lik[3]    -4.28    0.00  0.05   -4.38   -4.30   -4.27   -4.25   -4.20  8314
## log_lik[4]    -5.71    0.01  0.49   -6.74   -6.02   -5.68   -5.36   -4.85  5174
## log_lik[5]   -11.19    0.01  1.08  -13.42  -11.90  -11.16  -10.45   -9.16 15309
## log_lik[6]   -16.78    0.02  1.19  -19.19  -17.56  -16.74  -15.96  -14.52  6289
## log_lik[7]   -24.33    0.02  1.64  -27.71  -25.40  -24.27  -23.20  -21.30  7969
## log_lik[8]   -10.68    0.01  0.67  -12.07  -11.11  -10.65  -10.22   -9.45 16679
## log_lik[9]    -8.69    0.00  0.55   -9.83   -9.05   -8.67   -8.31   -7.69 13070
## log_lik[10]   -5.05    0.00  0.24   -5.59   -5.20   -5.02   -4.88   -4.66  4385
## log_lik[11]   -8.29    0.01  0.60   -9.52   -8.68   -8.26   -7.88   -7.20  5004
## log_lik[12]   -9.07    0.00  0.55  -10.20   -9.42   -9.04   -8.69   -8.06 16560
## log_lik[13]   -5.06    0.00  0.20   -5.50   -5.18   -5.04   -4.92   -4.72 19806
## log_lik[14]   -7.28    0.01  0.50   -8.34   -7.61   -7.25   -6.93   -6.40  5050
## log_lik[15]  -20.00    0.02  1.76  -23.59  -21.15  -19.96  -18.80  -16.68 10280
## log_lik[16]   -4.36    0.00  0.06   -4.51   -4.39   -4.35   -4.33   -4.28  5638
## log_lik[17]  -13.80    0.02  1.36  -15.85  -14.67  -14.04  -13.31  -10.42  3203
## log_lik[18]   -4.41    0.00  0.08   -4.60   -4.45   -4.40   -4.36   -4.30 13857
## log_lik[19]   -4.86    0.00  0.30   -5.54   -5.05   -4.84   -4.64   -4.36  5298
## log_lik[20]   -5.07    0.01  0.41   -6.04   -5.29   -5.01   -4.78   -4.45  5313
## log_lik[21]   -5.11    0.01  0.37   -5.93   -5.34   -5.08   -4.84   -4.49  4833
## log_lik[22]   -4.19    0.00  0.18   -4.76   -4.18   -4.13   -4.10   -4.05  2603
## log_lik[23]   -4.53    0.00  0.10   -4.77   -4.58   -4.51   -4.45   -4.37 15001
## log_lik[24]   -5.02    0.00  0.23   -5.54   -5.16   -4.99   -4.86   -4.66  4390
```

```
## log_lik[25]  -23.82    0.03  2.20  -28.26  -25.29  -23.79  -22.31  -19.68  5134
## log_lik[26]   -4.82    0.00  0.27   -5.42   -5.00   -4.80   -4.63   -4.36 17168
## log_lik[27]   -4.22    0.00  0.11   -4.57   -4.23   -4.19   -4.15   -4.10  3089
## log_lik[28]   -6.45    0.01  0.42   -7.35   -6.73   -6.43   -6.15   -5.70  4767
## log_lik[29]   -5.24    0.00  0.24   -5.76   -5.40   -5.22   -5.07   -4.83 12316
## log_lik[30]   -4.71    0.00  0.15   -5.06   -4.79   -4.69   -4.60   -4.48  4685
## log_lik[31]   -4.89    0.00  0.20   -5.35   -5.01   -4.86   -4.74   -4.58  4334
## log_lik[32]   -7.17    0.01  0.46   -8.16   -7.46   -7.14   -6.84   -6.36  5108
## log_lik[33]   -7.54    0.00  0.45   -8.49   -7.84   -7.52   -7.23   -6.73 16920
## log_lik[34]   -4.30    0.00  0.07   -4.47   -4.33   -4.29   -4.25   -4.20 19364
## log_lik[35]   -9.55    0.01  1.04  -11.68  -10.24   -9.53   -8.82   -7.64  5239
## log_lik[36]   -4.27    0.01  0.40   -5.51   -4.23   -4.12   -4.06   -3.97  2513
## log_lik[37]   -4.30    0.00  0.07   -4.46   -4.33   -4.29   -4.25   -4.20 18622
## log_lik[38]   -4.40    0.00  0.11   -4.67   -4.46   -4.38   -4.32   -4.24  7136
## b0            -9.47    0.18 10.83  -33.57   -7.65   -7.17   -6.80   -6.17  3514
## phi           10.07    0.01  1.07    8.07    9.33   10.04   10.78   12.27  6143
## mu            95.02    0.10  6.79   81.52   90.41   95.14   99.67  108.03  4927
## val1          14.64    0.00  0.00   14.64   14.64   14.64   14.64   14.64     2
## val2          12.66    0.07  3.22    2.61   12.52   13.51   14.40   15.91  2423
## lp__        -391.12    0.03  1.73 -395.44 -392.02 -390.52 -389.83 -389.31  2517
##             Rhat
## y0[1]          1
## x0[1]          1
## theta[1]       1
## log_lik[1]     1
## log_lik[2]     1
## log_lik[3]     1
## log_lik[4]     1
## log_lik[5]     1
## log_lik[6]     1
## log_lik[7]     1
## log_lik[8]     1
## log_lik[9]     1
## log_lik[10]    1
## log_lik[11]    1
## log_lik[12]    1
## log_lik[13]    1
## log_lik[14]    1
## log_lik[15]    1
## log_lik[16]    1
## log_lik[17]    1
## log_lik[18]    1
## log_lik[19]    1
## log_lik[20]    1
## log_lik[21]    1
## log_lik[22]    1
## log_lik[23]    1
## log_lik[24]    1
## log_lik[25]    1
## log_lik[26]    1
## log_lik[27]    1
## log_lik[28]    1
## log_lik[29]    1
## log_lik[30]    1
```

```
## log_lik[31]    1
## log_lik[32]    1
## log_lik[33]    1
## log_lik[34]    1
## log_lik[35]    1
## log_lik[36]    1
## log_lik[37]    1
## log_lik[38]    1
## b0             1
## phi            1
## mu             1
## val1           1
## val2           1
## lp__           1
##
## Samples were drawn using NUTS(diag_e) at Fri Jan 20 17:19:06 2023.
## For each parameter, n_eff is a crude measure of effective sample size,
## and Rhat is the potential scale reduction factor on split chains (at
## convergence, Rhat=1).
```

```
## save(file = "fit_tbl.Rda", fit_tbl)
qpoisson_fit_tbl <- fit_tbl
```

- Models fit without any warnings.

Negative Binomial

```
iter <- 15000
tmax <- 46
t0max <- tmax - 0.5;
t0min <- 20;
## values to use for model predictions
tp = seq(25, tmax, length.out = 100)
n_cores <- 4
n_chains <- n_cores

##y0_grouping <- map_int(data$male, ~ if_else(. %in% y0_group[[1]], 1, 2))
model <- "nb"
stan_file <- "two.piece_nb_1.0.stan"
## For debugging
##cmodel <- cmdstan_model(stan_file = stan_file)

stan_model(file = stan_file,
           verbose = TRUE)
```

```
##
## TRANSLATING MODEL '' FROM Stan CODE TO C++ CODE NOW.
```

```
## Define groups

flags <- c("separate", "grouping_1", "pooled")
```

```
flags_x <- flags
flags_y <- flags
fit_tbl <- crossing(model = model,
                    x0 = flags_x, y0 = flags_y,
                    desc = "NA_character",
                    y0_group_list = list(NA),
                    x0_group_list = list(NA),
                    fit = list(NA),
                    llik = list(NA),
                    r_eff = list(NA),
                    loo = list(NA)
                    )



for(x_flag in flags_x) {
    for(y_flag in flags_y) {

        desc <- paste0(model, ": ", x_flag, ", ", y_flag)
        curr_row <- which(fit_tbl$x0 == x_flag & fit_tbl$y0 == y_flag)

        fit_tbl[ curr_row, ]$desc <- desc
        print(desc)

        x0_group_list <- list()
        y0_group_list <- list()

        switch(x_flag,
               separate = {
                   x0_group_list <- data$male %>% unique() %>% as.list()
               },
               grouping_1 = {
                   ## set up groupings based on 2022-12-20 analysis
                   ## Using male ID's instead index to make code more robust
                   x0_group_list[[1]] <- c("T235", "T237", "T244", "T247", "T257", "T260")
                   x0_group_list[[2]] <- c("T234", "T236", "T243", "T246", "T258")
               },
               pooled = {
                   x0_group_list[[1]] <- data$male
               }
               )

        switch(y_flag,
               separate = {
                   y0_group_list <- data$male %>% unique() %>% as.list()
               },
               grouping_1 = {
                   ## set up groupings based on 2022-12-20 analysis
                   ## Using male ID's instead index to make code more robust
                   y0_group_list[[1]] <- c("T234", "T243", "T244", "T246", "T258", "T260")
                   y0_group_list[[2]] <- c("T235", "T236", "T237", "T247", "T257")
               },
               pooled = {
```

```
                y0_group_list[[1]] <- data$male
            }
            )

        fit_tbl[ curr_row, ]$x0_group_list[[1]] <- x0_group_list

        fit_tbl[ curr_row, ]$y0_group_list[[1]] <- y0_group_list

        ## Convert lists to a vector of concatenated strings
        ## This will simplify mapping male to an x0/y0 index
        x0_group <-lapply(x0_group_list, paste, collapse = " ") %>% unlist()
        y0_group <-lapply(y0_group_list, paste, collapse = " ") %>% unlist()

        x0_index <- sapply(as.character(data$male), function(x) str_which(x0_group, x))
        y0_index <- sapply(as.character(data$male), function(x) str_which(y0_group, x))

        fit <- stan(file = stan_file,
                    model_name = desc,
                    data=list(x = temp,
                              y = motif_count,
                              N = N,
                              X = length(x0_group),
                              Y = length(y0_group),
                              NB = 1,
                              xx = x0_index,
                              yy = y0_index,
                              nbb = rep(1,N),
                              xmax = tmax,
                              x0_min = t0min,
                              x0_max = t0max,
                              y_xmax = 0,
                              y0_min = 10,
                              sd_y0_prior = 200,
                              alpha_theta_prior = 10,
                              alpha_phi_prior = 10,
                              ##tp = tp,
                              ## max threshold value.
                              ## having it too close to xmax *sometimes* leads to sampling
                              ## near xmax, but with lower lp and very high E13) b0 values
                              y_xmax = 0),
                    cores = n_cores,
                    chains = n_chains,
                    iter = iter,
                    warmup = floor(iter/2),
                    verbose = FALSE)

        fit_tbl[ curr_row, ]$fit <- list(fit)

    }
}
```

```
## [1] "nb: separate, separate"
## [1] "nb: separate, grouping_1"
```

```
## [1] "nb: separate, pooled"
## [1] "nb: grouping_1, separate"
## [1] "nb: grouping_1, grouping_1"
## [1] "nb: grouping_1, pooled"
## [1] "nb: pooled, separate"
## [1] "nb: pooled, grouping_1"
## [1] "nb: pooled, pooled"
```

```
nb_fit_tbl <- fit_tbl

## save(file = "fit_tbl.Rda", fit_tbl)
```

Model Comparison

LOO Analysis

```
fit_tbl <- bind_rows(qpoisson_fit_tbl, nb_fit_tbl, .id = NULL)

for(curr_row in 1:length(fit_tbl$fit)) {

  desc <- fit_tbl[[curr_row, "desc"]]
  fit <- fit_tbl[[curr_row, "fit"]][[1]]
  print(paste0("Model ", curr_row, ": ", desc))

  # loo analysis based on: http://mc-stan.org/loo/articles/loo2-with-rstan.html
  #
  # Extract pointwise log-likelihood
  # using merge_chains=FALSE returns an array, which is easier to
  # use with relative_eff()
  llik <- extract_log_lik(fit, merge_chains = FALSE)
  fit_tbl[[curr_row, "llik"]] <- list(llik)

  # as of loo v2.0.0 we can optionally provide relative effective sample sizes
  # when calling loo, which allows for better estimates of the PSIS effective
  # sample sizes and Monte Carlo error
  r_eff <- relative_eff(exp(llik), cores = n_cores)
  fit_tbl[[curr_row, "r_eff"]] <- list(r_eff)

  # preferably use more than 2 cores (as many cores as possible)
  # will use value of 'mc.cores' option if cores is not specified
  loo <- loo(llik, r_eff = r_eff,
             cores = n_cores,
             save_psis = TRUE,
             moment_match = TRUE)
  fit_tbl[[curr_row, "loo"]] <- list(loo)
  print(loo)

}
```

```
## [1] "Model 1: qpoi: grouping_1, grouping_1"
```

```
##
## Computed from 30000 by 38 log-likelihood matrix
##
##          Estimate   SE
## elpd_loo   -276.6 34.8
## p_loo        21.6  7.5
## looic       553.2 69.5
## ------
## Monte Carlo SE of elpd_loo is NA.
##
## Pareto k diagnostic values:
##                          Count Pct.    Min. n_eff
## (-Inf, 0.5]   (good)     34    89.5%   999
##  (0.5, 0.7]   (ok)        2     5.3%   536
##    (0.7, 1]   (bad)       2     5.3%   95
##    (1, Inf)   (very bad)  0     0.0%   <NA>
## See help('pareto-k-diagnostic') for details.
## [1] "Model 2: qpoi: grouping_1, pooled"
##
## Computed from 30000 by 38 log-likelihood matrix
##
##          Estimate   SE
## elpd_loo   -298.2 34.1
## p_loo        16.7  5.3
## looic       596.3 68.3
## ------
## Monte Carlo SE of elpd_loo is NA.
##
## Pareto k diagnostic values:
##                          Count Pct.    Min. n_eff
## (-Inf, 0.5]   (good)     33    86.8%   378
##  (0.5, 0.7]   (ok)        3     7.9%   1000
##    (0.7, 1]   (bad)       1     2.6%   173
##    (1, Inf)   (very bad)  1     2.6%   12
## See help('pareto-k-diagnostic') for details.
## [1] "Model 3: qpoi: grouping_1, separate"
##
## Computed from 30000 by 38 log-likelihood matrix
##
##          Estimate   SE
## elpd_loo   -290.8 49.1
## p_loo        61.0 24.0
## looic       581.6 98.2
## ------
## Monte Carlo SE of elpd_loo is NA.
##
## Pareto k diagnostic values:
##                          Count Pct.    Min. n_eff
## (-Inf, 0.5]   (good)     25    65.8%   9517
##  (0.5, 0.7]   (ok)        5    13.2%   1476
##    (0.7, 1]   (bad)       4    10.5%   42
##    (1, Inf)   (very bad)  4    10.5%   2
## See help('pareto-k-diagnostic') for details.
## [1] "Model 4: qpoi: pooled, grouping_1"
```

```
##
## Computed from 30000 by 38 log-likelihood matrix
##
##          Estimate   SE
## elpd_loo   -284.3 37.0
## p_loo        29.0  9.8
## looic       568.7 74.0
## ------
## Monte Carlo SE of elpd_loo is NA.
##
## Pareto k diagnostic values:
##                          Count Pct.    Min. n_eff
## (-Inf, 0.5]   (good)     32    84.2%   188
##  (0.5, 0.7]   (ok)        3     7.9%   135
##    (0.7, 1]   (bad)       2     5.3%   48
##    (1, Inf)   (very bad)  1     2.6%   54
## See help('pareto-k-diagnostic') for details.
## [1] "Model 5: qpoi: pooled, pooled"
##
## Computed from 30000 by 38 log-likelihood matrix
##
##          Estimate   SE
## elpd_loo   -305.8 36.2
## p_loo        20.8  6.7
## looic       611.6 72.4
## ------
## Monte Carlo SE of elpd_loo is NA.
##
## Pareto k diagnostic values:
##                          Count Pct.    Min. n_eff
## (-Inf, 0.5]   (good)     35    92.1%   568
##  (0.5, 0.7]   (ok)        2     5.3%   252
##    (0.7, 1]   (bad)       0     0.0%   <NA>
##    (1, Inf)   (very bad)  1     2.6%   18
## See help('pareto-k-diagnostic') for details.
## [1] "Model 6: qpoi: pooled, separate"
##
## Computed from 30000 by 38 log-likelihood matrix
##
##          Estimate   SE
## elpd_loo   -298.5 45.2
## p_loo        62.8 21.8
## looic       597.0 90.5
## ------
## Monte Carlo SE of elpd_loo is NA.
##
## Pareto k diagnostic values:
##                          Count Pct.    Min. n_eff
## (-Inf, 0.5]   (good)     24    63.2%   212
##  (0.5, 0.7]   (ok)        3     7.9%   25
##    (0.7, 1]   (bad)       6    15.8%   8
##    (1, Inf)   (very bad)  5    13.2%   0
## See help('pareto-k-diagnostic') for details.
## [1] "Model 7: qpoi: separate, grouping_1"
```

```
##
## Computed from 30000 by 38 log-likelihood matrix
##
##          Estimate   SE
## elpd_loo   -285.8 40.5
## p_loo        42.9 15.9
## looic       571.5 81.1
## ------
## Monte Carlo SE of elpd_loo is NA.
##
## Pareto k diagnostic values:
##                          Count Pct.    Min. n_eff
## (-Inf, 0.5]   (good)     29    76.3%   1699
##  (0.5, 0.7]   (ok)        6    15.8%   305
##    (0.7, 1]   (bad)       0     0.0%   <NA>
##    (1, Inf)   (very bad)  3     7.9%   6
## See help('pareto-k-diagnostic') for details.
## [1] "Model 8: qpoi: separate, pooled"
##
## Computed from 30000 by 38 log-likelihood matrix
##
##          Estimate   SE
## elpd_loo   -305.8 40.3
## p_loo        37.0 12.1
## looic       611.7 80.7
## ------
## Monte Carlo SE of elpd_loo is NA.
##
## Pareto k diagnostic values:
##                          Count Pct.    Min. n_eff
## (-Inf, 0.5]   (good)     23    60.5%   332
##  (0.5, 0.7]   (ok)        6    15.8%   158
##    (0.7, 1]   (bad)       4    10.5%   18
##    (1, Inf)   (very bad)  5    13.2%   1
## See help('pareto-k-diagnostic') for details.
## [1] "Model 9: qpoi: separate, separate"
##
## Computed from 30000 by 38 log-likelihood matrix
##
##          Estimate   SE
## elpd_loo   -295.7 48.8
## p_loo        67.9 24.6
## looic       591.4 97.6
## ------
## Monte Carlo SE of elpd_loo is NA.
##
## Pareto k diagnostic values:
##                          Count Pct.    Min. n_eff
## (-Inf, 0.5]   (good)     23    60.5%   2005
##  (0.5, 0.7]   (ok)        8    21.1%   258
##    (0.7, 1]   (bad)       4    10.5%   22
##    (1, Inf)   (very bad)  3     7.9%   4
## See help('pareto-k-diagnostic') for details.
## [1] "Model 10: nb: grouping_1, grouping_1"
```

```
##
## Computed from 30000 by 38 log-likelihood matrix
##
##          Estimate  SE
## elpd_loo   -215.2 4.9
## p_loo         2.0 0.9
## looic       430.5 9.8
## ------
## Monte Carlo SE of elpd_loo is 0.0.
##
## Pareto k diagnostic values:
##                          Count Pct.    Min. n_eff
## (-Inf, 0.5]   (good)     37    97.4%   12204
##  (0.5, 0.7]   (ok)        1     2.6%   1259
##    (0.7, 1]   (bad)       0     0.0%   <NA>
##    (1, Inf)   (very bad)  0     0.0%   <NA>
##
## All Pareto k estimates are ok (k < 0.7).
## See help('pareto-k-diagnostic') for details.
## [1] "Model 11: nb: grouping_1, pooled"
##
## Computed from 30000 by 38 log-likelihood matrix
##
##          Estimate  SE
## elpd_loo   -219.0 4.7
## p_loo         1.6 0.5
## looic       438.0 9.5
## ------
## Monte Carlo SE of elpd_loo is 0.0.
##
## All Pareto k estimates are good (k < 0.5).
## See help('pareto-k-diagnostic') for details.
## [1] "Model 12: nb: grouping_1, separate"
##
## Computed from 30000 by 38 log-likelihood matrix
##
##          Estimate  SE
## elpd_loo   -219.1 4.0
## p_loo         4.3 1.1
## looic       438.2 8.0
## ------
## Monte Carlo SE of elpd_loo is NA.
##
## Pareto k diagnostic values:
##                          Count Pct.    Min. n_eff
## (-Inf, 0.5]   (good)     34    89.5%   7657
##  (0.5, 0.7]   (ok)        3     7.9%   1595
##    (0.7, 1]   (bad)       1     2.6%   3266
##    (1, Inf)   (very bad)  0     0.0%   <NA>
## See help('pareto-k-diagnostic') for details.
## [1] "Model 13: nb: pooled, grouping_1"
##
## Computed from 30000 by 38 log-likelihood matrix
##
```

```
##          Estimate   SE
## elpd_loo   -215.4  5.1
## p_loo         1.9  0.8
## looic       430.8 10.1
## ------
## Monte Carlo SE of elpd_loo is 0.0.
##
## All Pareto k estimates are good (k < 0.5).
## See help('pareto-k-diagnostic') for details.
## [1] "Model 14: nb: pooled, pooled"
##
## Computed from 30000 by 38 log-likelihood matrix
##
##          Estimate  SE
## elpd_loo   -218.7 4.7
## p_loo         1.3 0.4
## looic       437.3 9.4
## ------
## Monte Carlo SE of elpd_loo is 0.0.
##
## All Pareto k estimates are good (k < 0.5).
## See help('pareto-k-diagnostic') for details.
## [1] "Model 15: nb: pooled, separate"
##
## Computed from 30000 by 38 log-likelihood matrix
##
##          Estimate  SE
## elpd_loo   -219.8 4.2
## p_loo         4.5 1.2
## looic       439.7 8.3
## ------
## Monte Carlo SE of elpd_loo is NA.
##
## Pareto k diagnostic values:
##                          Count Pct.    Min. n_eff
## (-Inf, 0.5]   (good)     32    84.2%   6431
##  (0.5, 0.7]   (ok)        4    10.5%   1389
##    (0.7, 1]   (bad)       2     5.3%   420
##    (1, Inf)   (very bad)  0     0.0%   <NA>
## See help('pareto-k-diagnostic') for details.
## [1] "Model 16: nb: separate, grouping_1"
##
## Computed from 30000 by 38 log-likelihood matrix
##
##          Estimate  SE
## elpd_loo   -215.6 4.8
## p_loo         2.3 1.0
## looic       431.1 9.6
## ------
## Monte Carlo SE of elpd_loo is 0.0.
##
## Pareto k diagnostic values:
##                          Count Pct.    Min. n_eff
## (-Inf, 0.5]   (good)     37    97.4%   16309
```

```
##  (0.5, 0.7]   (ok)        1     2.6%   983
##    (0.7, 1]   (bad)       0     0.0%   <NA>
##    (1, Inf)   (very bad)  0     0.0%   <NA>
##
## All Pareto k estimates are ok (k < 0.7).
## See help('pareto-k-diagnostic') for details.
## [1] "Model 17: nb: separate, pooled"
##
## Computed from 30000 by 38 log-likelihood matrix
##
##          Estimate  SE
## elpd_loo   -218.7 4.6
## p_loo         2.0 0.6
## looic       437.4 9.2
## ------
## Monte Carlo SE of elpd_loo is 0.0.
##
## All Pareto k estimates are good (k < 0.5).
## See help('pareto-k-diagnostic') for details.
## [1] "Model 18: nb: separate, separate"
##
## Computed from 30000 by 38 log-likelihood matrix
##
##          Estimate  SE
## elpd_loo   -219.5 3.9
## p_loo         4.4 1.1
## looic       439.0 7.8
## ------
## Monte Carlo SE of elpd_loo is NA.
##
## Pareto k diagnostic values:
##                          Count Pct.    Min. n_eff
## (-Inf, 0.5]   (good)     34    89.5%   7042
##  (0.5, 0.7]   (ok)        3     7.9%   2619
##    (0.7, 1]   (bad)       1     2.6%   1424
##    (1, Inf)   (very bad)  0     0.0%   <NA>
## See help('pareto-k-diagnostic') for details.
```

```
comp <- loo_compare(fit_tbl$loo)
index <- comp %>% rownames() %>% sub(pattern = "model", x= ., "") %>% as.integer()
desc <-fit_tbl$desc[index]
rownames(comp) <- desc

#loo_tbl<- bind_cols( desc = desc, index = index, comp) %>% tibble() %>% arrange(index)

print(comp)
```

```
##                             elpd_diff se_diff
## nb: grouping_1, grouping_1    0.0       0.0
## nb: pooled, grouping_1       -0.1       0.4
## nb: separate, grouping_1     -0.3       0.2
## nb: pooled, pooled           -3.4       1.7
## nb: separate, pooled         -3.5       1.6
## nb: grouping_1, pooled       -3.7       1.7
```

```
## nb: grouping_1, separate      -3.9       1.2
## nb: separate, separate        -4.3       1.3
## nb: pooled, separate          -4.6       1.0
## qpoi: grouping_1, grouping_1 -61.3      33.4
## qpoi: pooled, grouping_1     -69.1      35.4
## qpoi: separate, grouping_1   -70.5      38.9
## qpoi: grouping_1, separate   -75.6      48.3
## qpoi: separate, separate     -80.5      47.8
## qpoi: grouping_1, pooled     -82.9      32.3
## qpoi: pooled, separate       -83.3      44.1
## qpoi: pooled, pooled         -90.6      34.6
## qpoi: separate, pooled       -90.6      39.0
```

Plot Results

```
for(curr_row in 1:length(fit_tbl$fit)) {

    desc <- fit_tbl[[curr_row, "desc"]]
    fit <- fit_tbl[[curr_row, "fit"]]

    x0_group_list <- fit_tbl[[curr_row, "x0_group_list"]][[1]]
    y0_group_list <- fit_tbl[[curr_row, "y0_group_list"]][[1]]


}



    pars <- c("x0", "y0", "theta")
    pars_full <- c(pars, "lp__")

    print(desc)
    print(fit, pars = pars)
                                        #traceplot(model, pars = pars, inc_warmup = FALSE)
                                        #plot(model, pars = pars) #, ggtitle(title))

        pairs(model, pars = pars_full)

        ## Plot parameter estimate summaries
        tmp_plot <- list()
        for(par in pars) {
            tmp_plot[[par]] <- stan_plot(model, pars = par)
        }
        gt <- arrangeGrob(grobs = tmp_plot)
        as_ggplot(gt)

    }
}
```

```
## Error: <text>:32:5: unexpected '}'
## 31:
## 32:     }
##         ^
```