Models comparison

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11/13/2020

Comparison of hierarchical models with and without school variable

```
regions <- c('Lazio', 'Lombardia', 'Abruzzo', 'Veneto', 'Emilia-Romagna', 'Toscana', 'Campania', 'Friuli
regions
```

```
##  [1] "Lazio"                "Lombardia"            "Abruzzo"
##  [4] "Veneto"               "Emilia-Romagna"       "Toscana"
##  [7] "Campania"             "Friuli Venezia Giulia" "Sicilia"
## [10] "Calabria"             "Marche"               "Puglia"
```

```
hier_data <- get_hier_data(data_it, regions, initial_date = as.Date('2020-08-20') )

p_delay <- get_delay_distribution()

stan_data_hier <- list(J = length(regions),
                       N = nrow(hier_data$exposures),
                       N_nonzero = length(hier_data$nonzero_days),
                       nonzero_days = hier_data$nonzero_days,
                       conv_gt = get_gt_convolution(nrow(hier_data$exposures)),
                       length_delay = length(p_delay),
                       p_delay = p_delay,
                       exposures = hier_data$exposures,
                       nonzero_positives = hier_data$positives[hier_data$nonzero_days ,]

)


compiled_hier <- stan_model('../stan/hier_rt_model.stan')
```

```
## Trying to compile a simple C file
```

```
## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## clang -mmacosx-version-min=10.13 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG   -I
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.0/Resources/library/StanHeaders/incl
## In file included from /Library/Frameworks/R.framework/Versions/4.0/Resources/library/RcppEigen/inclu
## In file included from /Library/Frameworks/R.framework/Versions/4.0/Resources/library/RcppEigen/inclu
## /Library/Frameworks/R.framework/Versions/4.0/Resources/library/RcppEigen/include/Eigen/src/Core/util/
## namespace Eigen {
## ^
## /Library/Frameworks/R.framework/Versions/4.0/Resources/library/RcppEigen/include/Eigen/src/Core/util/
## namespace Eigen {
##                 ^
```

```
##                ;
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.0/Resources/library/StanHeaders/incl
## In file included from /Library/Frameworks/R.framework/Versions/4.0/Resources/library/RcppEigen/inclu
## /Library/Frameworks/R.framework/Versions/4.0/Resources/library/RcppEigen/include/Eigen/Core:96:10: fa
## #include <complex>
##          ^~~~~~~~
## 3 errors generated.
## make: *** [foo.o] Error 1
```

```
fit_hier <- sampling(compiled_hier, data = stan_data_hier, iter= 500, cores=getOption("mc.cores", 1L))
```

```
##
## SAMPLING FOR MODEL 'hier_rt_model' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 0.019733 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 197.33 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration:   1 / 500 [  0%]  (Warmup)
## Chain 1: Iteration:  50 / 500 [ 10%]  (Warmup)
## Chain 1: Iteration: 100 / 500 [ 20%]  (Warmup)
## Chain 1: Iteration: 150 / 500 [ 30%]  (Warmup)
## Chain 1: Iteration: 200 / 500 [ 40%]  (Warmup)
## Chain 1: Iteration: 250 / 500 [ 50%]  (Warmup)
## Chain 1: Iteration: 251 / 500 [ 50%]  (Sampling)
## Chain 1: Iteration: 300 / 500 [ 60%]  (Sampling)
## Chain 1: Iteration: 350 / 500 [ 70%]  (Sampling)
## Chain 1: Iteration: 400 / 500 [ 80%]  (Sampling)
## Chain 1: Iteration: 450 / 500 [ 90%]  (Sampling)
## Chain 1: Iteration: 500 / 500 [100%]  (Sampling)
## Chain 1:
## Chain 1:  Elapsed Time: 949.348 seconds (Warm-up)
## Chain 1:                328.697 seconds (Sampling)
## Chain 1:                1278.04 seconds (Total)
## Chain 1:
##
## SAMPLING FOR MODEL 'hier_rt_model' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 0.01032 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 103.2 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration:   1 / 500 [  0%]  (Warmup)
## Chain 2: Iteration:  50 / 500 [ 10%]  (Warmup)
## Chain 2: Iteration: 100 / 500 [ 20%]  (Warmup)
## Chain 2: Iteration: 150 / 500 [ 30%]  (Warmup)
## Chain 2: Iteration: 200 / 500 [ 40%]  (Warmup)
## Chain 2: Iteration: 250 / 500 [ 50%]  (Warmup)
## Chain 2: Iteration: 251 / 500 [ 50%]  (Sampling)
## Chain 2: Iteration: 300 / 500 [ 60%]  (Sampling)
## Chain 2: Iteration: 350 / 500 [ 70%]  (Sampling)
## Chain 2: Iteration: 400 / 500 [ 80%]  (Sampling)
```

```
## Chain 2: Iteration: 450 / 500 [ 90%]  (Sampling)
## Chain 2: Iteration: 500 / 500 [100%]  (Sampling)
## Chain 2:
## Chain 2:  Elapsed Time: 882.498 seconds (Warm-up)
## Chain 2:                328.913 seconds (Sampling)
## Chain 2:                1211.41 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'hier_rt_model' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 0.010311 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 103.11 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration:   1 / 500 [  0%]  (Warmup)
## Chain 3: Exception: Exception: poisson_rng: Rate parameter is 0, but must be > 0!  (in 'model59b9149
##   (in 'model59b9149d6a4c_hier_rt_model' at line 148)
##
## Chain 3: Iteration:  50 / 500 [ 10%]  (Warmup)
## Chain 3: Iteration: 100 / 500 [ 20%]  (Warmup)
## Chain 3: Iteration: 150 / 500 [ 30%]  (Warmup)
## Chain 3: Iteration: 200 / 500 [ 40%]  (Warmup)
## Chain 3: Iteration: 250 / 500 [ 50%]  (Warmup)
## Chain 3: Iteration: 251 / 500 [ 50%]  (Sampling)
## Chain 3: Iteration: 300 / 500 [ 60%]  (Sampling)
## Chain 3: Iteration: 350 / 500 [ 70%]  (Sampling)
## Chain 3: Iteration: 400 / 500 [ 80%]  (Sampling)
## Chain 3: Iteration: 450 / 500 [ 90%]  (Sampling)
## Chain 3: Iteration: 500 / 500 [100%]  (Sampling)
## Chain 3:
## Chain 3:  Elapsed Time: 1003.03 seconds (Warm-up)
## Chain 3:                329.35 seconds (Sampling)
## Chain 3:                1332.38 seconds (Total)
## Chain 3:
##
## SAMPLING FOR MODEL 'hier_rt_model' NOW (CHAIN 4).
## Chain 4:
## Chain 4: Gradient evaluation took 0.010565 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 105.65 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration:   1 / 500 [  0%]  (Warmup)
## Chain 4: Exception: Exception: poisson_rng: Rate parameter is 0, but must be > 0!  (in 'model59b9149
##   (in 'model59b9149d6a4c_hier_rt_model' at line 148)
##
## Chain 4: Exception: Exception: poisson_rng: Rate parameter is 0, but must be > 0!  (in 'model59b9149
##   (in 'model59b9149d6a4c_hier_rt_model' at line 148)
##
## Chain 4: Exception: Exception: poisson_rng: Rate parameter is 0, but must be > 0!  (in 'model59b9149
##   (in 'model59b9149d6a4c_hier_rt_model' at line 148)
##
## Chain 4: Exception: Exception: poisson_rng: Rate parameter is 0, but must be > 0!  (in 'model59b9149
```

```
##   (in 'model59b9149d6a4c_hier_rt_model' at line 148)
##
## Chain 4: Exception: Exception: poisson_rng: Rate parameter is 0, but must be > 0!  (in 'model59b9149
##   (in 'model59b9149d6a4c_hier_rt_model' at line 148)
##
## Chain 4: Exception: Exception: poisson_rng: Rate parameter is 0, but must be > 0!  (in 'model59b9149
##   (in 'model59b9149d6a4c_hier_rt_model' at line 148)
##
## Chain 4: Exception: Exception: poisson_rng: Rate parameter is 0, but must be > 0!  (in 'model59b9149
##   (in 'model59b9149d6a4c_hier_rt_model' at line 148)
##
## Chain 4: Iteration:  50 / 500 [ 10%]  (Warmup)
## Chain 4: Iteration: 100 / 500 [ 20%]  (Warmup)
## Chain 4: Iteration: 150 / 500 [ 30%]  (Warmup)
## Chain 4: Iteration: 200 / 500 [ 40%]  (Warmup)
## Chain 4: Iteration: 250 / 500 [ 50%]  (Warmup)
## Chain 4: Iteration: 251 / 500 [ 50%]  (Sampling)
## Chain 4: Iteration: 300 / 500 [ 60%]  (Sampling)
## Chain 4: Iteration: 350 / 500 [ 70%]  (Sampling)
## Chain 4: Iteration: 400 / 500 [ 80%]  (Sampling)
## Chain 4: Iteration: 450 / 500 [ 90%]  (Sampling)
## Chain 4: Iteration: 500 / 500 [100%]  (Sampling)
## Chain 4:
## Chain 4:  Elapsed Time: 897.761 seconds (Warm-up)
## Chain 4:                303.021 seconds (Sampling)
## Chain 4:                1200.78 seconds (Total)
## Chain 4:
```

```
## Warning in validityMethod(object): The following variables have undefined
## values: log_lik[1,1],The following variables have undefined values:
## log_lik[2,1],The following variables have undefined values: log_lik[3,1],The
## following variables have undefined values: log_lik[4,1],The following
## variables have undefined values: log_lik[5,1],The following variables have
## undefined values: log_lik[6,1],The following variables have undefined values:
## log_lik[7,1],The following variables have undefined values: log_lik[8,1],The
## following variables have undefined values: log_lik[9,1],The following
## variables have undefined values: log_lik[10,1],The following variables have
## undefined values: log_lik[11,1],The following variables have undefined values:
## log_lik[12,1],The following variables have undefined values: log_lik[13,1],The
## following variables have undefined values: log_lik[14,1],The following
## variables have undefined values: log_lik[15,1],The following variables have
## undefined values: log_lik[16,1],The following variables have undefined values:
## log_lik[17,1],The following variables have undefined values: log_lik[18,1],The
## following variables have undefined values: log_lik[19,1],The following
## variables have undefined values: log_lik[20,1],The following variables have
## undefined values: log_lik[21,1],The following variables have undefined values:
## log_lik[22,1],The following variables have undefined values: log_lik[23,1],The
## following variables have undefined values: log_lik[24,1],The following
## variables have undefined values: log_lik[25,1],The following variables have
## undefined values: log_lik[26,1],The following variables have undefined values:
## log_lik[27,1],The following variables have undefined values: log_lik[28,1],The
## following variables have undefined values: log_lik[29,1],The following
## variables have undefined values: log_lik[30,1],The following variables have
## undefined values: log_lik[31,1],The following variables have undefined values:
```

```
## log_lik[32,1],The following variables have undefined values: log_lik[33,1],The
## following variables have undefined values: log_lik[34,1],The following
## variables have undefined values: log_lik[35,1],The following variables have
## undefined values: log_lik[36,1],The following variables have undefined values:
## log_lik[37,1],The following variables have undefined values: log_lik[38,1],The
## following variables have undefined values: log_lik[39,1],The following
## variables have undefined values: log_lik[40,1],The following variables have
## undefined values: log_lik[41,1],The following variables have undefined values:
## log_lik[42,1],The following variables have undefined values: log_lik[43,1],The
## following variables have undefined values: log_lik[44,1],The following
## variables have undefined values: log_lik[45,1],The following variables have
## undefined values: log_lik[46,1],The following variables have undefined values:
## log_lik[47,1],The following variables have undefined values: log_lik[48,1],The
## following variables have undefined values: log_lik[49,1],The following
## variables have undefined values: log_lik[50,1],The following variables have
## undefined values: log_lik[51,1],The following variables have undefined values:
## log_lik[52,1],The following variables have undefined values: log_lik[53,1],The
## following variables have undefined values: log_lik[54,1],The following
## variables have undefined values: log_lik[55,1],The following variables have
## undefined values: log_lik[56,1],The following variables have undefined values:
## log_lik[57,1],The following variables have undefined values: log_lik[58,1],The
## following variables have undefined values: log_lik[59,1],The following
## variables have undefined values: log_lik[60,1],The following variables have
## undefined values: log_lik[61,1],The following variables have undefined values:
## log_lik[62,1],The following variables have undefined values: log_lik[63,1],The
## following variables have undefined values: log_lik[64,1],The following
## variables have undefined values: log_lik[65,1],The following variables have
## undefined values: log_lik[66,1],The following variables have undefined values:
## log_lik[67,1],The following variables have undefined values: log_lik[68,1],The
## following variables have undefined values: log_lik[69,1],The following
## variables have undefined values: log_lik[70,1],The following variables have
## undefined values: log_lik[71,1],The following variables have undefined values:
## log_lik[72,1],The following variables have undefined values: log_lik[73,1],The
## following variables have undefined values: log_lik[74,1],The following
## variables have undefined values: log_lik[75,1],The following variables have
## undefined values: log_lik[76,1],The following variables have undefined values:
## log_lik[77,1],The following variables have undefined values: log_lik[78,1],The
## following variables have undefined values: log_lik[79,1],The following
## variables have undefined values: log_lik[80,1],The following variables have
## undefined values: log_lik[81,1],The following variables have undefined values:
## log_lik[82,1],The following variables have undefined values: log_lik[83,1],The
## following variables have undefined values: log_lik[1,2],The following
## variables have undefined values: log_lik[2,2],The following variables have
## undefined values: log_lik[3,2],The following variables have undefined values:
## log_lik[4,2],The following variables have undefined values: log_lik[5,2],The
## following variables have undefined values: log_lik[6,2],The following
## variables have undefined values: log_lik[7,2],The following variables have
## undefined values: log_lik[8,2],The following variables have undefined values:
## log_lik[9,2],The following variables have undefined values: log_lik[10,2],The
## following variables have undefined values: log_lik[11,2],The following
## variables have undefined values: log_lik[12,2],The following variables have
## undefined values: log_lik[13,2],The following variables have undefined values:
## log_lik[14,2],The following variables have undefined values: log_lik[15,2],The
## following variables have undefined values: log_lik[16,2],The following
```

```
## variables have undefined values: log_lik[17,2],The following variables have
## undefined values: log_lik[18,2],The following variables have undefined values:
## log_lik[19,2],The following variables have undefined values: log_lik[20,2],The
## following variables have undefined values: log_lik[21,2],The following
## variables have undefined values: log_lik[22,2],The following variables have
## undefined values: log_lik[23,2],The following variables have undefined values:
## log_lik[24,2],The following variables have undefined values: log_lik[25,2],The
## following variables have undefined values: log_lik[26,2],The following
## variables have undefined values: log_lik[27,2],The following variables have
## undefined values: log_lik[28,2],The following variables have undefined values:
## log_lik[29,2],The following variables have undefined values: log_lik[30,2],The
## following variables have undefined values: log_lik[31,2],The following
## variables have undefined values: log_lik[32,2],The following variables have
## undefined values: log_lik[33,2],The following variables have undefined values:
## log_lik[34,2],The following variables have undefined values: log_lik[35,2],The
## following variables have undefined values: log_lik[36,2],The following
## variables have undefined values: log_lik[37,2],The following variables have
## undefined values: log_lik[38,2],The following variables have undefined values:
## log_lik[39,2],The following variables have undefined values: log_lik[40,2],The
## following variables have undefined values: log_lik[41,2],The following
## variables have undefined values: log_lik[42,2],The following variables have
## undefined values: log_lik[43,2],The following variables have undefined values:
## log_lik[44,2],The following variables have undefined values: log_lik[45,2],The
## following variables have undefined values: log_lik[46,2],The following
## variables have undefined values: log_lik[47,2],The following variables have
## undefined values: log_lik[48,2],The following variables have undefined values:
## log_lik[49,2],The following variables

## Warning: Bulk Effective Samples Size (ESS) is too low, indicating posterior means and medians may be
## Running the chains for more iterations may help. See
## http://mc-stan.org/misc/warnings.html#bulk-ess

## Warning: Tail Effective Samples Size (ESS) is too low, indicating posterior variances and tail quanti
## Running the chains for more iterations may help. See
## http://mc-stan.org/misc/warnings.html#tail-ess
```

```r
## school effect

school_opening <- as.Date('2020-09-14')
school <- rep(0, length(hier_data$dates))
school[which(hier_data$dates > school_opening +10)] <- 1
grow_s <- which(hier_data$dates>=school_opening &hier_data$dates <= school_opening +10)
school[grow_s] <- (grow_s - which(hier_data$dates ==school_opening))^2 /100

stan_data_hier_school <- list(J = length(regions),
                        N = nrow(hier_data$exposures),
                        N_nonzero = length(hier_data$nonzero_days),
                        nonzero_days = hier_data$nonzero_days,
                        conv_gt = get_gt_convolution(nrow(hier_data$exposures)),
                        length_delay = length(p_delay),
                        p_delay = p_delay,
                        exposures = hier_data$exposures,
                        nonzero_positives = hier_data$positives[hier_data$nonzero_days ,],
                        school = school[hier_data$nonzero_days]
```

```
)
```

```
compiled_hier_school <- stan_model('../stan/hier_model_school.stan')
```

```
## Trying to compile a simple C file
```

```
## Running /Library/Frameworks/R.framework/Resources/bin/R CMD SHLIB foo.c
## clang -mmacosx-version-min=10.13 -I"/Library/Frameworks/R.framework/Resources/include" -DNDEBUG   -I
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.0/Resources/library/StanHeaders/incl
## In file included from /Library/Frameworks/R.framework/Versions/4.0/Resources/library/RcppEigen/inclu
## In file included from /Library/Frameworks/R.framework/Versions/4.0/Resources/library/RcppEigen/inclu
## /Library/Frameworks/R.framework/Versions/4.0/Resources/library/RcppEigen/include/Eigen/src/Core/util/
## namespace Eigen {
## ^
## /Library/Frameworks/R.framework/Versions/4.0/Resources/library/RcppEigen/include/Eigen/src/Core/util/
## namespace Eigen {
##                 ^
##                 ;
## In file included from <built-in>:1:
## In file included from /Library/Frameworks/R.framework/Versions/4.0/Resources/library/StanHeaders/incl
## In file included from /Library/Frameworks/R.framework/Versions/4.0/Resources/library/RcppEigen/inclu
## /Library/Frameworks/R.framework/Versions/4.0/Resources/library/RcppEigen/include/Eigen/Core:96:10: fa
## #include <complex>
##          ^~~~~~~~~
## 3 errors generated.
## make: *** [foo.o] Error 1
```

```
fit_hier_school <- sampling(compiled_hier_school, data = stan_data_hier_school, iter= 500, cores=getOpti
```

```
##
## SAMPLING FOR MODEL 'hier_model_school' NOW (CHAIN 1).
## Chain 1:
## Chain 1: Gradient evaluation took 0.018517 seconds
## Chain 1: 1000 transitions using 10 leapfrog steps per transition would take 185.17 seconds.
## Chain 1: Adjust your expectations accordingly!
## Chain 1:
## Chain 1:
## Chain 1: Iteration:   1 / 500 [  0%]  (Warmup)
## Chain 1: Iteration:  50 / 500 [ 10%]  (Warmup)
## Chain 1: Iteration: 100 / 500 [ 20%]  (Warmup)
## Chain 1: Iteration: 150 / 500 [ 30%]  (Warmup)
## Chain 1: Iteration: 200 / 500 [ 40%]  (Warmup)
## Chain 1: Iteration: 250 / 500 [ 50%]  (Warmup)
## Chain 1: Iteration: 251 / 500 [ 50%]  (Sampling)
## Chain 1: Iteration: 300 / 500 [ 60%]  (Sampling)
## Chain 1: Iteration: 350 / 500 [ 70%]  (Sampling)
## Chain 1: Iteration: 400 / 500 [ 80%]  (Sampling)
## Chain 1: Iteration: 450 / 500 [ 90%]  (Sampling)
## Chain 1: Iteration: 500 / 500 [100%]  (Sampling)
## Chain 1:
## Chain 1:  Elapsed Time: 823.561 seconds (Warm-up)
## Chain 1:                288.925 seconds (Sampling)
```

```
## Chain 1:                1112.49 seconds (Total)
## Chain 1:
##
## SAMPLING FOR MODEL 'hier_model_school' NOW (CHAIN 2).
## Chain 2:
## Chain 2: Gradient evaluation took 0.008973 seconds
## Chain 2: 1000 transitions using 10 leapfrog steps per transition would take 89.73 seconds.
## Chain 2: Adjust your expectations accordingly!
## Chain 2:
## Chain 2:
## Chain 2: Iteration:   1 / 500 [  0%]  (Warmup)
## Chain 2: Iteration:  50 / 500 [ 10%]  (Warmup)
## Chain 2: Iteration: 100 / 500 [ 20%]  (Warmup)
## Chain 2: Iteration: 150 / 500 [ 30%]  (Warmup)
## Chain 2: Iteration: 200 / 500 [ 40%]  (Warmup)
## Chain 2: Iteration: 250 / 500 [ 50%]  (Warmup)
## Chain 2: Iteration: 251 / 500 [ 50%]  (Sampling)
## Chain 2: Iteration: 300 / 500 [ 60%]  (Sampling)
## Chain 2: Iteration: 350 / 500 [ 70%]  (Sampling)
## Chain 2: Iteration: 400 / 500 [ 80%]  (Sampling)
## Chain 2: Iteration: 450 / 500 [ 90%]  (Sampling)
## Chain 2: Iteration: 500 / 500 [100%]  (Sampling)
## Chain 2:
## Chain 2:  Elapsed Time: 830.566 seconds (Warm-up)
## Chain 2:                288.731 seconds (Sampling)
## Chain 2:                1119.3 seconds (Total)
## Chain 2:
##
## SAMPLING FOR MODEL 'hier_model_school' NOW (CHAIN 3).
## Chain 3:
## Chain 3: Gradient evaluation took 0.00905 seconds
## Chain 3: 1000 transitions using 10 leapfrog steps per transition would take 90.5 seconds.
## Chain 3: Adjust your expectations accordingly!
## Chain 3:
## Chain 3:
## Chain 3: Iteration:   1 / 500 [  0%]  (Warmup)
## Chain 3: Iteration:  50 / 500 [ 10%]  (Warmup)
## Chain 3: Iteration: 100 / 500 [ 20%]  (Warmup)
## Chain 3: Iteration: 150 / 500 [ 30%]  (Warmup)
## Chain 3: Iteration: 200 / 500 [ 40%]  (Warmup)
## Chain 3: Iteration: 250 / 500 [ 50%]  (Warmup)
## Chain 3: Iteration: 251 / 500 [ 50%]  (Sampling)
## Chain 3: Iteration: 300 / 500 [ 60%]  (Sampling)
## Chain 3: Iteration: 350 / 500 [ 70%]  (Sampling)
## Chain 3: Iteration: 400 / 500 [ 80%]  (Sampling)
## Chain 3: Iteration: 450 / 500 [ 90%]  (Sampling)
## Chain 3: Iteration: 500 / 500 [100%]  (Sampling)
## Chain 3:
## Chain 3:  Elapsed Time: 914.519 seconds (Warm-up)
## Chain 3:                298.778 seconds (Sampling)
## Chain 3:                1213.3 seconds (Total)
## Chain 3:
##
## SAMPLING FOR MODEL 'hier_model_school' NOW (CHAIN 4).
```

```
## Chain 4:
## Chain 4: Gradient evaluation took 0.009006 seconds
## Chain 4: 1000 transitions using 10 leapfrog steps per transition would take 90.06 seconds.
## Chain 4: Adjust your expectations accordingly!
## Chain 4:
## Chain 4:
## Chain 4: Iteration:   1 / 500 [  0%]  (Warmup)
## Chain 4: Iteration:  50 / 500 [ 10%]  (Warmup)
## Chain 4: Iteration: 100 / 500 [ 20%]  (Warmup)
## Chain 4: Iteration: 150 / 500 [ 30%]  (Warmup)
## Chain 4: Iteration: 200 / 500 [ 40%]  (Warmup)
## Chain 4: Iteration: 250 / 500 [ 50%]  (Warmup)
## Chain 4: Iteration: 251 / 500 [ 50%]  (Sampling)
## Chain 4: Iteration: 300 / 500 [ 60%]  (Sampling)
## Chain 4: Iteration: 350 / 500 [ 70%]  (Sampling)
## Chain 4: Iteration: 400 / 500 [ 80%]  (Sampling)
## Chain 4: Iteration: 450 / 500 [ 90%]  (Sampling)
## Chain 4: Iteration: 500 / 500 [100%]  (Sampling)
## Chain 4:
## Chain 4:  Elapsed Time: 1017.59 seconds (Warm-up)
## Chain 4:                327.088 seconds (Sampling)
## Chain 4:                1344.68 seconds (Total)
## Chain 4:
```

```
## Warning: Bulk Effective Samples Size (ESS) is too low, indicating posterior means and medians may be
## Running the chains for more iterations may help. See
## http://mc-stan.org/misc/warnings.html#bulk-ess
```

```
## Warning: Tail Effective Samples Size (ESS) is too low, indicating posterior variances and tail quanti
## Running the chains for more iterations may help. See
## http://mc-stan.org/misc/warnings.html#tail-ess
```

```
log_lik <- extract_log_lik(fit_hier)
loo_simple <- loo(log_lik)
waic_simple <- waic(log_lik)

log_lik_school <- extract_log_lik(fit_hier_school)
loo_school <- loo(log_lik_school)
waic_school <- waic(log_lik_school)
```

```
loo_compare(loo_simple, loo_school)
```

```
##        elpd_diff se_diff
## model2  0.0       0.0
## model1 -1.2       2.0
```

looic

```
loo_simple$estimates[3,1]
```

```
## [1] 10803.22
```

```
loo_school$estimates[3,1]
```

```
## [1] 10800.92
```

waic

```
waic_simple$estimates[3,1]
```

```
## [1] 10801.69
```

```
waic_school$estimates[3,1]
```

```
## [1] 10799.22
```

```
loo_compare(waic_simple, waic_school)
```

```
##        elpd_diff se_diff
## model2  0.0       0.0
## model1 -1.2       2.0
```

```
plot((loo_simple$pointwise - loo_school$pointwise), x = seq(1,nrow(loo_simple$pointwise) * ncol(loo_simp
abline(h=0, col="red")
```