

# Bayesian prevalence analysis of autism prevalence in Chile

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```
#source("Chile_prev.R", local = knitr::knit_global())

library(nleqslv) # Only needed for robinice bayesian prevalence
library(janitor)
library(gridExtra)
library(readxl)
library(viridis)
library(wesanderson)
library(rgbf)
library(chilemapas) # For commune maps
library(leaflet)
library(plotly)
library(sf)
library(sp)
library(broom)
library(psych)
library(Hmisc)
library(poolr)
library(epitools)
library(corrplot)
library(caret)
library(mltools)
library(ggrepel)
library(rjags)
library(rstan)
library(posterior)
library(tidybayes)
library(bayesplot)
library(tidyverse)
```

## Set up

### Load data

```
chile_merged_raw <- read.csv("04_Data/Data_Chile_Merge.csv") %>% clean_names()

chile_merged <- chile_merged_raw %>%
  rename(sex_desc = sex,
        year = agno,
        school_code = rbd,
        school_check_code = dgv_rbd,
```

```

school_name = nom_rbd,
school_region_code = cod_reg_rbd,
school_region_name_abr = nom_reg_rbd_a,
school_province_code = cod_pro_rbd,
school_commune_code = cod_com_rbd,
school_commune_name = nom_com_rbd,
school_dept_code = cod_deprov_rbd,
school_dept_name = nom_deprov_rbd,
school_dependency_code = cod_depe, # has categories 1-6, no1 and no2 here are no1 in grouped
school_dependency_code_grouped = cod_depe2, # has categories 1-5
school_rurality_code = rural_rbd,
school_operation_status = estado_estab,
teaching_code1 = cod_ense, # min = 10, max = 910, eg preschool, special education hearing impaired
teaching_code2 = cod_ense2, # subject matter coding, 1-8
teaching_code3 = cod_ense3, # age based coding, 1-7
grade_code1 = cod_grado, # grade of schooling, 1-10, 21-25, 31-34, nests in teaching_code1
grade_code2 = cod_grado2, # equivalent grade of schooling for adult special education, 1-8, 99
grade_letter = let_cur, # refers to the class within the grade, close to start of alphabet is
course_timing = cod_jor, # time of day, morning, afternoon, both, night, no info
course_type = cod_tip_cur, # 0 = simple course, 1-4 = combined course, 99 = no info
course_descr = cod_des_cur, # Description of course (TP secondary education only). 0: Does not
student_id = mrun,
sex = gen_alu, # 0 = no info, 1 = male, 2 = female
dob = fec_nac_alu_2, # The second one has DD
age_june30 = edad_alu, # age at 30th June 2021
special_needs_status = int_alu, # integrated student indicator, 0 = no, 1 = yes. Mostly no
special_needs_code = cod_int_alu, # ADHD, blindness, etc. 0 = none. 105 = autism, 203 = ADHD. .
student_region_code = cod_reg_alu,
student_commune_code = cod_com_alu,
student_commune_name = nom_com_alu,
economic_sector_code = cod_sec,
economic_specialty_code = cod_espe,
economic_branch_code = cod_rama,
economic_profspec_code = cod_men,
teaching_code_new = ens)

chile_stdpop_raw <- read_excel("04_Data/pop_chile_2021_single_age.xlsx") %>%
  clean_names()

chile_stdpop <- chile_stdpop_raw %>%
  filter(sex != 9) %>%
  rename("std_pop" = "pop_2021") %>%
  mutate(pop_prop = std_pop / sum(std_pop))

chile_communes <- read_excel("04_Data/Outputs/region_service_commune.xlsx") %>%
  clean_names() %>%
  rename(school_region_name_abr = region_name,
         school_commune_name = commune_name)

# https://www.ine.gob.cl/estadisticas/sociales/demografia-y-vitales/proyecciones-de-poblacion
chile_regionpop_raw <- read_excel("04_Data/ine_estimaciones-y-proyecciones-2002-2035_base-2017_region_a
  clean_names()

```

Try Bayesian analysis of autism prevalence and specificity and sensitivity of school assessment “Bayesian Estimation of Disease Prevalence and the Parameters of Diagnostic Tests in the Absence of a Gold Standard” Lawrence Joseph, Theresa W. Gyorkos, Louis Coupal <https://www.cambridge.org/core/journals/epidemiology-and-psychiatric-sciences/article/bayesian-approach-to-estimating-the-population-prevalence-of-mood-and-anxiety-disorders-using-multiple-measures/DB1D2CA6C27C7E8C85C60B62B969BB72>

Use sensitivity and specificity of Social Attention and Communication Surveillance-Revised (SACS-R) tool “Diagnostic Accuracy of the Social Attention and Communication Surveillance-Revised With Preschool Tool for Early Autism Detection in Very Young Children” Josephine Barbaro, Nancy Sadka, Melissa Gilbert, et al <https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2789926>

```
chile_bayes_aut <- chile_merged %>%
  filter(age_june30 >= 6 & age_june30 <= 18,
        #special_needs_status == 1,
        sex != 0) %>%
  mutate(alzheimer = ifelse(special_needs_code == 105, 1, 0),
         age_cat = ifelse(age_june30 <= 8, 1, ifelse(age_june30 <= 11, 2, ifelse(age_june30 <= 14, 3, 4)),
         age_cat_name = ifelse(age_cat == 1, "6-8", ifelse(age_cat == 2, "9-11", ifelse(age_cat == 3, "12-14", "15-18")),
         # 1 = 6-8, 2 = 9-11, 3 = 12-14, 4 = 15-18
         age_cat_name = factor(age_cat_name, levels = c("6-8", "9-11", "12-14", "15-18"))),
```

```

ethnic_2_group = ifelse(ethnic_3_group == "Aymara", "Other ethnic group", ethnic_3_group),
school_fee_temp = school_fee,
school_fee = ifelse(school_fee == "", "No information",
                    ifelse(school_fee == "GRATUITO", "Free",
                           ifelse(school_fee == "$1.000 A $10.000", "$1,000-$10,000",
                                  ifelse(school_fee == "$10.001 A $25.000", "$10,001-$25,000",
                                         ifelse(school_fee == "$25.001 A $50.000", "$25,001-$50,000",
                                                ifelse(school_fee == "$50.001 A $100.000", "$50,001-$100,000",
                                                       ifelse(school_fee == "MAS DE $100.000", "More than $100,000",
                                                              ifelse(school_fee == "SIN INFORMACION", "No information"
                                                              
school_fee = factor(school_fee, levels = c("Free", "$1,000-$10,000", "$10,001-$25,000", "$25,001-$50,000",
school_fee_group = ifelse(school_fee == "Free", "Free",
                           ifelse(school_fee %in% c("$1,000-$10,000", "$10,001-$25,000", "$25,001-$50,000"),
                                  ifelse(school_fee == "$100,001+", "High",
                                         ifelse(school_fee == "No information", "No information"
school_fee_group = factor(school_fee_group, levels = c("Free", "Low", "High", "No information"))
left_join(chile_comunes, by = c("school_commune_name", "school_region_name_abr")) %>%
  select(school_region_name_abr,
         sex,
         sex_desc,
         age_june30,
         #edad_alu_2, # equal to age_june30
         age_cat,
         age_cat_name,
         school_rurality_code,
         #rural_rbd_2, # not quite equal to school_rurality_code as it has NA's
         pago_matricula,
         pago_mensual,
         school_fee,
         school_fee_group,
         school_fee_temp,
         ethnicity,
         mapuche,
         nationality,
         ethnic_3_group,
         ethnic_2_group,
         #asd_chile, # equal to autism
         autism,
         school_commune_name,
         health_service_name
  )
# Prevalence of autism in Chile dataset
sum(chile_bayes_aut$autism) / nrow(chile_bayes_aut) # 0.00476 = 0.476%, very low
## [1] 0.004760322
# Is prevalence the same across geographic regions, age, sex?
n_std_pop <- sum(chile_stdpop$std_pop)

```

## Define some functions to keep code clean

```
get_grouped_prev_plot <- function(x, grouping_vars) {  
  # Calculates sample prevalence and its confidence intervals for supplied feature grouping  
  # x = chile_bayes_aut, needs columns called autism, count  
  # grouping_vars = variables in x to group by  
  
  x_grouped <- x %>%  
  group_by(across(all_of(grouping_vars))) %>%  
  summarise(count = n()) %>%  
  pivot_wider(names_from = autism, values_from = count) %>%  
  rename("n_noautism" = "0", "n_autism" = "1") %>% #, "age" = "age_june30") %>%  
  mutate(n_autism = ifelse(is.na(n_autism), 0, n_autism), # If there are no cases of autism in the group  
         sample_pop_size = n_noautism + n_autism, # Total sample population is autism cases + not cases  
         sample_prevalence = n_autism / sample_pop_size, # Prevalence of autism in the group  
         ci_lower = sample_prevalence - (1.96 * sqrt(sample_prevalence * (1 - sample_prevalence)) / sample_size),  
         ci_upper = sample_prevalence + (1.96 * sqrt(sample_prevalence * (1 - sample_prevalence)) / sample_size))  
  ungroup()  
  return(x_grouped)  
}  
  
get_grouped_prev <- function(x, stdpop, grouping_vars) {  
  # Calculates sample prevalence, age- and sex-standardised prevalence and group weighting for supplied feature grouping  
  # x = chile_bayes_aut, needs columns called autism, count  
  # stdpop = standard population with age and sex counts  
  # grouping_vars = variables in x to group by  
  
  n_stdpop <- sum(stdpop$std_pop)  
  
  x_grouped <- x %>%  
  group_by(across(all_of(grouping_vars))) %>%  
  summarise(count = n()) %>%  
  pivot_wider(names_from = autism, values_from = count) %>%  
  rename("n_noautism" = "0", "n_autism" = "1", "age" = "age_june30") %>%  
  mutate(n_autism = ifelse(is.na(n_autism), 0, n_autism), # If there are no cases of autism in the group  
         sample_pop_size = n_noautism + n_autism, # Total sample population is autism cases + not cases  
         sample_prevalence = n_autism / sample_pop_size) %>% # Prevalence of autism in the group  
  left_join(stdpop, by = c("age", "sex")) %>%  
  mutate(aut_prev_std = n_autism / sample_pop_size * pop_prop, # Prevalence of autism in the group, standardised  
         w = std_pop / (sample_pop_size * n_stdpop), # Weight of the group using standard population  
         w2 = pop_prop / sample_pop_size,  
         #sum_std_pop = sum(std_pop))  
  ) %>%  
  ungroup()  
  return(x_grouped)  
}  
  
get_adjusted_prev <- function(x, grouping_vars) {  
  # Turns grouped prevalences into age- and sex- adjusted prevalences with Fay and Feuer Gamma confidence intervals  
  # x = output from get_grouped_prev  
  x_adj <- x %>%  
  group_by(across(all_of(grouping_vars))) %>%  
  summarise(sum_sample_pop_size = sum(sample_pop_size),  
           crude_rate = sum(n_autism) / sum(sample_pop_size),  
           feuer_gamma = (crude_rate - sum_sample_pop_size * aut_prev_std) / (sum_sample_pop_size * (1 - aut_prev_std)),  
           fay_gamma = (crude_rate - sum_sample_pop_size * aut_prev_std) / (sum_sample_pop_size * (1 - aut_prev_std) * (1 + (sum_sample_pop_size * aut_prev_std) / (sum_sample_pop_size * (1 - aut_prev_std))))  
  ) %>%  
  ungroup()  
  return(x_adj)  
}
```

```

crude_count = sum(n_autism),
adjusted_rate = sum(n_autism / sample_pop_size * pop_prop),
adjusted_count = round(adjusted_rate * sum_sample_pop_size, 0), # had to fudge this to get
#adjusted_count = adjusted_rate * sum_sample_pop_size,
var = sum(pop_prop^2 * n_autism / sample_pop_size^2),
#se2 = sqrt(sum((std_pop/sum(std_pop))^2 * n_autism/sample_pop_size^2)),
w_M = max(w),
ci_lower = ifelse(var == 0, 0, var / (2*adjusted_rate) * qchisq(p = 0.05/2, df = 2*adjusted_rate)),
ci_upper = (var + w_M^2) / (2*(adjusted_rate + w_M)) * qchisq(p = 1-0.05/2, df = 2*(adjusted_rate))
arrange(across(all_of(grouping_vars)))
}

do_jags_rand_model <- function(x, feat, model, theta_mu, theta_sigma, pars, nBurn = 1000, nIter = 1000,
# x = output from get_adjusted_prev. Needs to have columns sum_sample_pop_size, adjusted_count
# feat = feature being used as random effect
# model = JAGS random effects model
# theta_mu, theta_sigma = mean and sd of beta prior distribution
# pars = model parameters to report
# nBurn = number of burn-in samples
# nIter = number of posterior iterations

nFeat <- length(unique(x[[feat]]))
FeatNames <- sort(unique(x[[feat]]))

# Define beta prior
theta_a <- theta_mu * (theta_mu * (1-theta_mu) / theta_sigma^2 - 1)
theta_b <- (1 - theta_mu) * (theta_mu * (1-theta_mu) / theta_sigma^2 - 1)

# Initial values for model chains
rand_ini <- list(list(theta = rep(0.001, nFeat)), #, spec = 0.5, sens = 0.5),
list(theta = rep(0.01, nFeat))) #, spec = 0.9, sens = 0.9))

# Run JAGS model
rand_data <- list(theta_a = theta_a,
theta_b = theta_b,
nObs = x$sum_sample_pop_size,
aut_sample = x$adjusted_count,
nFeat = nFeat)
rand_jag <- jags.model(textConnection(model),
data = rand_data,
inits = rand_ini,
n.chains = 2,
quiet = TRUE)
update(rand_jag, n.iter = nBurn)
rand_sam <- coda.samples(model = rand_jag,
variable.names = pars,
n.iter = nIter)

# Convergence checks
if(convergence_checks) {
print(mcmc_trace(rand_sam, paste0("theta[", 1:nFeat, "]"))) # Convergence looks fine and rhats <= 1
print(mcmc_trace(rand_sam, paste0("aut_pred[", 1:nFeat, "]"))) # Convergence looks fine and rhats <= 1
rand_summ <- summary(subset_draws(as_draws(rand_sam), pars),
}

```

```

        ~quantile(.x, probs=c(0.025, 0.5, 0.975)),
        ~mcse_quantile(.x, probs=c(0.025, 0.5, 0.975)),
        "rhat") %>%
    arrange(desc(rhat))
    print(rand_summ)
}

# Extract posterior density
prev_post <- as_tibble(as_draws_matrix(rand_sam), rownames = "Iteration") %>%
  select(c("Iteration", contains("theta[")))) %>%
  pivot_longer(cols = contains("theta["),
                names_to = "Feat",
                values_to = "predicted_prev") %>%
  mutate(Feat_names = factor(Feat, levels = c(paste0("theta[", 1:nFeat, "]"))), labels = FeatNames)) %>%
  select(Iteration, Feat_names, predicted_prev)

return(prev_post)
}

plot_post_density <- function(jags_post, sample_data, feat, theta_mu, theta_sigma, title_text = "") {
  # Plots posterior densities and their 95% credible intervals, and sample prevalence confidence intervals
  # jags_post = output from do_jags_rand_model, ie posterior densities
  # sample data = output from get_adjusted_prev, ie sample prevalences with confidence intervals
  # feat = the same feature used as the random effect in do_jags_rand_model
  # theta_mu, theta_sigma = mean and sd of beta prior distribution used in do_jags_rand_model

  # calculate posterior credible intervals
  post_ci <- jags_post %>%
    group_by(across(all_of(feat))) %>%
    summarise(post_lower = quantile(predicted_prev, 0.025),
              post_upper = quantile(predicted_prev, 0.975))

  print(ggplot() +
    geom_density(data = jags_post, aes(x = predicted_prev)) +
    geom_vline(data = post_ci, aes(xintercept = post_lower), color = "blue", linetype = "dotted") +
    geom_vline(data = post_ci, aes(xintercept = post_upper), color = "blue", linetype = "dotted") +
    geom_vline(data = sample_data, aes(xintercept = ci_lower), color = "red", linetype = "dashed") +
    geom_vline(data = sample_data, aes(xintercept = ci_upper), color = "red", linetype = "dashed") +
    facet_wrap(as.formula(paste0("~", feat))) +
    labs(title = paste0("Prior mean = ", signif(theta_mu, 3), ", prior sd = ", signif(theta_sigma,
})
}

```

## Set up Chile maps

```

commune_geoms <- data.frame(mapa_comunas)
communes_lookup <- data.frame(codigos_territoriales)
regions_lookup <- communes_lookup %>%
  group_by(codigo_region, nombre_region) %>%
  summarise() %>%
  mutate(school_region_name_abr = ifelse(nombre_region == "Antofagasta", "ANTOF",
                                         ifelse(nombre_region == "Arica y Parinacota", "AYP",

```

```

        ifelse(nombre_region == "Atacama", "ATCMA",
        ifelse(nombre_region == "Aysen del General Carlos Ibanez del Campo", "AYSEN",
        ifelse(nombre_region == "Biobio", "BBIO",
        ifelse(nombre_region == "Coquimbo", "COQ",
        ifelse(nombre_region == "La Araucania", "ARAUC",
        ifelse(nombre_region == "Libertador General Bernardo OHiggins", "LGBO",
        ifelse(nombre_region == "Los Lagos", "LAGOS",
        ifelse(nombre_region == "Los Rios", "RIOS",
        ifelse(nombre_region == "Magallanes y de la Antartica Chilena", "MAG"),
        ifelse(nombre_region == "Maule", "MAULE",
        ifelse(nombre_region == "Metropolitana de Santiago", "RM",
        ifelse(nombre_region == "Nuble", "NUBLE",
        ifelse(nombre_region == "Tarapaca", "TPCA",
        ifelse(nombre_region == "Valparaiso", "VALPO", NA))))))))))))))),

ADM1_PCODE = paste0("CL", codigo_region)

## `summarise()` has grouped output by 'codigo_region'. You can override using the
## `.groups` argument.

#region_geoms <- generar_circunscripciones(mapa = chilemapas::mapa_comunas) %>% # This has Nuble for all
# full_join(regions_lookup, by = "codigo_region")

# https://data.humdata.org/dataset/cod-ab-chl
chile.adm1 <- st_read("04_Data/CHL_adm_humdata/chl_admbnda_adm1_bcn_20211008.shp") #%>%

## Reading layer `chl_admbnda_adm1_bcn_20211008` from data source
##   `C:\Users\delat\OneDrive\MPhil Population Health Sciences 2022-2023\12 Dissertation\04_Data\CHL_adm...
##   using driver `ESRI Shapefile'
## Simple feature collection with 16 features and 12 fields
## Geometry type: MULTIPOLYGON
## Dimension:      XY
## Bounding box:  xmin: -109.4549 ymin: -55.98 xmax: -66.41821 ymax: -17.4984
## Geodetic CRS:  WGS 84
#st_transform(crs = 32629)

demog_geom <- chile.adm1 %>%
  left_join(regions_lookup, by = "ADM1_PCODE") %>%
  left_join(chile_regionpop, by = "nombre_region") %>%
  left_join(chile_regionincome, by = "nombre_region") %>%
  select(-region)

#chile.adm2 <- st_read("04_Data/CHL_adm/CHL_adm2.shp") # Also doesn't have Biobio
#chile.adm2 <- st_transform(chile.adm2, crs = 32629)

#region_geoms_demog <- region_geoms %>%
#  left_join(chile_regionpop, by = "nombre_region") %>%
#  left_join(chile_regionincome, by = "nombre_region") %>%
#  select(-region)

# Population
ggplot(demog_geom) +
  geom_sf(mapping = aes(geometry = geometry, fill = youth_pop_2021), linewidth = 0.01) +
  geom_sf_text(mapping = aes(geometry = geometry, label = nombre_region), nudge_x = 8, size = 3) +
  scale_fill_viridis(option = "viridis", direction = 1, name = "Population") + #, limits = c(23000, 400

```

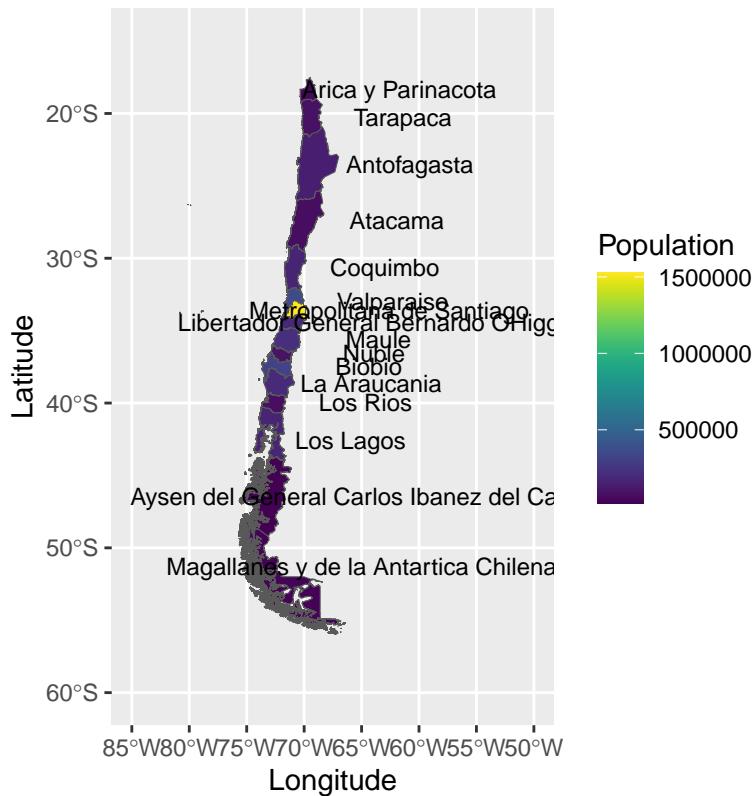
```

  labs(title = "Population aged 0-14 (2021 projections)" +
    xlab("Longitude") +
    ylab("Latitude") +
    coord_sf(xlim = c(-85, -50), ylim = c(-60, -15))

## Warning in st_point_on_surface.sfc(sf::st_zm(x)): st_point_on_surface may not
## give correct results for longitude/latitude data

```

Population aged 0–14 (2021 projections)



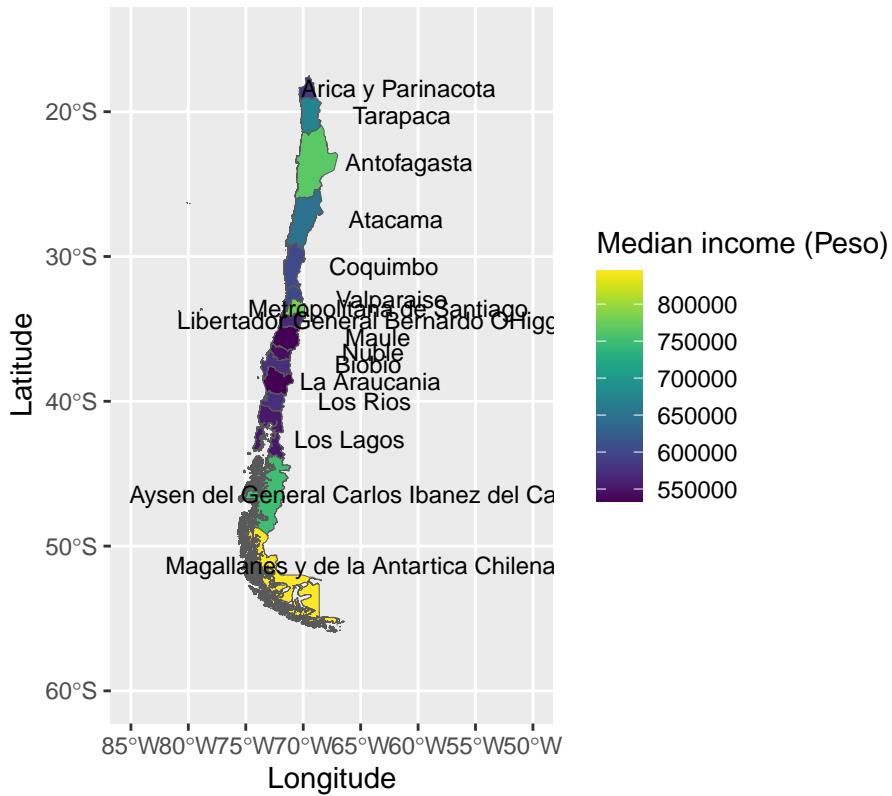
```

# Income
ggplot(demog_geom) +
  geom_sf(mapping = aes(geometry = geometry, fill = ingreso_medio_nominal), linewidth = 0.01) +
  geom_sf_text(mapping = aes(geometry = geometry, label = nombre_region), nudge_x = 8, size = 3) +
  scale_fill_viridis(option = "viridis", direction = 1, name = "Median income (Peso)") +
  labs(title = "Net income from main job (2021)") +
  xlab("Longitude") +
  ylab("Latitude") +
  coord_sf(xlim = c(-85, -50), ylim = c(-60, -15))

## Warning in st_point_on_surface.sfc(sf::st_zm(x)): st_point_on_surface may not
## give correct results for longitude/latitude data

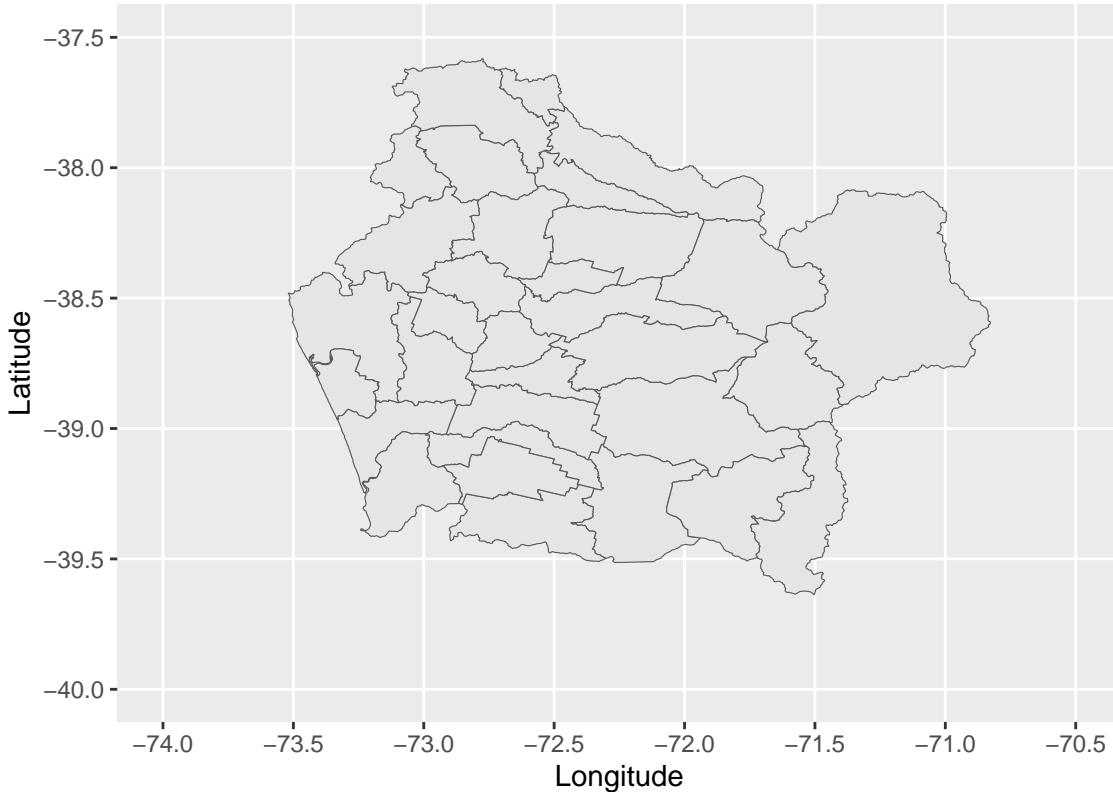
```

## Net income from main job (2021)



```
# ARAUC communes
arauc <- commune_geoms %>% filter(codigo_region == "09")
ggplot(arauc) +
  geom_sf(mapping = aes(geometry = geometry)) +
  coord_sf(xlim = c(-74, -70.5), ylim = c(-40, -37.5)) +
  labs(title = "Communes in La Araucania") +
  xlab("Longitude") +
  ylab("Latitude")
```

## Communes in La Araucania



## Bayesian prevalence analysis

Find age- and sex-adjusted sample prevalence

```
aut_prev <- get_grouped_prev(x = chile_bayes_aut, stdpop = chile_stdpop,
                               grouping_vars = c("age_june30", "age_cat_name", "sex", "sex_desc", "autism"))

## `summarise()` has grouped output by 'age_june30', 'age_cat_name', 'sex',
## 'sex_desc'. You can override using the ` `.groups` argument.

aut_prev_adj <- aut_prev %>%
  summarise(sum_sample_pop_size = sum(sample_pop_size),
           crude_rate = sum(n_autism) / sum(sample_pop_size),
           crude_count = sum(n_autism),
           adjusted_rate = sum(n_autism / sample_pop_size * pop_prop),
           adjusted_count = round(adjusted_rate * sum_sample_pop_size, 0), # had to fudge this to get a
#adjusted_count = adjusted_rate * sum_sample_pop_size,
           var = sum(pop_prop^2 * n_autism / sample_pop_size^2),
           #se2 = sqrt(sum((std_pop/sum(std_pop))^2 * n_autism/sample_pop_size^2)),
           w_M = max(w),
           ci_lower = ifelse(var == 0, 0, var / (2*adjusted_rate) * qchisq(p = 0.05/2, df = 2*adjusted_rate)),
           ci_upper = (var + w_M^2) / (2*(adjusted_rate + w_M)) * qchisq(p = 1-0.05/2, df = 2*(adjusted_rate)))
```

Set global parameters

```
nObs <- nrow(chile_bayes_aut)
nIter <- 1000
```

```

nBurn <- 1000
pars <- c("theta_a", "theta_b", "theta", "aut_sample", "aut_pred")

theta_mu_prior <- aut_prev_adj$adjusted_rate
theta_sigma_prior <- (aut_prev_adj$ci_upper - aut_prev_adj$ci_lower) / (2*1.96)
theta_mu_extrapolate <- c(0.005, 0.01, 0.015, 0.03) # 0.5%, 1%, 1.5%, 3% prevalence
theta_sigma_extrapolate <- c(rep(0.0001/1.96, 4)) # Same as chosen prior
#theta_mu <- c(theta_mu_prior, theta_mu_sens)
#theta_sigma <- c(theta_sigma_prior, theta_sigma_sens)
#theta_a <- theta_mu * (theta_mu * (1-theta_mu) / theta_sigma^2 - 1)
#theta_b <- (1 - theta_mu) * (theta_mu * (1-theta_mu) / theta_sigma^2 - 1)

rand_model <- "model {
  for(i in 1:nFeat) { # For each category in the feature grouping
    theta[i] ~ dbeta(theta_a, theta_b)
    aut_sample[i] ~ dbin(theta[i], nObs[i])
    aut_pred[i] ~ dbin(theta[i], nObs[i])
  }
}"

```

## Common effects model with unadjusted or age- and sex-adjusted sample prevalence

Do age- and sex-adjustment (same as below for random effect models)

```

# Uniform prior
theta_a_common <- 1
theta_b_common <- 1
# This corresponds to a mean of 0.5

# OR Informative prior (global population prevalence)
# Say autism has mean prevalence of 3% and we are 95% confidence that the prevalence is between 2% and ...
# Then mu = 0.03, sigma = (0.04-0.02) / (2*1.96)
theta_mu_common <- 0.03
theta_sigma_common <- (0.04-0.02) / (2*1.96)
theta_a_common <- theta_mu_common * (theta_mu_common * (1-theta_mu_common) / theta_sigma_common^2 - 1)
theta_b_common <- (1 - theta_mu_common) * (theta_mu_common * (1-theta_mu_common) / theta_sigma_common^2)

common_model <- "model {
  theta ~ dbeta(theta_a, theta_b) # Prior
  aut_sample ~ dbin(theta, nObs) # Prevalence in sample data

  aut_pred ~ dbin(theta, nObs) # Predicted prevalence in new sample of same size

  #spec ~ dnorm(spec_mu, 1/spec_sd) # dnorm requires prevalence not sd or var
  #sens ~ dnorm(sens_mu, 1/sens_sd)
  #aut_post <- aut_sample/nObs * sens + (1 - aut_sample/nObs) * spec
}"

common_data <- list(theta_a = theta_a_common,
                      theta_b = theta_b_common,
                      nObs = nObs,

```

```

#aut_sample = sum(chile_bayes_aut$autism) # unadjusted sample prevalence
aut_sample = aut_prev_adj$adjusted_count # age- and sex- adjusted sample prevalence
#spec_mu = 0.996,
#spec_sd = (1.00-0.99) / (2*1.96),
#sens_mu = 0.62,
#sens_sd = (0.66-0.57) / (2*1.96)
)

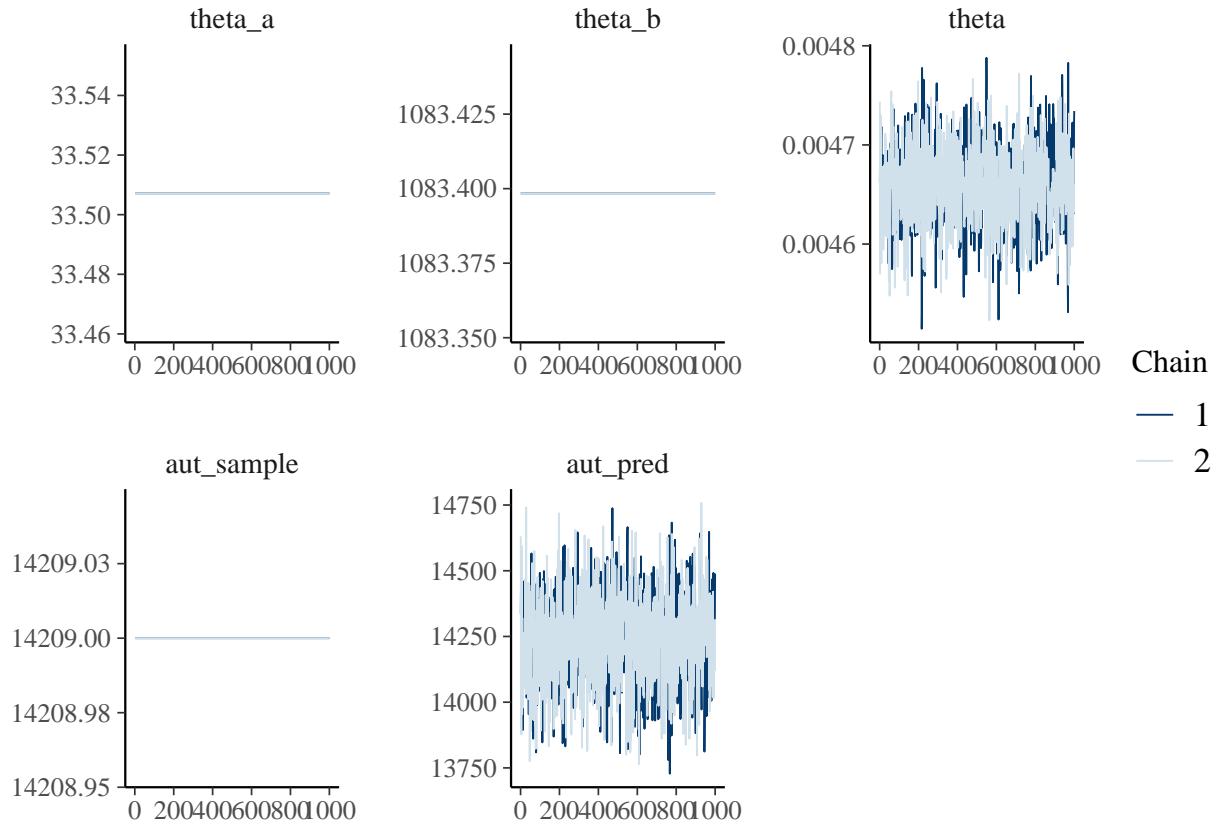
common_ini <- list(list(theta = 0.001), #, spec = 0.5, sens = 0.5),
                     list(theta = 0.01)) #, spec = 0.9, sens = 0.9))

common_pars <- c("theta_a", "theta_b", "theta",
                 ##"spec", "sens",
                 "aut_sample", "aut_pred")

# Run JAGS model and discard burn-in samples
common_jag <- jags.model(textConnection(common_model),
                           data = common_data,
                           inits = common_ini,
                           n.chains = 2,
                           quiet = TRUE)
update(common_jag, n.iter = nBurn)
common_sam <- coda.samples(model = common_jag,
                            variable.names = common_pars,
                            n.iter = nIter)

# Check for convergence in parameters of interest
mcmc_trace(common_sam, common_pars) # Convergence looks fine and rhats <= 1.1

```

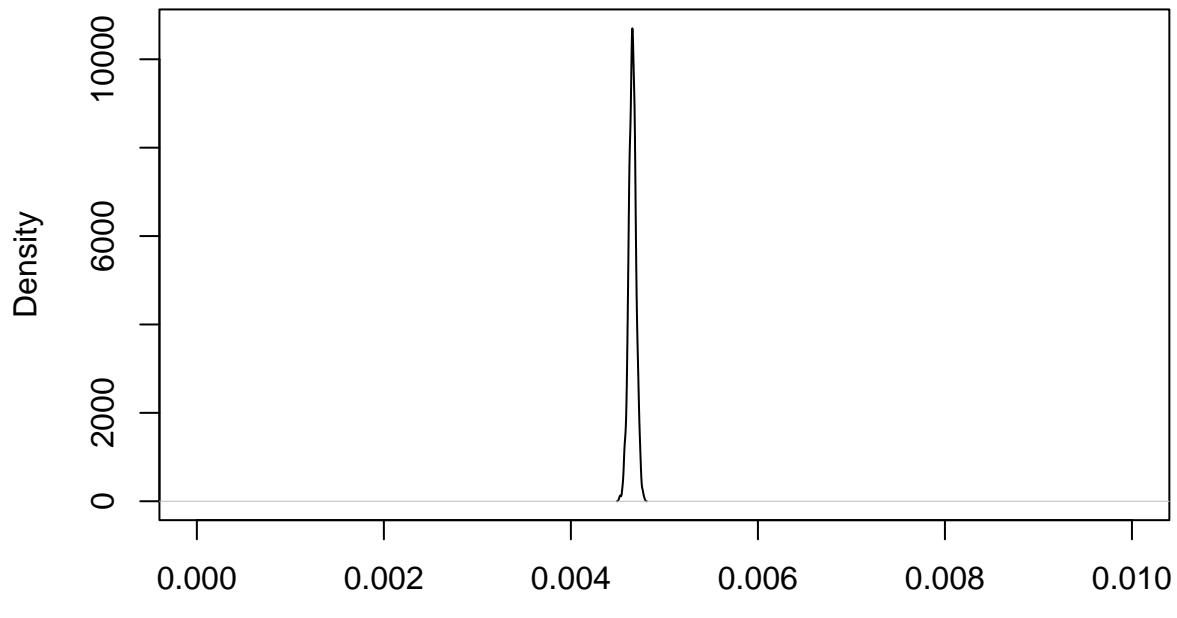


```
summary(as_draws(common_sam)) # mean posterior theta is 0.00477
```

```
## # A tibble: 5 x 10
##   varia~1   mean   median     sd     mad     q5     q95    rhat ess_b~2 ess_t~3
##   <chr>     <dbl>    <dbl>   <dbl>   <dbl>   <dbl>   <dbl>   <dbl>    <dbl>    <dbl>
## 1 aut_pr~ 1.42e+4 1.42e+4 1.66e+2 1.65e+2 1.40e+4 1.45e+4 0.999  1557.   1369.
## 2 aut_sa~ 1.42e+4 1.42e+4 0        0        1.42e+4 1.42e+4 NA      NA      NA
## 3 theta    4.66e-3 4.66e-3 3.91e-5 3.81e-5 4.59e-3 4.72e-3 1.00    1428.   1265.
## 4 theta_a  3.35e+1 3.35e+1 0        0        3.35e+1 3.35e+1 NA      NA      NA
## 5 theta_b  1.08e+3 1.08e+3 0        0        1.08e+3 1.08e+3 NA      NA      NA
## # ... with abbreviated variable names 1: variable, 2: ess_bulk, 3: ess_tail
```

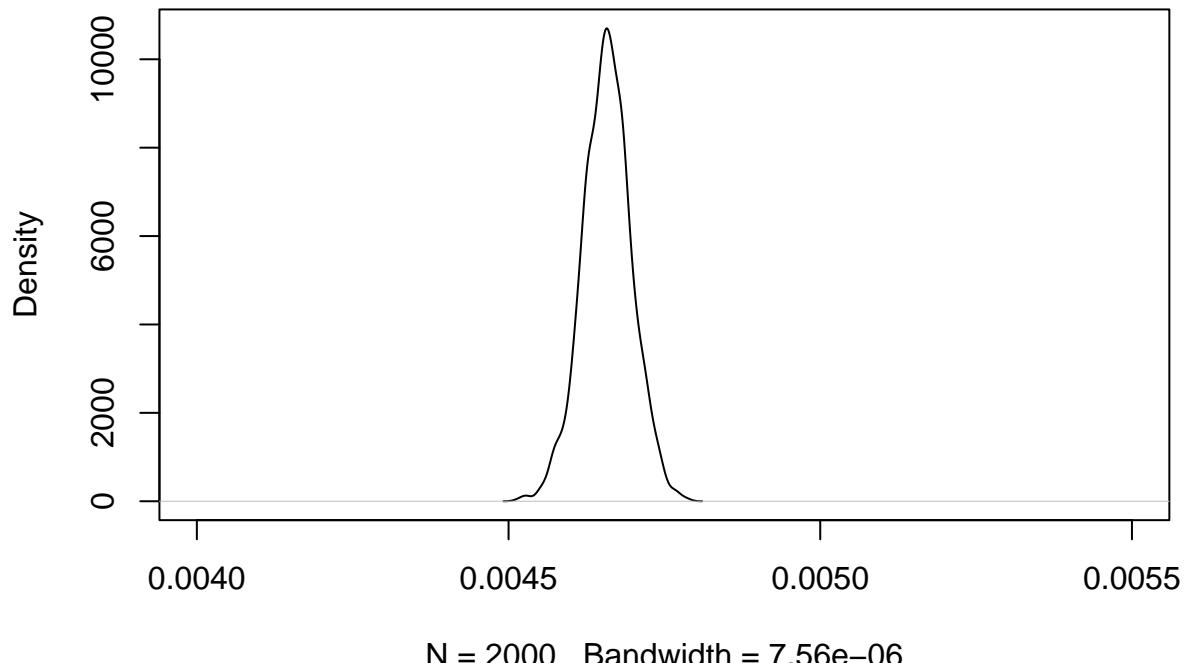
```
plot(density(extract_variable(common_sam, "theta")), xlim = c(0,0.01))
```

```
density.default(x = extract_variable(common_sam, "theta"))
```



```
plot(density(extract_variable(common_sam, "theta")), xlim = c(0.004,0.0055))
```

```
density.default(x = extract_variable(common_sam, "theta"))
```



```
# Very very narrow posterior distribution centered approx at sample prevalence of 0.00476.  
# Not that surprising given uniform prior was used.  
  
# Informative prior made no difference to posterior distribution
```

## Random effects analysis

95% CIs for aggregate data visualisations using: <https://openstax.org/books/introductory-business-statistics/pages/8-3-a-confidence-interval-for-a-population-proportion>

Standardise prevalence by Chile's age and sex based population sizes using [https://seer.cancer.gov/seerstat/WebHelp/Rate\\_Algorithms.htm](https://seer.cancer.gov/seerstat/WebHelp/Rate_Algorithms.htm) and <https://wonder.cdc.gov/wonder/help/cancer/fayfeuerconfidenceintervals.pdf>

See [https://github.com/Dpananos/bayes\\_multiple\\_measures/blob/master/analysis/sensitivity\\_analysis.R](https://github.com/Dpananos/bayes_multiple_measures/blob/master/analysis/sensitivity_analysis.R) for more sensitivity analysis ideas

## Random effect on sex

```
chile_stdpop_f <- chile_stdpop %>%  
  filter(sex == 2) %>%  
  mutate(pop_prop = std_pop / sum(std_pop))  
chile_stdpop_m <- chile_stdpop %>%  
  filter(sex == 1) %>%  
  mutate(pop_prop = std_pop / sum(std_pop))  
  
aut_prev_f <- chile_bayes_aut %>%
```

```

filter(sex == 2) %>%
get_grouped_prev(stdpop = chile_stdpop_f, grouping_vars = c("age_june30", "sex", "autism"))

## `summarise()` has grouped output by 'age_june30', 'sex'. You can override using
## the `.`groups` argument.

aut_prev_adj_f <- get_adjusted_prev(aut_prev_f, grouping_vars = c()) %>% mutate(sex_desc = "Female")

aut_prev_m <- chile_bayes_aut %>%
  filter(sex == 1) %>%
  get_grouped_prev(stdpop = chile_stdpop_m, grouping_vars = c("age_june30", "sex", "autism"))

## `summarise()` has grouped output by 'age_june30', 'sex'. You can override using
## the `.`groups` argument.

aut_prev_adj_m <- get_adjusted_prev(aut_prev_m, grouping_vars = c()) %>% mutate(sex_desc = "Male")

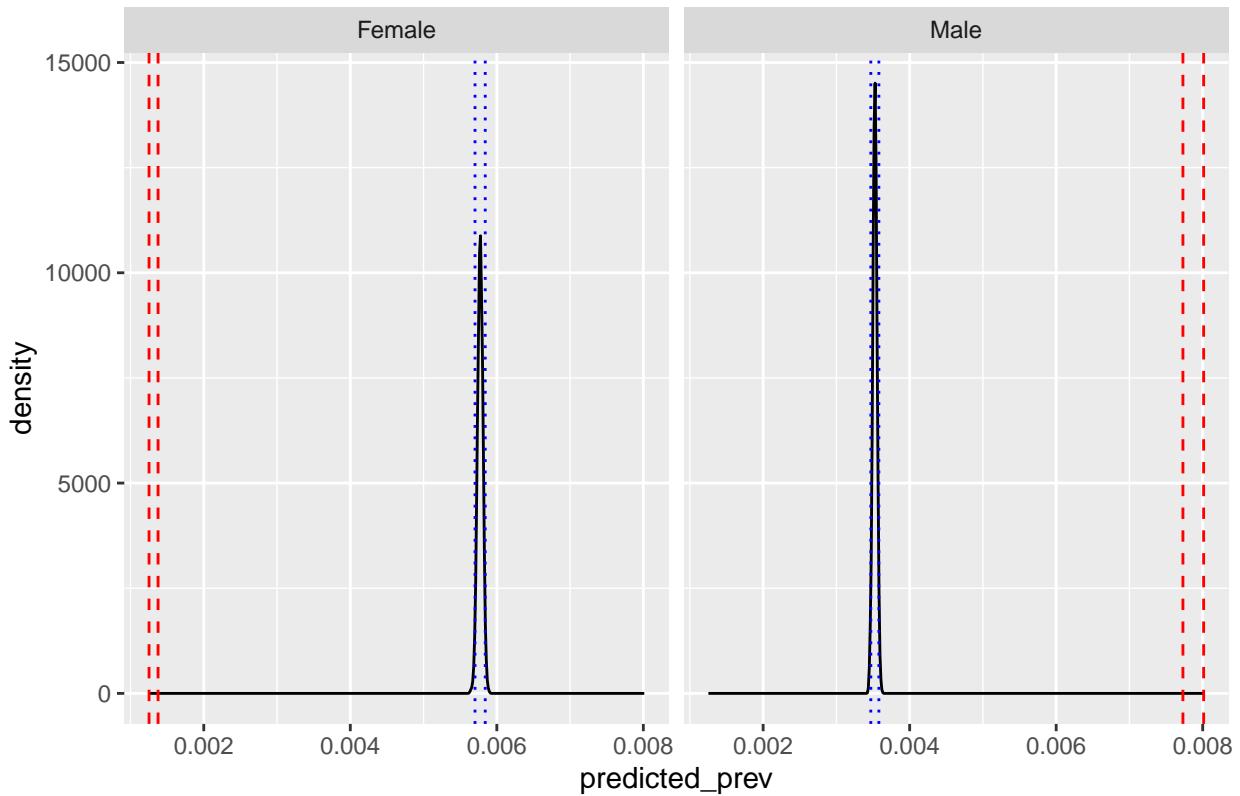
aut_prev_sex_adj <- rbind(aut_prev_adj_m, aut_prev_adj_f)
# have to put m first because 1 comes before 2 and otherwise will mess up naming in do_jags_rand_model

aut_prev_sex_post <- do_jags_rand_model(x = aut_prev_sex_adj,
                                         feat = "sex_desc",
                                         model = rand_model,
                                         theta_mu = theta_mu_prior,
                                         theta_sigma = theta_sigma_prior,
                                         pars = pars,
                                         convergence_checks = FALSE) %>%
  rename("sex_desc" = "Feat_names")

plot_post_density(aut_prev_sex_post, aut_prev_sex_adj, feat = "sex_desc", theta_mu = theta_mu_prior, the
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.

```

Prior mean = 0.00465, prior sd = 3.98e-05



Pretty clear difference across sexes, as expected

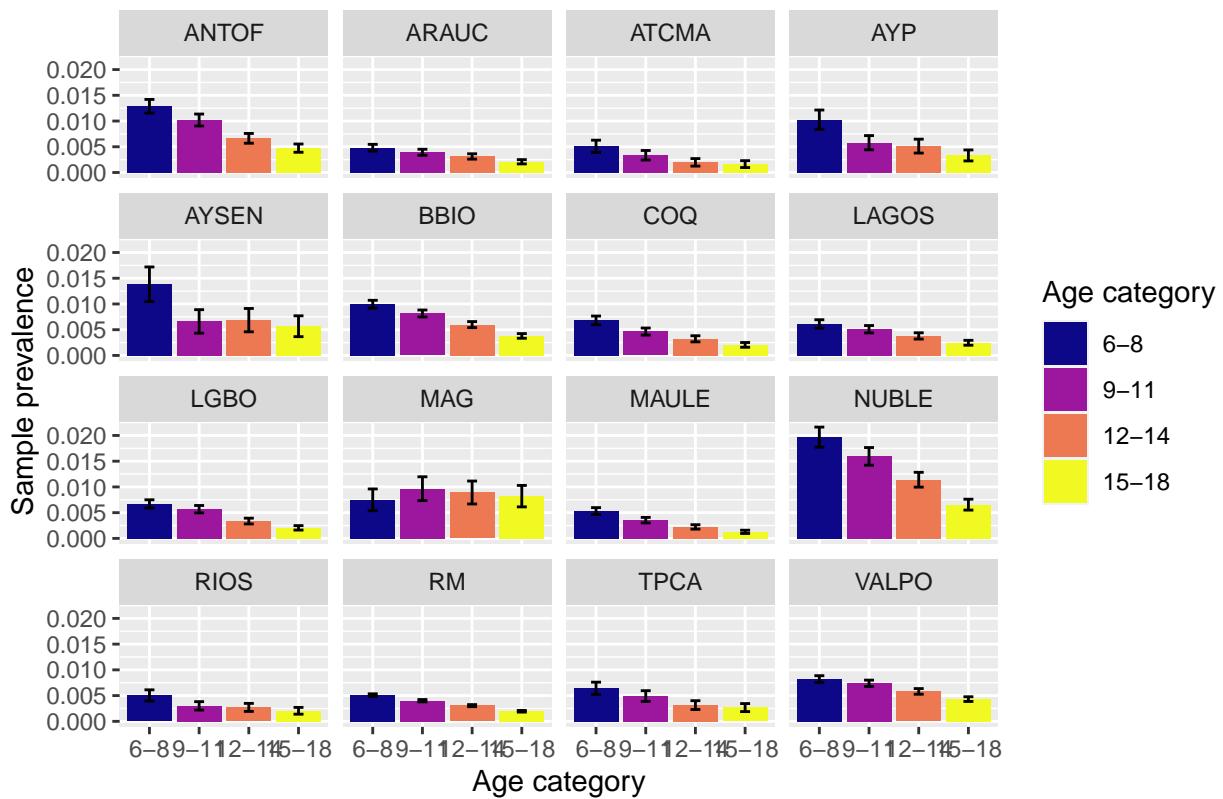
### Random effect on region

```
aut_prev_region.agecat <- get_grouped_prev_plot(x = chile_bayes_aut, c("school_region_name_abr", "age_cat_name"))

## `summarise()` has grouped output by 'school_region_name_abr', 'age_cat_name'.
## You can override using the `.groups` argument.

ggplot(data = aut_prev_region.agecat) +
  geom_col(aes(x = age_cat_name, y = sample_prevalence, group = age_cat_name, fill = age_cat_name), pos =
  geom_errorbar(aes(x = age_cat_name, ymin = ci_lower, ymax = ci_upper, group = age_cat_name), width =
  scale_fill_viridis_d(option = "plasma") +
  #theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  facet_wrap(~school_region_name_abr) +
  labs(title = "Autism prevalence by school region",
       x = "Age category",
       y = "Sample prevalence",
       fill = "Age category")
```

## Autism prevalence by school region



```

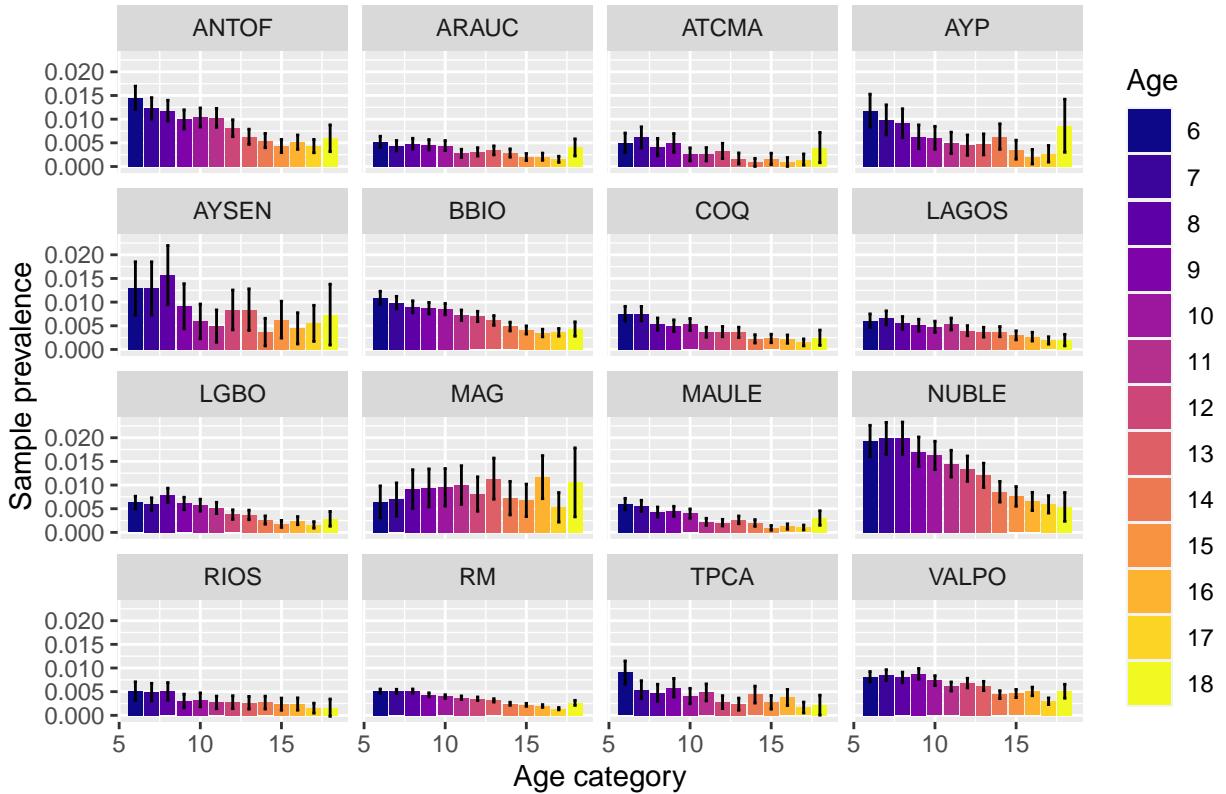
aut_prev_region.age <- get_grouped_prev_plot(x = chile_bayes_aut, c("school_region_name_abr", "age_june30"))

## `summarise()` has grouped output by 'school_region_name_abr', 'age_june30'. You
## can override using the `.groups` argument.

ggplot(data = aut_prev_region.age) +
  geom_col(aes(x = age_june30, y = sample_prevalence, group = age_june30, fill = as.factor(age_june30)))
  geom_errorbar(aes(x = age_june30, ymin = ci_lower, ymax = ci_upper, group = age_june30), width = 0.2,
    scale_fill_viridis_d(option = "plasma") +
    #theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
    #xlim(c(5.5, 18.5)) +
    facet_wrap(~school_region_name_abr) +
    labs(title = "Autism prevalence by school region",
        x = "Age category",
        y = "Sample prevalence",
        fill = "Age")

```

## Autism prevalence by school region

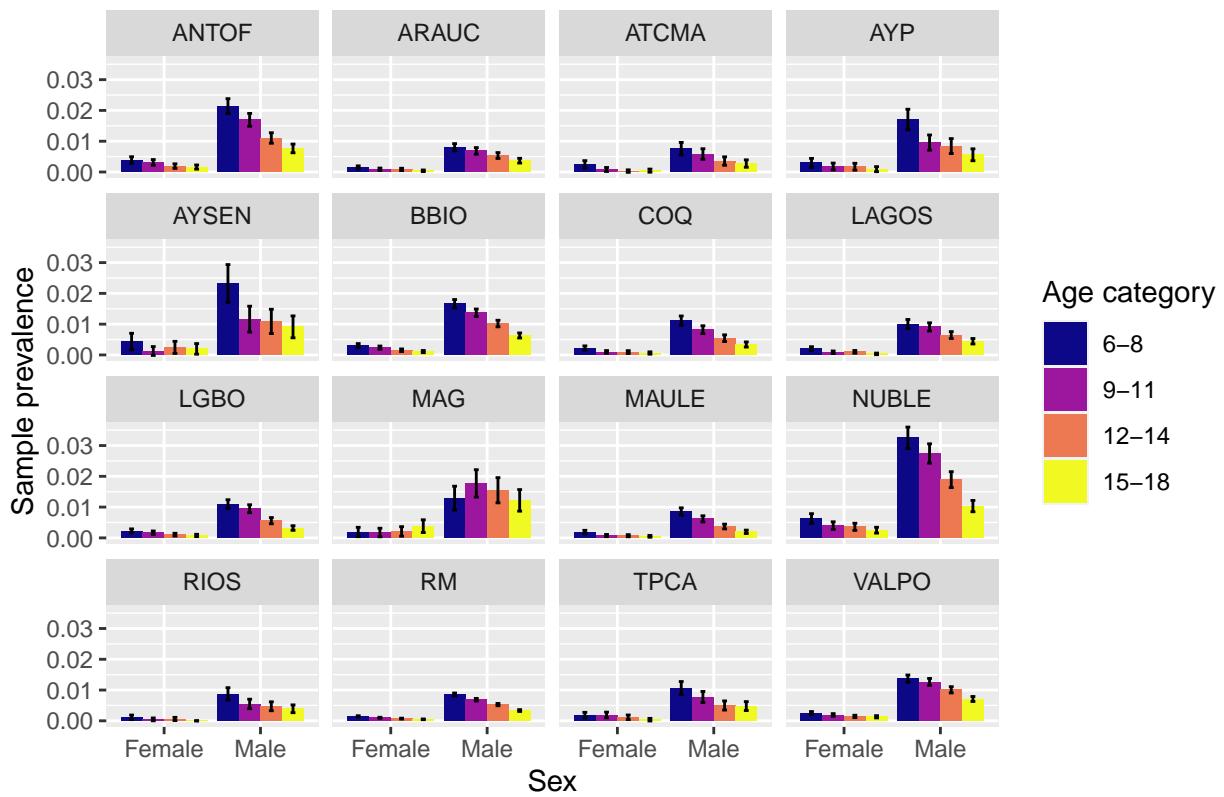


```
aut_prev_region.agecat.sex <- get_grouped_prev_plot(x = chile_bayes_aut, c("school_region_name_abr", "age_cat_name", "sex_desc"))

## `summarise()` has grouped output by 'school_region_name_abr', 'age_cat_name',
## 'sex_desc'. You can override using the `.groups` argument.

ggplot(data = aut_prev_region.agecat.sex) +
  geom_col(aes(x = sex_desc, y = sample_prevalence, group = age_cat_name, fill = age_cat_name), position = "dodge") +
  geom_errorbar(aes(x = sex_desc, ymin = ci_lower, ymax = ci_upper, group = age_cat_name), width = 0.2, position = "dodge") +
  scale_fill_viridis_d(option = "plasma") +
  #theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  facet_wrap(~school_region_name_abr) +
  labs(title = "Autism prevalence by sex",
       x = "Sex",
       y = "Sample prevalence",
       fill = "Age category")
```

## Autism prevalence by sex

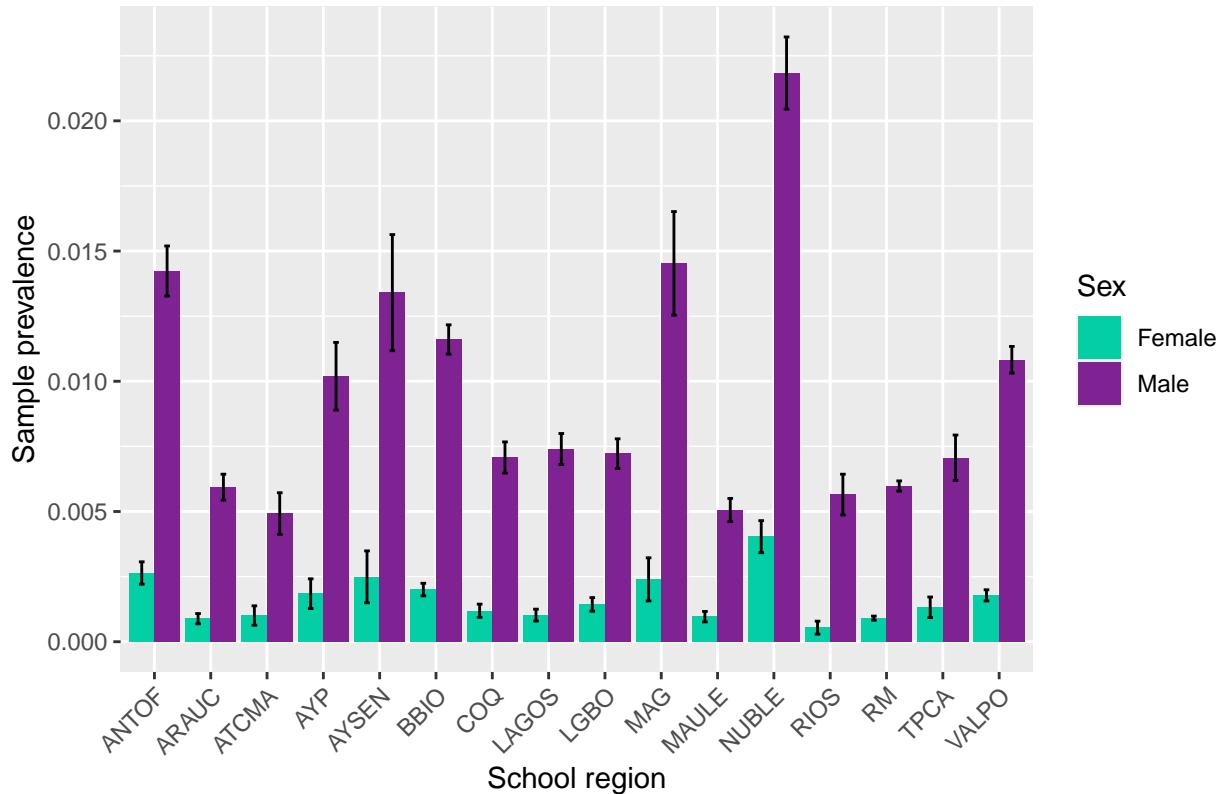


```
aut_prev_region.sex <- get_grouped_prev_plot(x = chile_bayes_aut, c("school_region_name_abr", "sex_desc"))

## `summarise()` has grouped output by 'school_region_name_abr', 'sex_desc'. You
## can override using the `.groups` argument.

ggplot(data = aut_prev_region.sex) +
  geom_col(aes(x = school_region_name_abr, y = sample_prevalence, group = sex_desc, fill = as.factor(se
    # 1 is male, 2 is female
  geom_errorbar(aes(x = school_region_name_abr, ymin = ci_lower, ymax = ci_upper, group = sex_desc), wi
  #scale_fill_manual(values = wes_palette("GrandBudapest1")) +
  scale_fill_manual(values = c("#03CEA4", "#802392")) +
  theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  labs(title = "Autism prevalence",
       x = "School region",
       y = "Sample prevalence",
       fill = "Sex")
```

## Autism prevalence



```

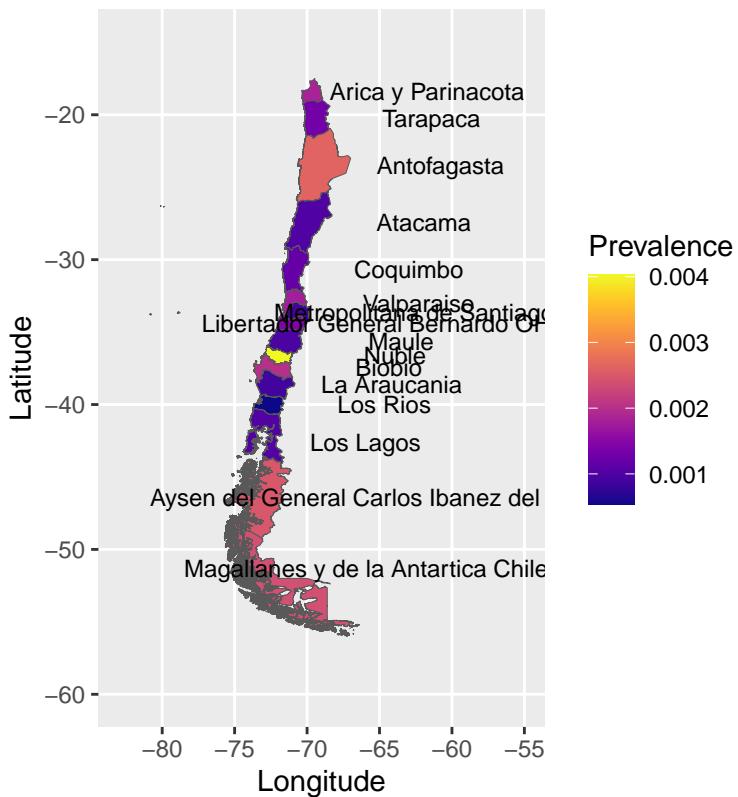
aut_prev_region.geom.f <- aut_prev_region.sex %>%
  filter(sex_desc == "Female") %>%
  left_join(regions_lookup, by = "school_region_name_abr") %>%
  left_join(demog_geom, by = c("nombre_region", "codigo_region"))

ggplot(aut_prev_region.geom.f) +
  geom_sf(mapping = aes(geometry = geometry, fill = sample_prevalence), linewidth = 0.01) +
  geom_sf_text(mapping = aes(geometry = geometry, label = nombre_region), nudge_x = 8, size = 3) +
  scale_fill_viridis(option = "plasma", name = "Prevalence") + #, limits = c(0, 0.025)) +
  labs(title = "Autism prevalence (females)") +
  xlab("Longitude") +
  ylab("Latitude") +
  coord_sf(xlim = c(-83, -55), ylim = c(-60, -15))

## Warning in st_point_on_surface.sfc(sf::st_zm(x)): st_point_on_surface may not
## give correct results for longitude/latitude data

```

## Autism prevalence (females)



```

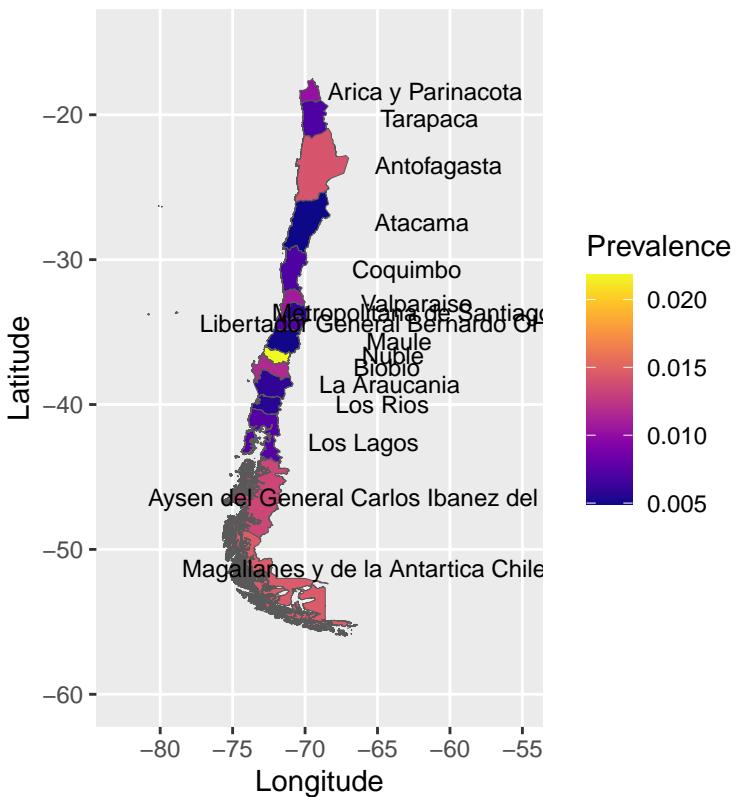
aut_prev_region.geom.m <- aut_prev_region.sex %>%
  filter(sex_desc == "Male") %>%
  left_join(regions_lookup, by = "school_region_name_abr") %>%
  left_join(demog_geom, by = c("nombre_region", "codigo_region"))

ggplot(aut_prev_region.geom.m) +
  geom_sf(mapping = aes(geometry = geometry, fill = sample_prevalence), linewidth = 0.01) +
  geom_sf_text(mapping = aes(geometry = geometry, label = nombre_region), nudge_x = 8, size = 3) +
  scale_fill_viridis(option = "plasma", name = "Prevalence") + #, limits = c(0, 0.025)) +
  labs(title = "Autism prevalence (males)") +
  xlab("Longitude") +
  ylab("Latitude") +
  coord_sf(xlim = c(-83, -55), ylim = c(-60, -15))

## Warning in st_point_on_surface.sfc(sf::st_zm(x)): st_point_on_surface may not
## give correct results for longitude/latitude data

```

## Autism prevalence (males)



```
# Need to add standardised scale to both f and m

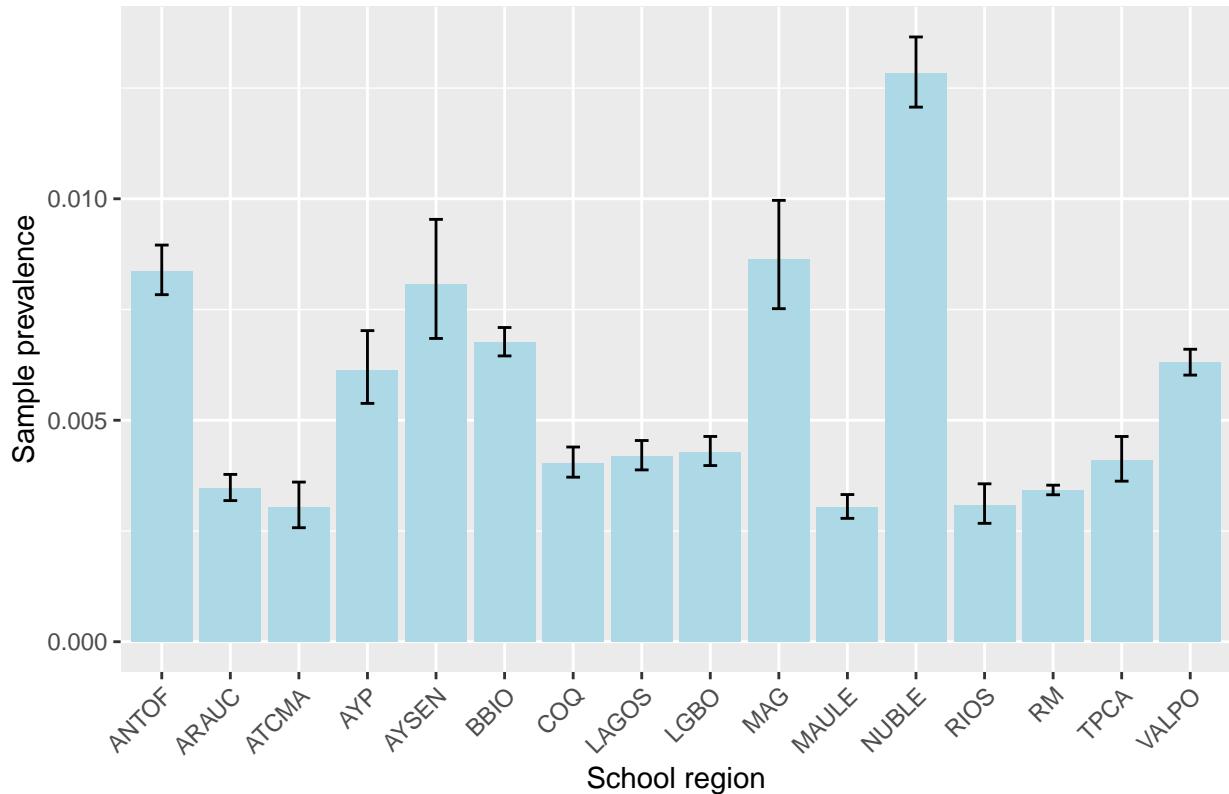
aut_prev_region <- get_grouped_prev(x = chile_bayes_aut, stdpop = chile_stdpop,
                                     grouping_vars = c("school_region_name_abr", "age_june30", "age_cat_name",
                                     "sex", "sex_desc"))

## `summarise()` has grouped output by 'school_region_name_abr', 'age_june30',
## 'age_cat_name', 'sex', 'sex_desc'. You can override using the `.groups` argument.

aut_prev_region_adj <- get_adjusted_prev(aut_prev_region, grouping_vars = "school_region_name_abr")

ggplot(data = aut_prev_region_adj) +
  geom_col(aes(x = school_region_name_abr, y = adjusted_rate), fill = "lightblue", position = "dodge") +
  geom_errorbar(aes(x = school_region_name_abr, ymin = ci_lower, ymax = ci_upper), width = 0.2) +
  theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  labs(title = "Age- and sex-adjusted autism prevalence",
       x = "School region",
       y = "Sample prevalence")
```

## Age- and sex-adjusted autism prevalence



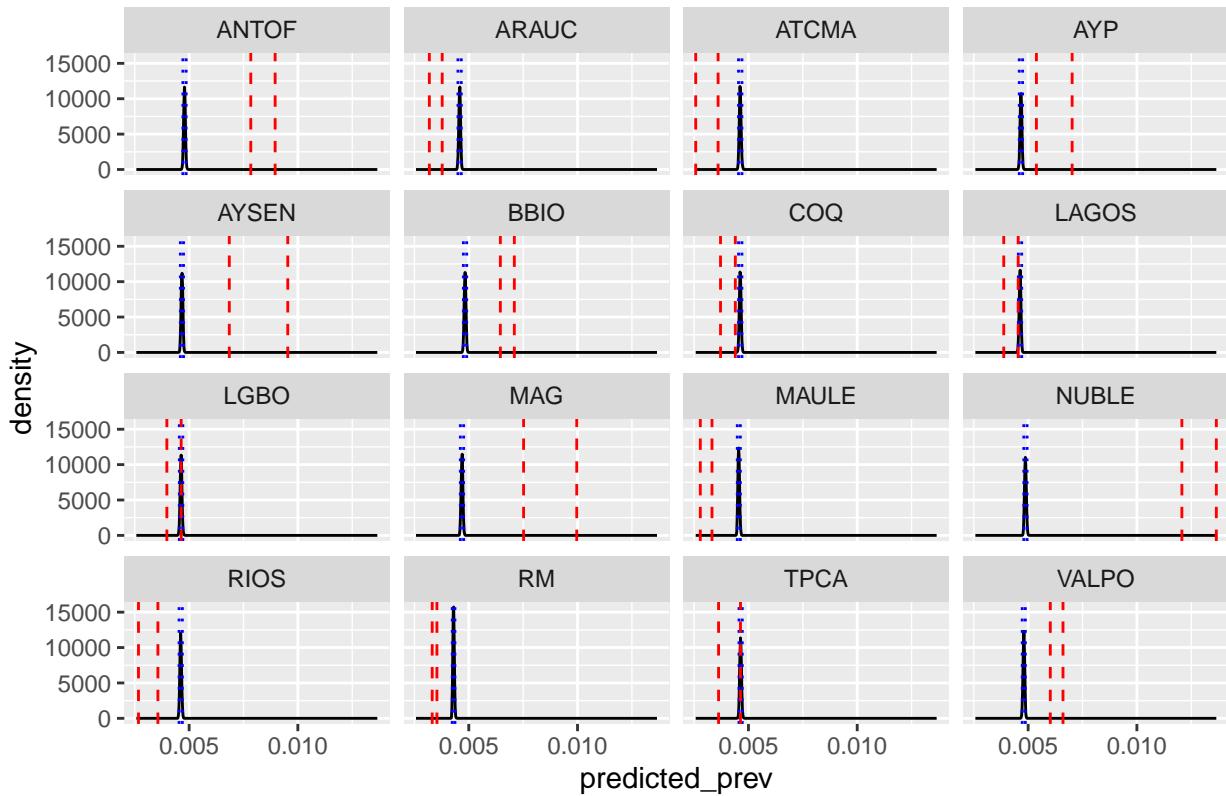
```

aut_prev_region_post <- do_jags_rand_model(x = aut_prev_region_adj,
                                             feat = "school_region_name_abr",
                                             model = rand_model,
                                             theta_mu = theta_mu_prior,
                                             theta_sigma = theta_sigma_prior,
                                             pars = pars,
                                             convergence_checks = FALSE) %>%
  rename("school_region_name_abr" = "Feat_names")

plot_post_density(aut_prev_region_post, aut_prev_region_adj, feat = "school_region_name_abr", theta_mu =
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.

```

Prior mean = 0.00465, prior sd = 3.98e-05



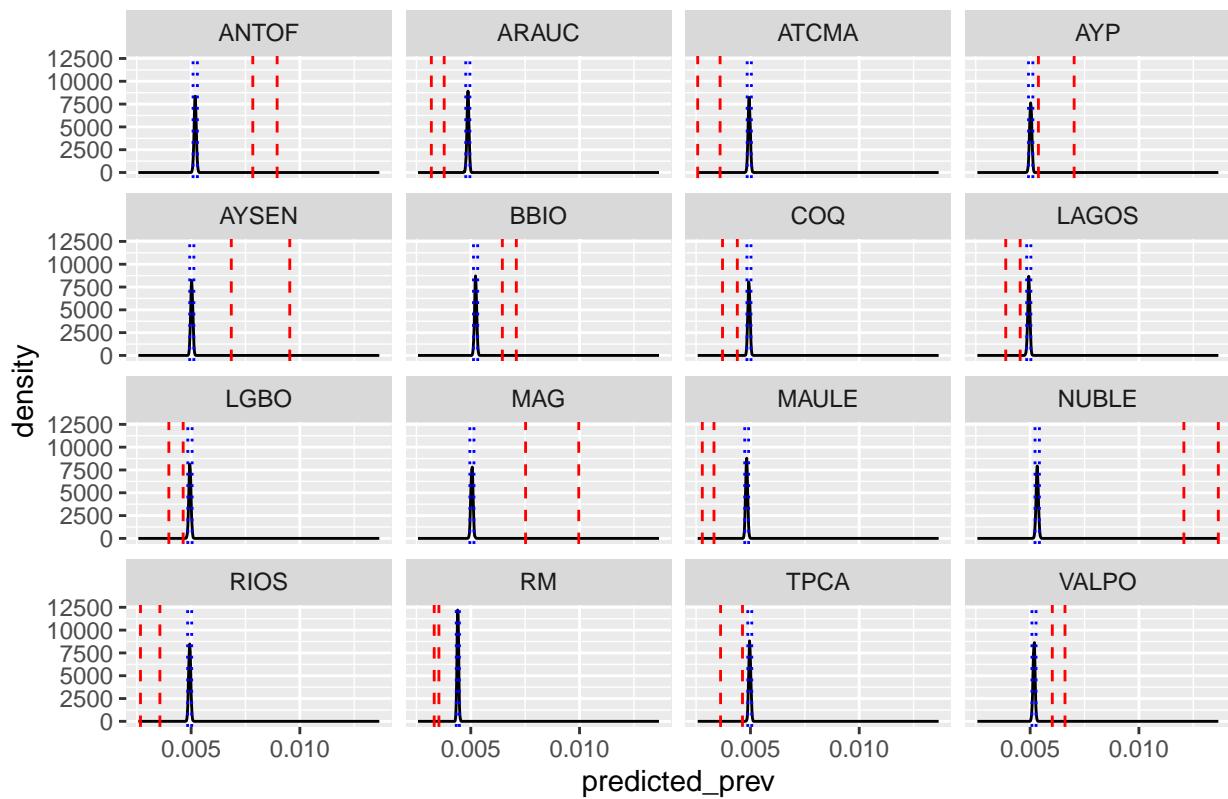
Predictions for higher population prevalence - increase prior mean

```
for(j in 1:length(theta_mu_extrapolate)) {
  aut_prev_region_post <- do_jags_rand_model(x = aut_prev_region_adj,
                                              feat = "school_region_name_abr",
                                              model = rand_model,
                                              theta_mu = theta_mu_extrapolate[j],
                                              theta_sigma = theta_sigma_extrapolate[j],
                                              pars = pars,
                                              convergence_checks = FALSE) %>%
    rename("school_region_name_abr" = "Feat_names")

  plot_post_density(aut_prev_region_post,
                    aut_prev_region_adj,
                    feat = "school_region_name_abr",
                    theta_mu = theta_mu_extrapolate[j],
                    theta_sigma = theta_sigma_extrapolate[j])
}

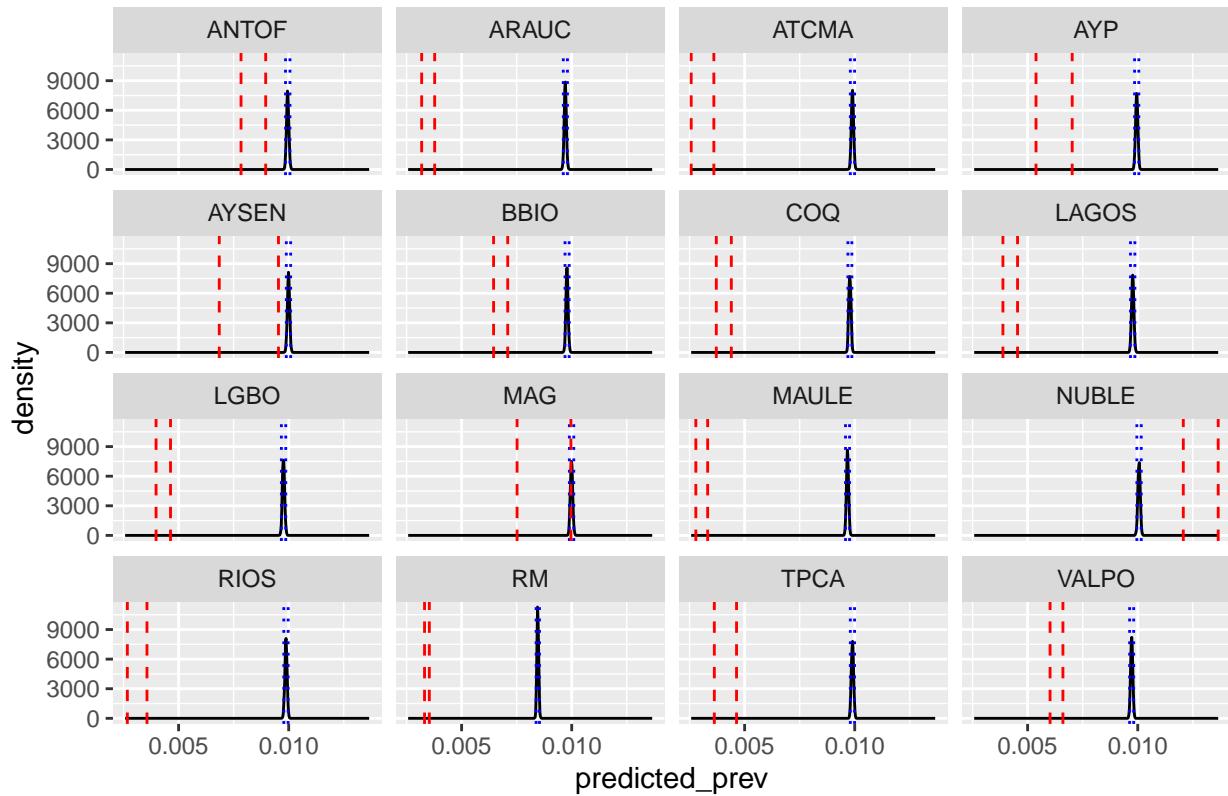
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.005, prior sd = 5.1e-05



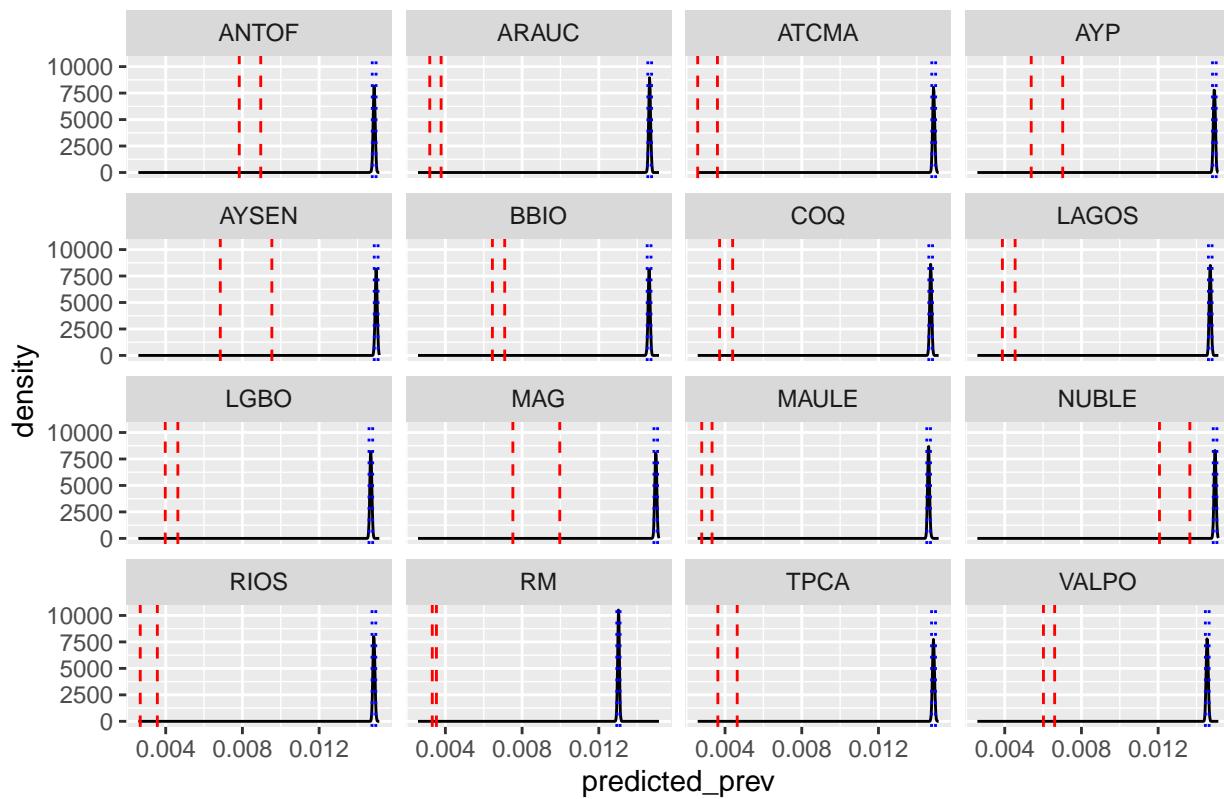
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.01, prior sd = 5.1e-05



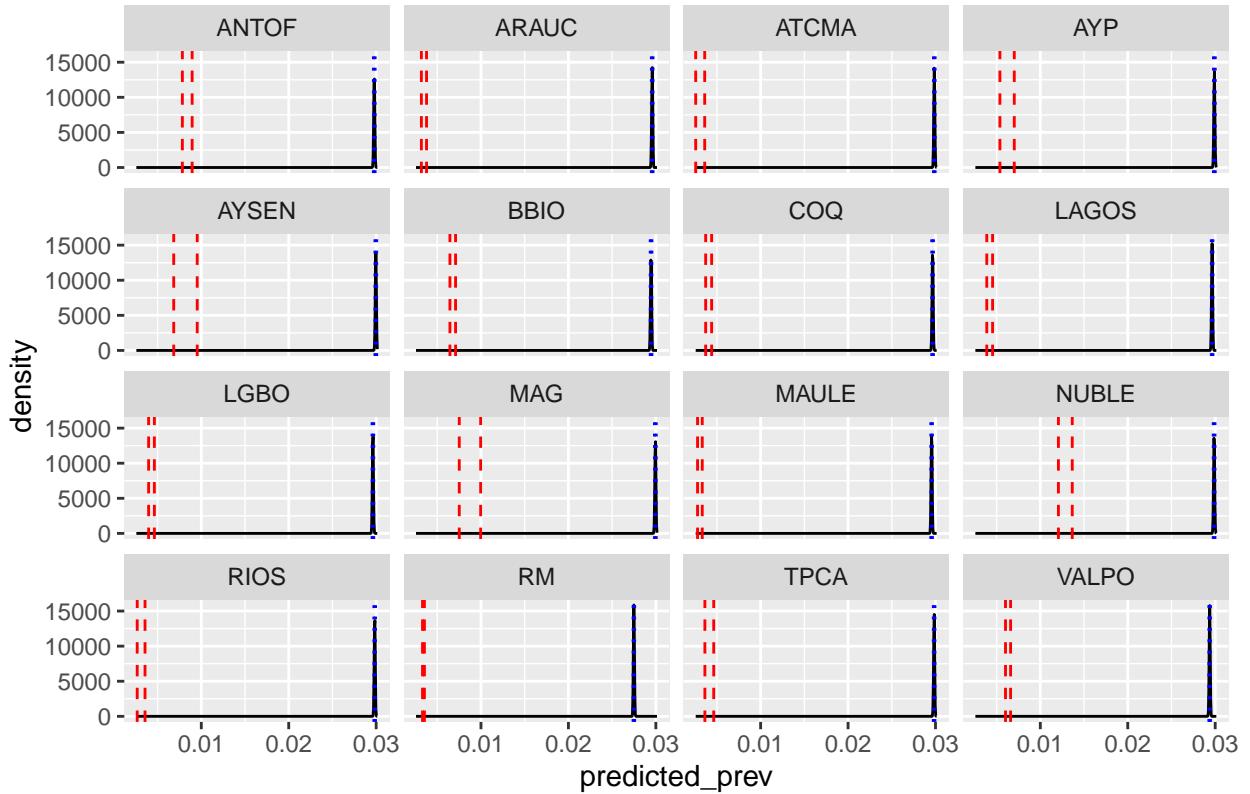
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.015, prior sd = 5.1e-05



```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.03, prior sd = 5.1e-05



### Random effect on region, sexes separate

Need sex specific priors - use age-adjusted prevalence from above

```

theta_mu_prior_f <- aut_prev_adj_f$adjusted_rate
theta_sigma_prior_f <- sqrt(aut_prev_adj_f$var)

theta_mu_prior_m <- aut_prev_adj_m$adjusted_rate
theta_sigma_prior_m <- sqrt(aut_prev_adj_m$var)

# Females
aut_prev_region_f <- chile_bayes_aut %>%
  filter(sex == 2) %>%
  get_grouped_prev(stdpop = chile_stdpop_f, grouping_vars = c("school_region_name_abr", "age_june30", ""))

## `summarise()` has grouped output by 'school_region_name_abr', 'age_june30',
## 'sex'. You can override using the `.groups` argument.
aut_prev_region_adj_f <- get_adjusted_prev(aut_prev_region_f, grouping_vars = "school_region_name_abr")

aut_prev_region_post_f <- do_jags_rand_model(x = aut_prev_region_adj_f,
                                              feat = "school_region_name_abr",
                                              model = rand_model,
                                              theta_mu = theta_mu_prior_f,
                                              theta_sigma = theta_sigma_prior_f,
                                              pars = pars,
                                              convergence_checks = FALSE) %>%

```

```

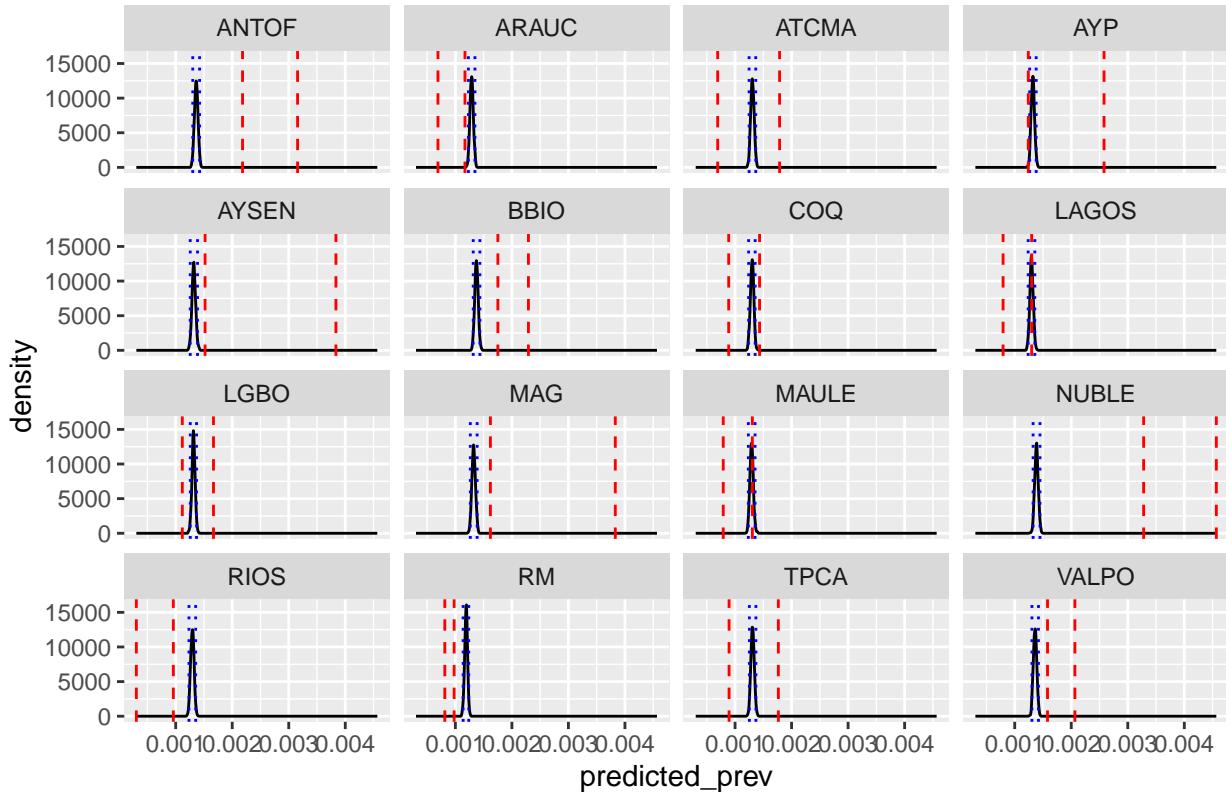
rename("school_region_name_abr" = "Feat_names")

plot_post_density(aut_prev_region_post_f, aut_prev_region_adj_f, feat = "school_region_name_abr", theta_mu = 0.00131, theta_sigma = 3.08e-05)

## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.

```

Prior mean = 0.00131, prior sd = 3.08e-05 (females)



```

# Males

aut_prev_region_m <- chile_bayes_aut %>%
  filter(sex == 1) %>%
  get_grouped_prev(stdpop = chile_stdpop_m, grouping_vars = c("school_region_name_abr", "age_june30", ""))

## `summarise()` has grouped output by 'school_region_name_abr', 'age_june30',
## 'sex'. You can override using the ` `.groups` argument.

aut_prev_region_adj_m <- get_adjusted_prev(aut_prev_region_m, grouping_vars = "school_region_name_abr")

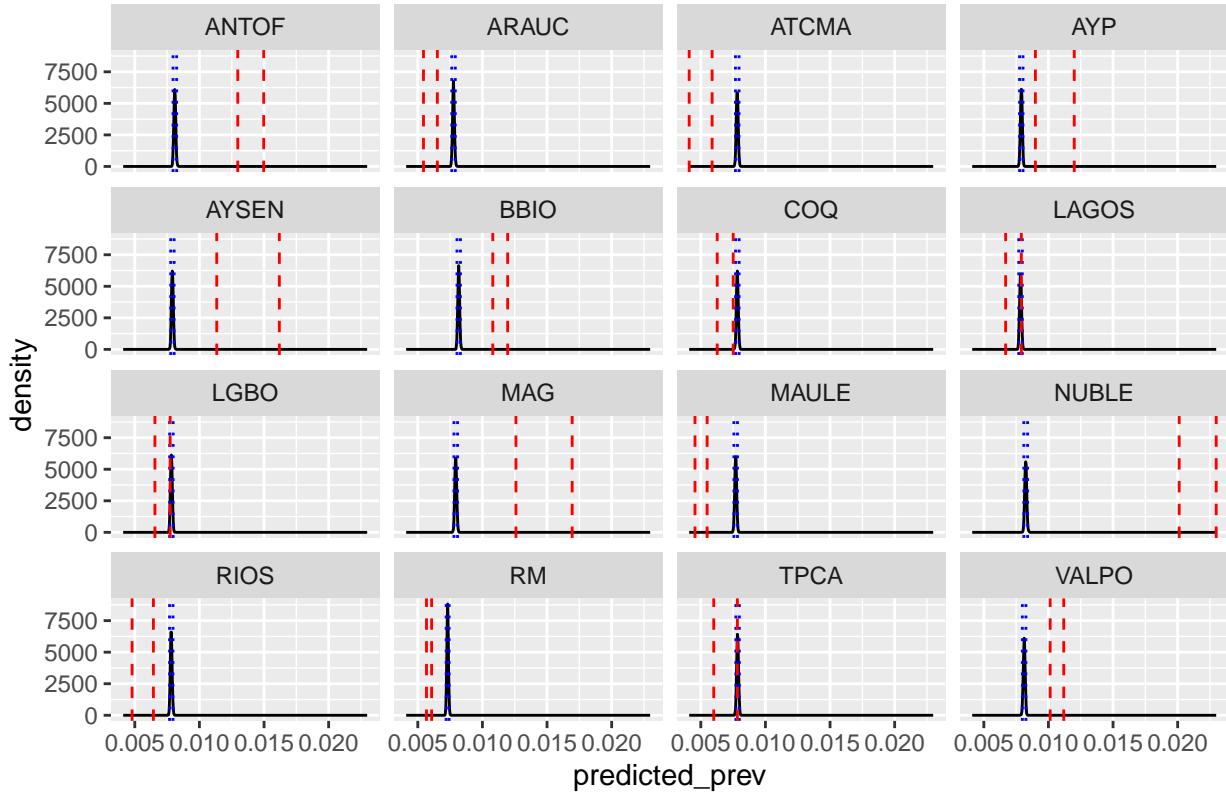
aut_prev_region_post_m <- do_jags_rand_model(x = aut_prev_region_adj_m,
                                              feat = "school_region_name_abr",
                                              model = rand_model,
                                              theta_mu = theta_mu_prior_m,
                                              theta_sigma = theta_sigma_prior_m,
                                              pars = pars,
                                              convergence_checks = FALSE) %>%
  rename("school_region_name_abr" = "Feat_names")

plot_post_density(aut_prev_region_post_m, aut_prev_region_adj_m, feat = "school_region_name_abr", theta_mu = 0.00131, theta_sigma = 3.08e-05)

```

```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.00787, prior sd = 7.17e-05 (males)



Maybe need different extrapolation priors for females?

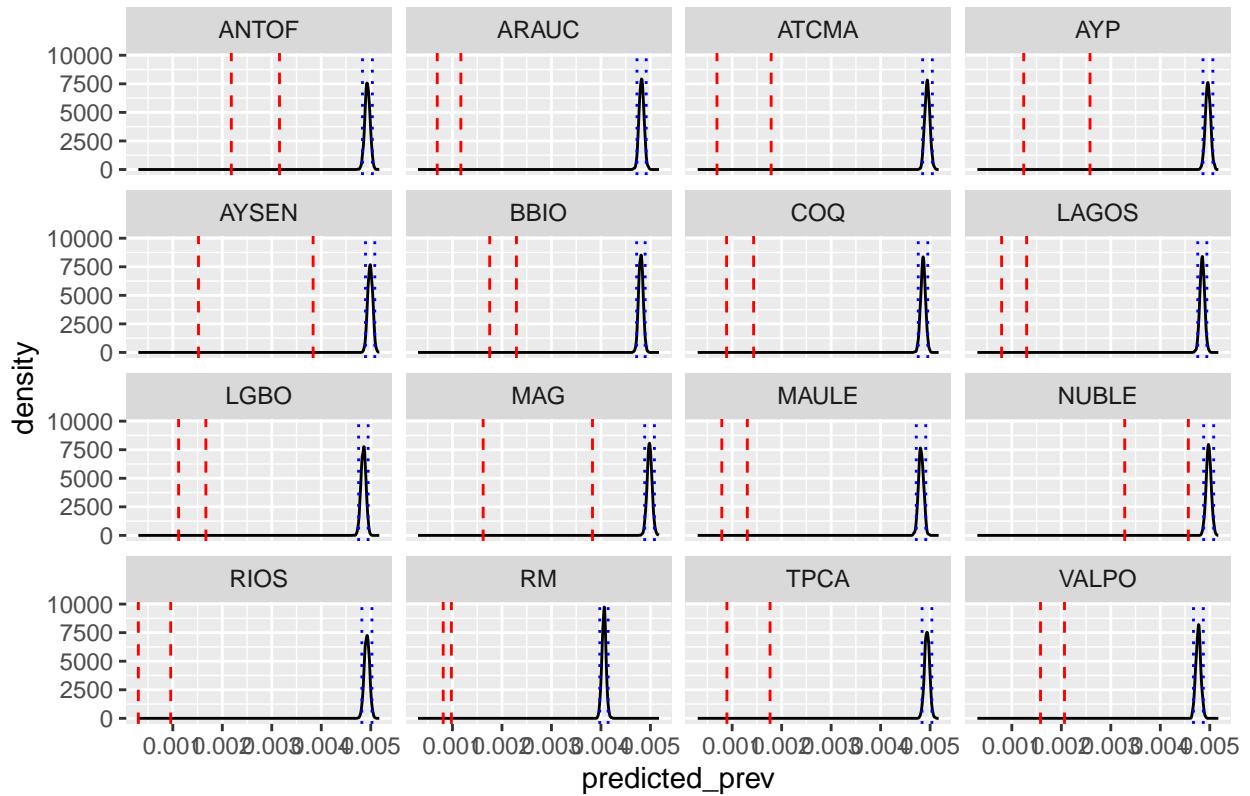
```
# Females
for(j in 1:length(theta_mu_extrapolate)) {
  aut_prev_region_post_f <- do_jags_rand_model(x = aut_prev_region_adj_f,
                                                feat = "school_region_name_abr",
                                                model = rand_model,
                                                theta_mu = theta_mu_extrapolate[j],
                                                theta_sigma = theta_sigma_extrapolate[j],
                                                pars = pars,
                                                convergence_checks = FALSE) %>%
    rename("school_region_name_abr" = "Feat_names")

  plot_post_density(aut_prev_region_post_f,
                    aut_prev_region_adj_f,
                    feat = "school_region_name_abr",
                    theta_mu = theta_mu_extrapolate[j],
                    theta_sigma = theta_sigma_extrapolate[j],
                    title_text = " (females)")

}

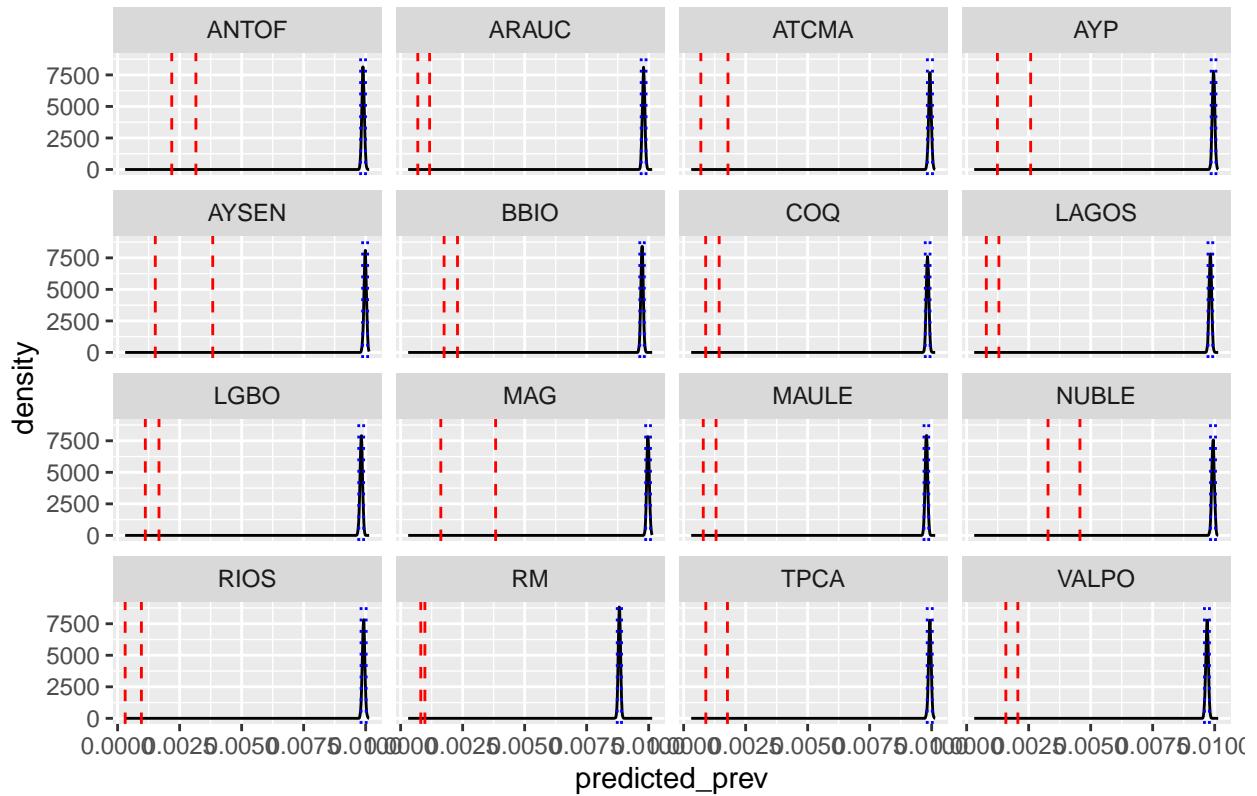
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.005, prior sd = 5.1e-05 (females)



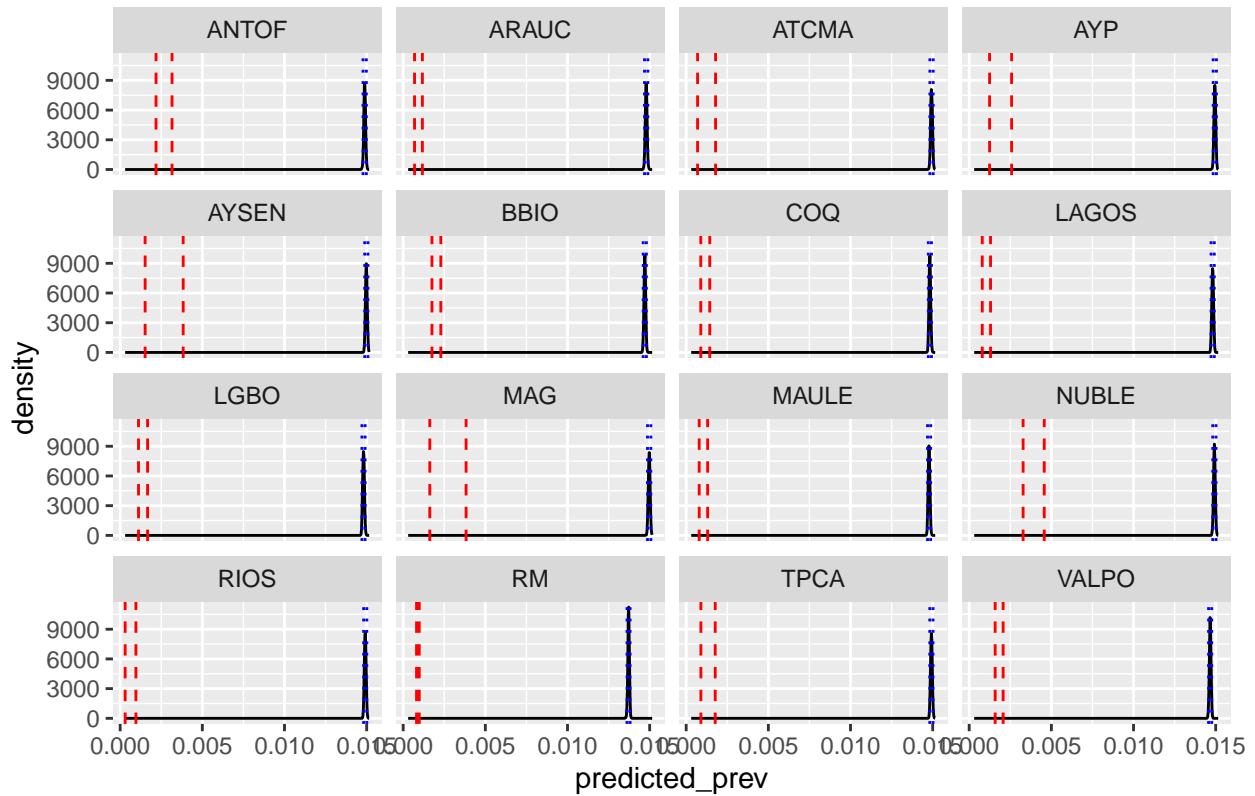
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.01, prior sd = 5.1e-05 (females)



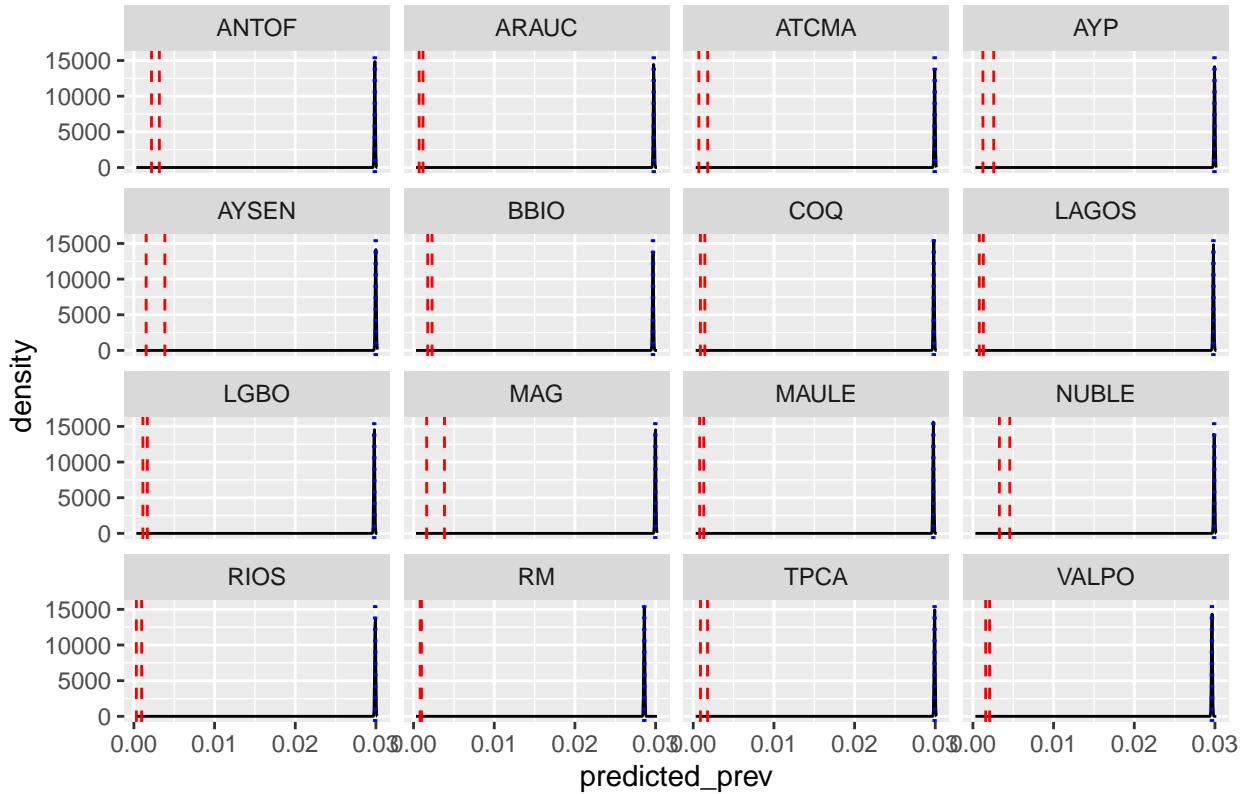
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.015, prior sd = 5.1e-05 (females)



```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.03, prior sd = 5.1e-05 (females)



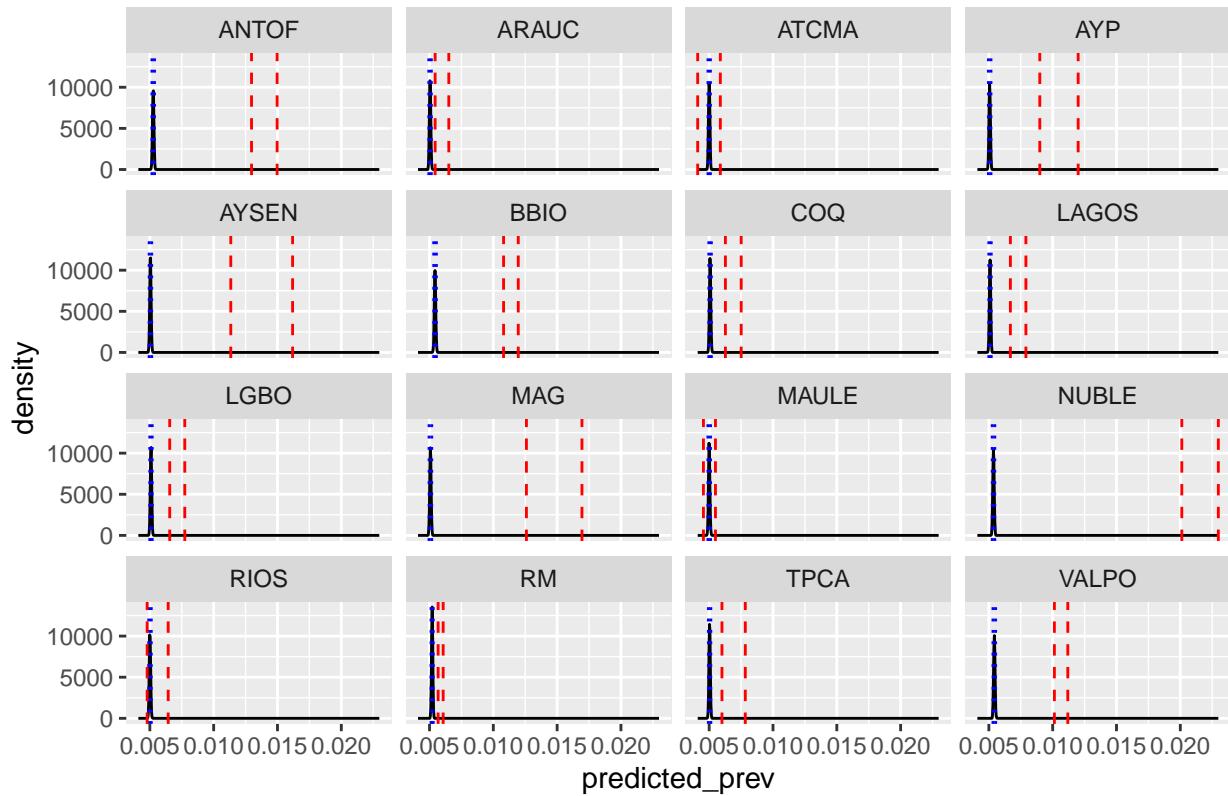
```
# Males
for(j in 1:length(theta_mu_extrapolate)) {
  aut_prev_region_post_m <- do_jags_rand_model(x = aut_prev_region_adj_m,
                                                feat = "school_region_name_abr",
                                                model = rand_model,
                                                theta_mu = theta_mu_extrapolate[j],
                                                theta_sigma = theta_sigma_extrapolate[j],
                                                pars = pars,
                                                convergence_checks = FALSE) %>%
  rename("school_region_name_abr" = "Feat_names")

  plot_post_density(aut_prev_region_post_m,
                    aut_prev_region_adj_m,
                    feat = "school_region_name_abr",
                    theta_mu = theta_mu_extrapolate[j],
                    theta_sigma = theta_sigma_extrapolate[j],
                    title_text = " (males)")

}

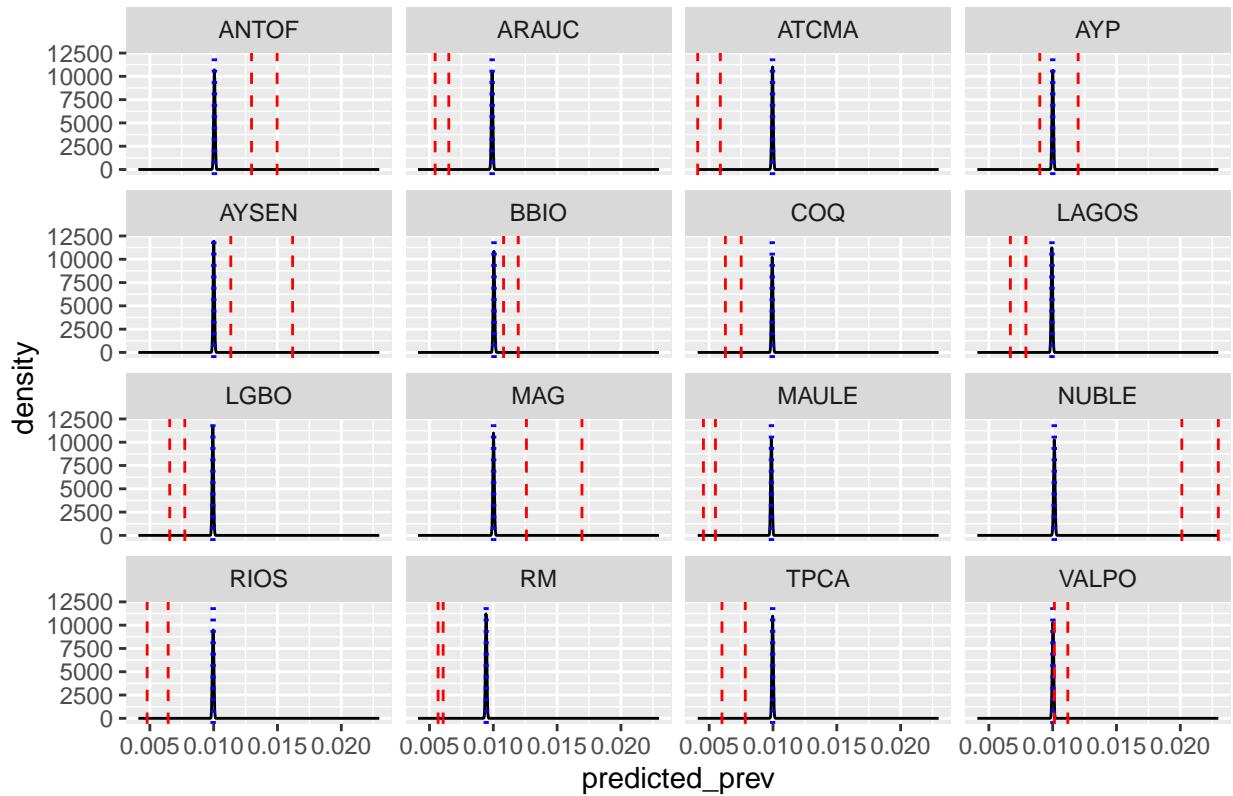
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.005, prior sd = 5.1e-05 (males)



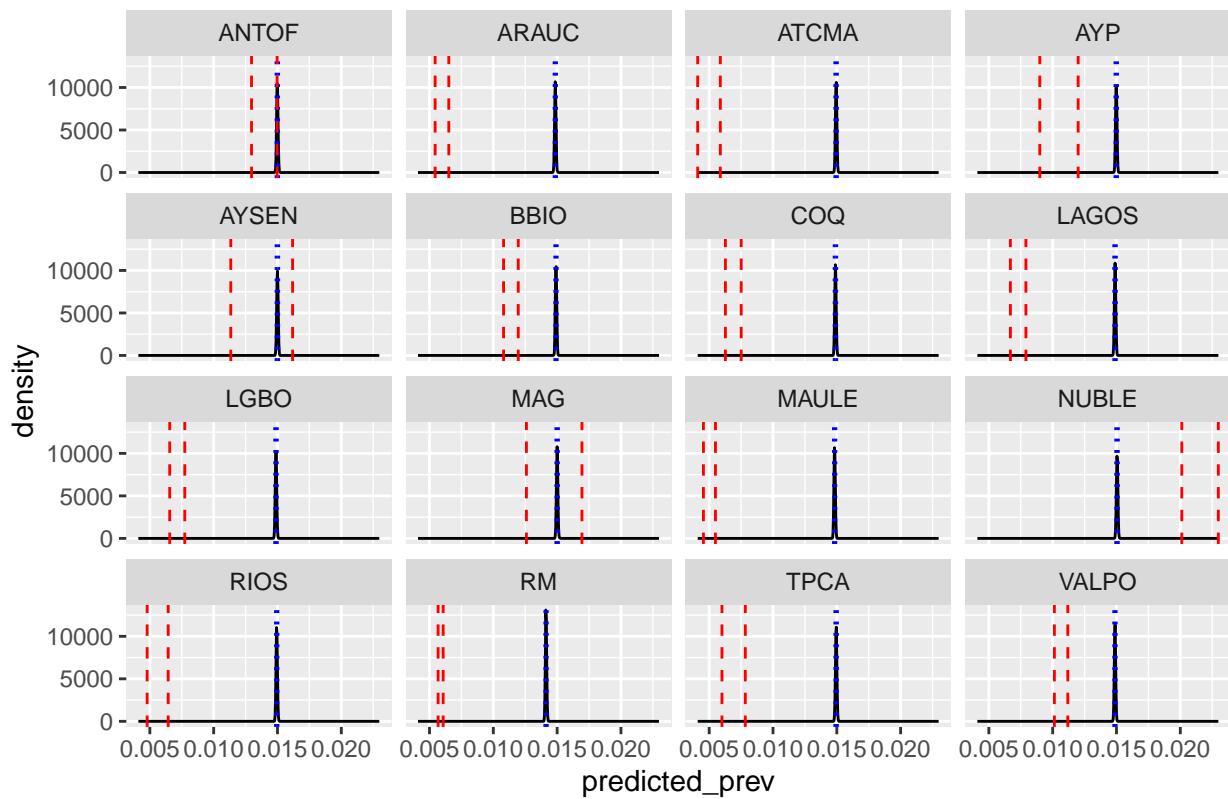
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.01, prior sd = 5.1e-05 (males)



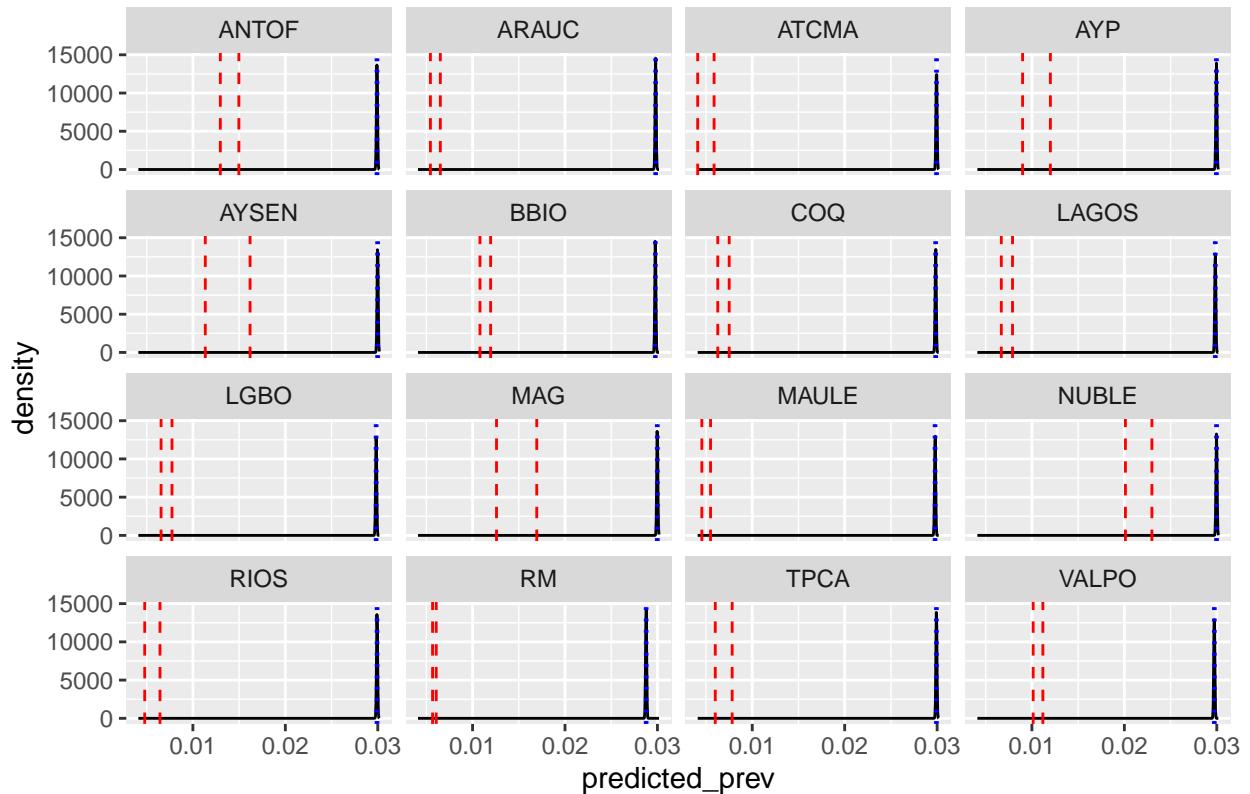
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.015, prior sd = 5.1e-05 (males)



```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

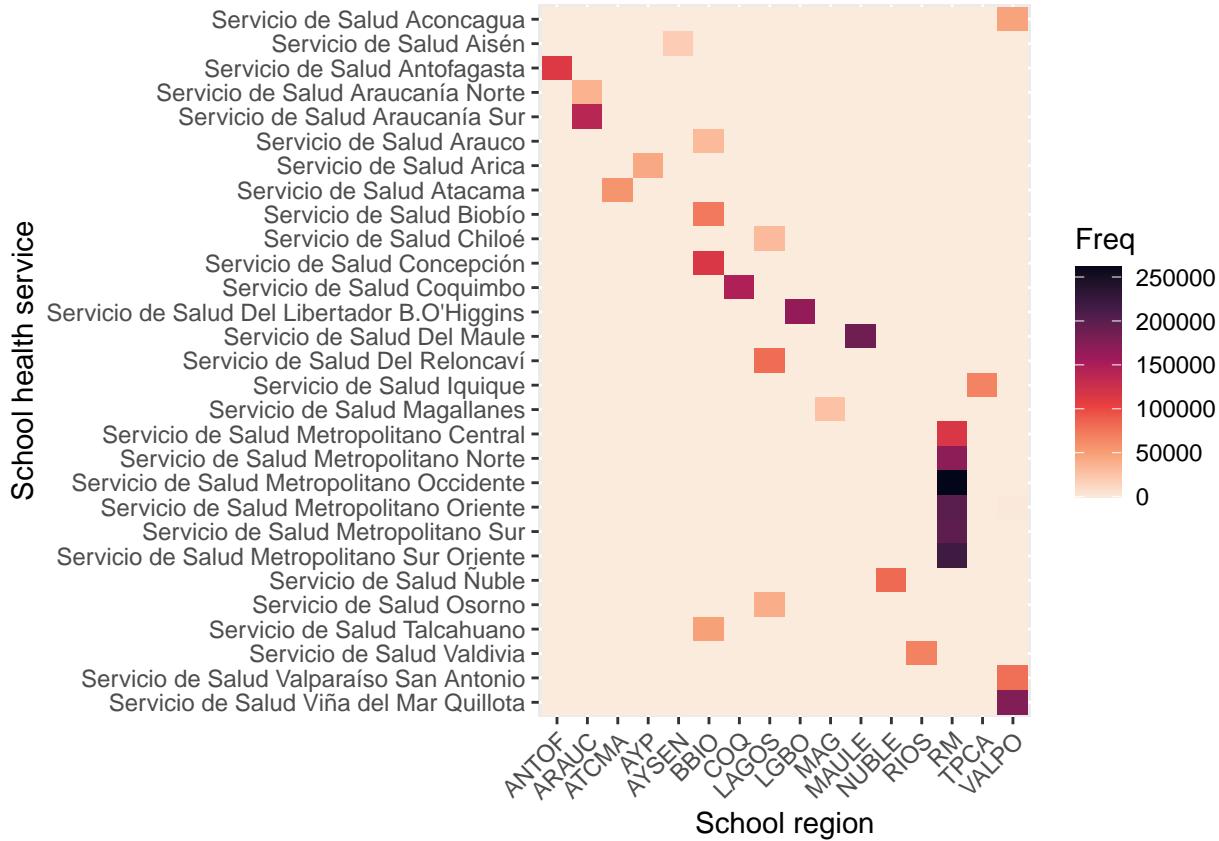
Prior mean = 0.03, prior sd = 5.1e-05 (males)



### Random effect on health service

Show which regions each health service operates in

```
map_tab_df <- as.data.frame(table(chile_bayes_aut$school_region_name_abr, chile_bayes_aut$health_service))
ggplot(map_tab_df, aes(x = Var1, y = Var2, fill = Freq)) +
  geom_tile() +
  #scale_fill_gradient(low = "white", high = "blue") +
  scale_fill_viridis_c(option = "rocket", direction = -1) +
  theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
  scale_y_discrete(limits = rev(levels(map_tab_df$Var2))) +
  labs(x = "School region", y = "School health service", fill = "Freq")
```



```
#map2_tab_df <- as.data.frame(table(chile_bayes_aut$school_commune_name, chile_bayes_aut$health_service_name))
#ggplot(map2_tab_df, aes(x = Var1, y = Var2, fill = Freq)) +
#  geom_tile() +
#  #scale_fill_gradient(low = "white", high = "blue") +
#  scale_fill_viridis_c(option = "rocket", direction = -1) +
#  theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
#  scale_y_discrete(limits = rev(levels(map2_tab_df$Var2))) +
#  labs(x = "School commune", y = "School health service", fill = "Freq")
```

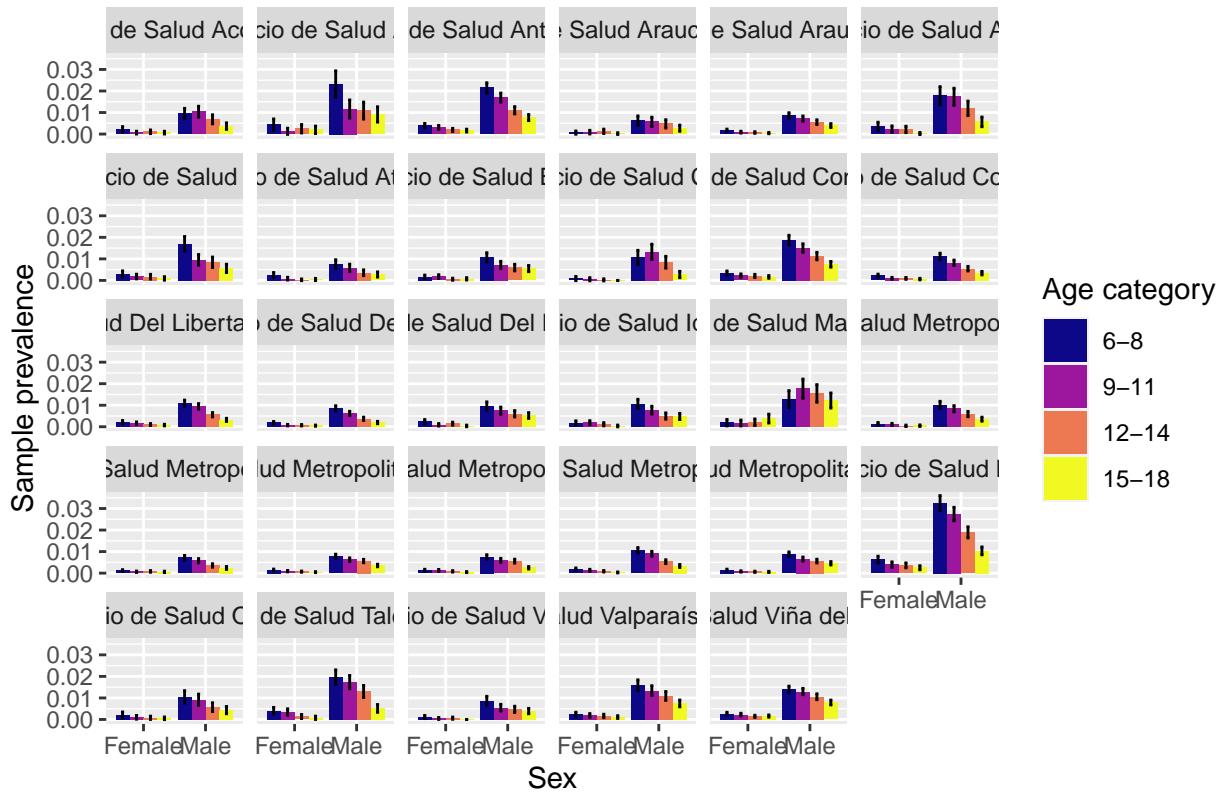
Each health service operates in only one region, some regions (RM, VALPO, LAGOS, BBIO, ARAUC) have multiple health services.

```
aut_prev_health.agecat.sex <- get_grouped_prev_plot(x = chile_bayes_aut, c("health_service_name", "age_cat_name", "sex_desc"))

## `summarise()` has grouped output by 'health_service_name', 'age_cat_name',
## 'sex_desc'. You can override using the ``.groups` argument.

ggplot(data = aut_prev_health.agecat.sex) +
  geom_col(aes(x = sex_desc, y = sample_prevalence, group = age_cat_name, fill = age_cat_name), position = "stack") +
  geom_errorbar(aes(x = sex_desc, ymin = ci_lower, ymax = ci_upper, group = age_cat_name), width = 0.2, position = "stack") +
  scale_fill_viridis_d(option = "plasma") +
  #theme(axis.text.x = element_text(angle = 90, hjust = 1, vjust = 0.2)) +
  facet_wrap(~health_service_name) +
  labs(title = "Autism prevalence by school health service",
       x = "Sex",
       y = "Sample prevalence",
       fill = "Age category")
```

## Autism prevalence by school health service

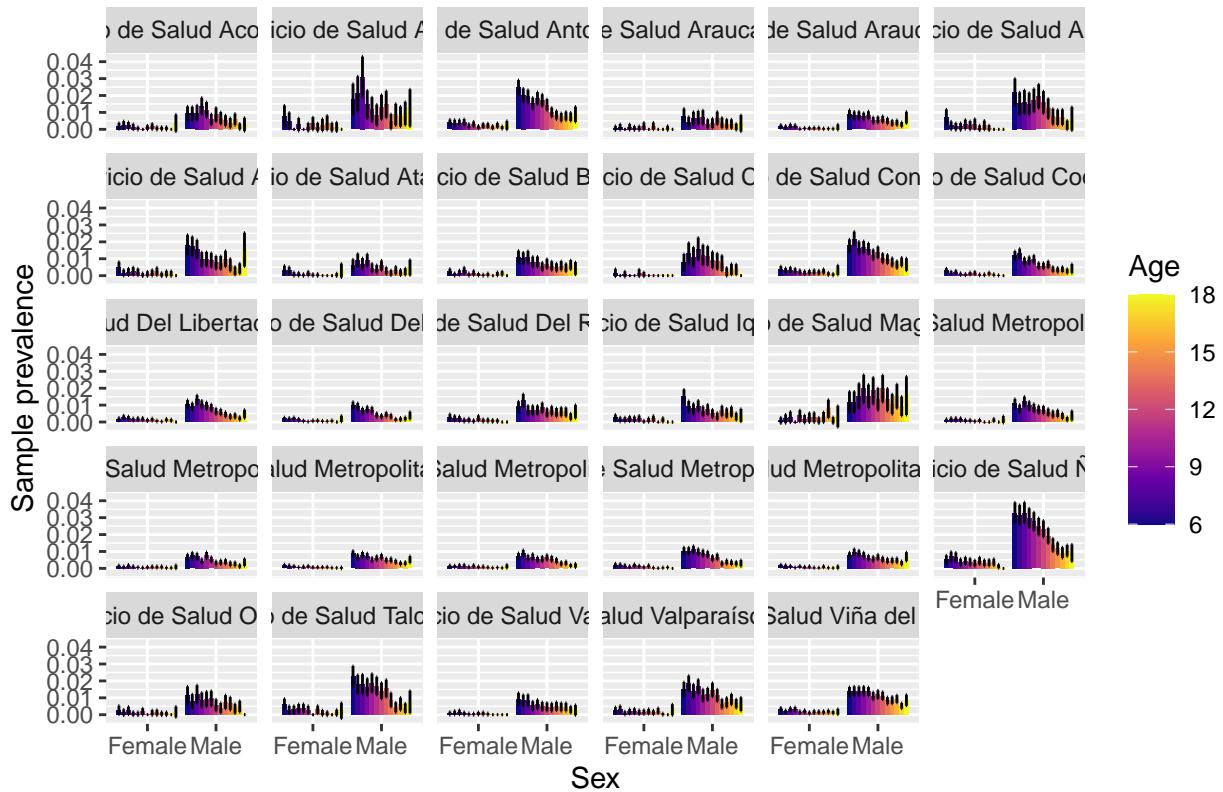


```
aut_prev_health.age.sex <- get_grouped_prev_plot(x = chile_bayes_aut, c("health_service_name", "age_june30"))

## `summarise()` has grouped output by 'health_service_name', 'age_june30',
## 'sex_desc'. You can override using the `.groups` argument.

ggplot(data = aut_prev_health.age.sex) +
  geom_col(aes(x = sex_desc, y = sample_prevalence, group = age_june30, fill = age_june30), position = position_dodge())
  geom_errorbar(aes(x = sex_desc, ymin = ci_lower, ymax = ci_upper, group = age_june30), width = 0.2, position = position_dodge())
  scale_fill_viridis_c(option = "plasma") +
  #theme(axis.text.x = element_text(angle = 90, hjust = 1, vjust = 0.2)) +
  facet_wrap(~health_service_name) +
  labs(title = "Autism prevalence by school health service",
       x = "Sex",
       y = "Sample prevalence",
       fill = "Age")
```

## Autism prevalence by school health service



```

aut_prev_health <- get_grouped_prev(x = chile_bayes_aut, stdpop = chile_stdpop,
                                     grouping_vars = c("health_service_name", "age_june30", "age_cat_name"))

## `summarise()` has grouped output by 'health_service_name', 'age_june30',
## 'age_cat_name', 'sex', 'sex_desc'. You can override using the `.groups` argument.
aut_prev_health_adj <- get_adjusted_prev(aut_prev_health, grouping_vars = "health_service_name")

# ggplot(data = aut_prev_health_adj) +
#   geom_col(aes(x = health_service_name, y = adjusted_rate), fill = "lightblue", position = "dodge") +
#   geom_errorbar(aes(x = health_service_name, ymin = ci_lower, ymax = ci_upper), width = 0.2) +
#   theme(axis.text.x = element_text(angle = 90, hjust = 1, vjust = 0.2)) +
#   labs(title = "Age- and sex-adjusted autism prevalence",
#        x = "School health service",
#        y = "Sample prevalence")

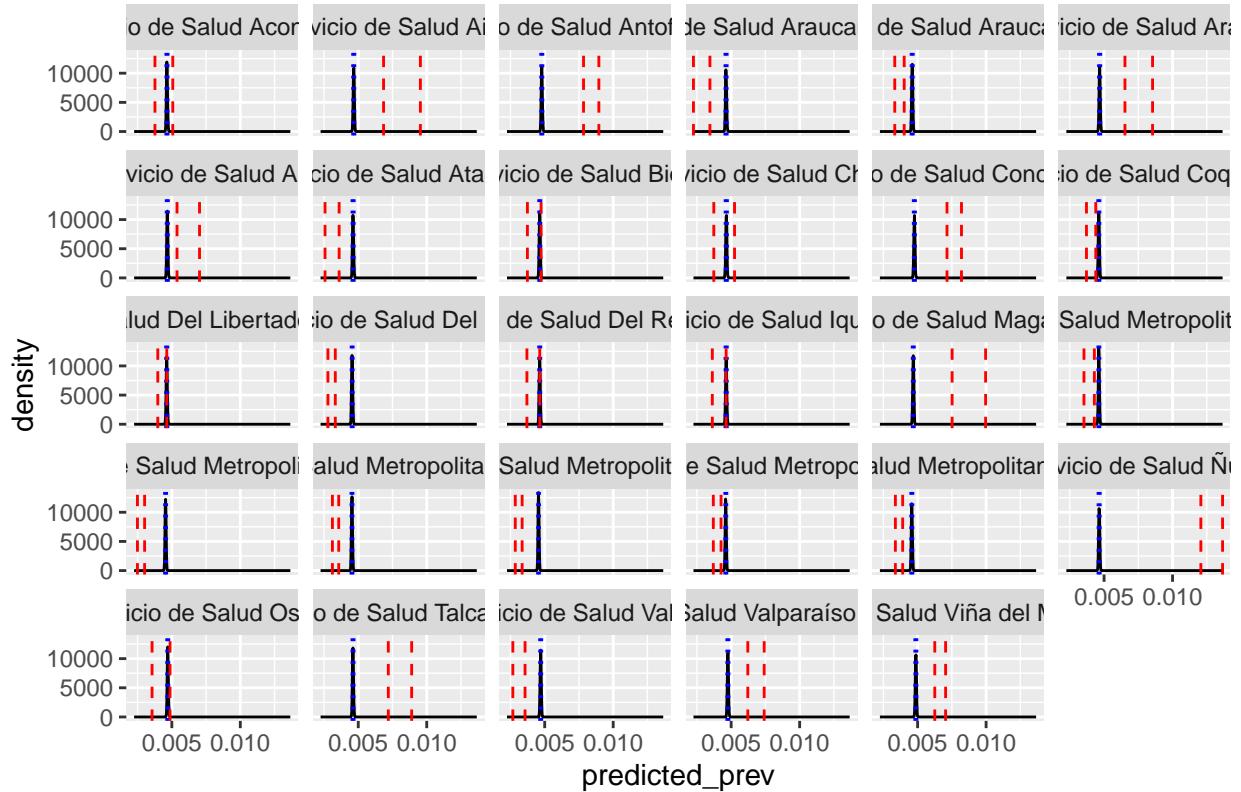
aut_prev_health_post <- do_jags_rand_model(x = aut_prev_health_adj,
                                             feat = "health_service_name",
                                             model = rand_model,
                                             theta_mu = theta_mu_prior,
                                             theta_sigma = theta_sigma_prior,
                                             pars = pars,
                                             convergence_checks = FALSE) %>%
  rename("health_service_name" = "Feat_names")

plot_post_density(aut_prev_health_post, aut_prev_health_adj, feat = "health_service_name", theta_mu = t

```

```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.00465, prior sd = 3.98e-05



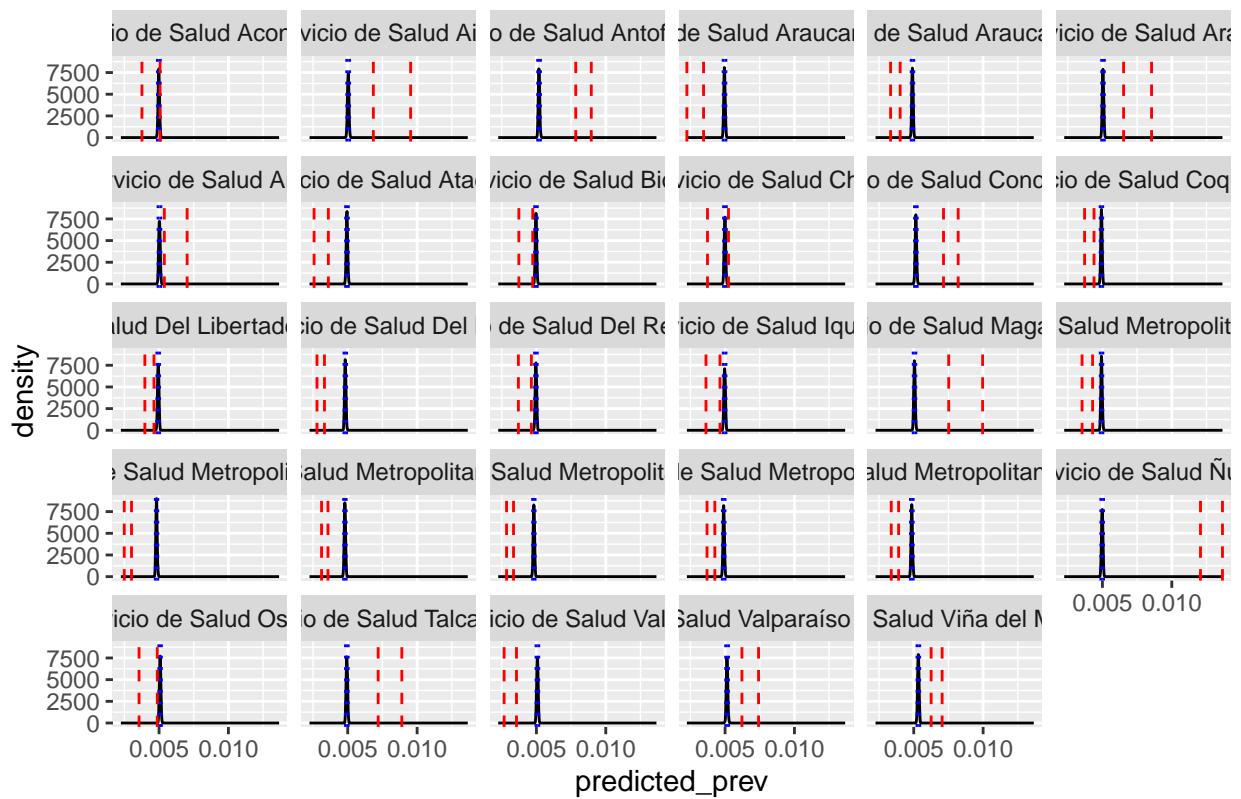
Predictions for higher population prevalence - increase prior mean

```
for(j in 1:length(theta_mu_extrapolate)) {
  aut_prev_health_post <- do_jags_rand_model(x = aut_prev_health_adj,
                                              feat = "health_service_name",
                                              model = rand_model,
                                              theta_mu = theta_mu_extrapolate[j],
                                              theta_sigma = theta_sigma_extrapolate[j],
                                              pars = pars,
                                              convergence_checks = FALSE) %>%
  rename("health_service_name" = "Feat_names")

  plot_post_density(aut_prev_health_post,
                    aut_prev_health_adj,
                    feat = "health_service_name",
                    theta_mu = theta_mu_extrapolate[j],
                    theta_sigma = theta_sigma_extrapolate[j])
}

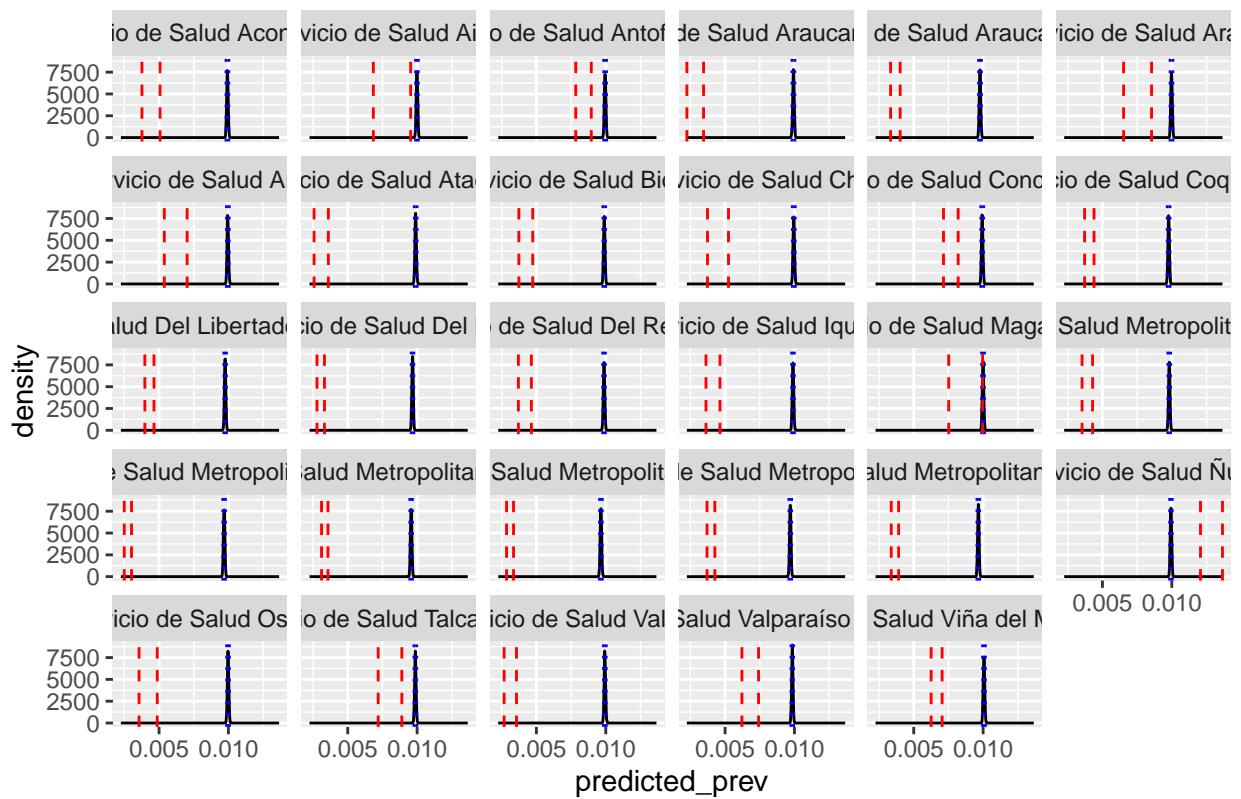
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.005, prior sd = 5.1e-05



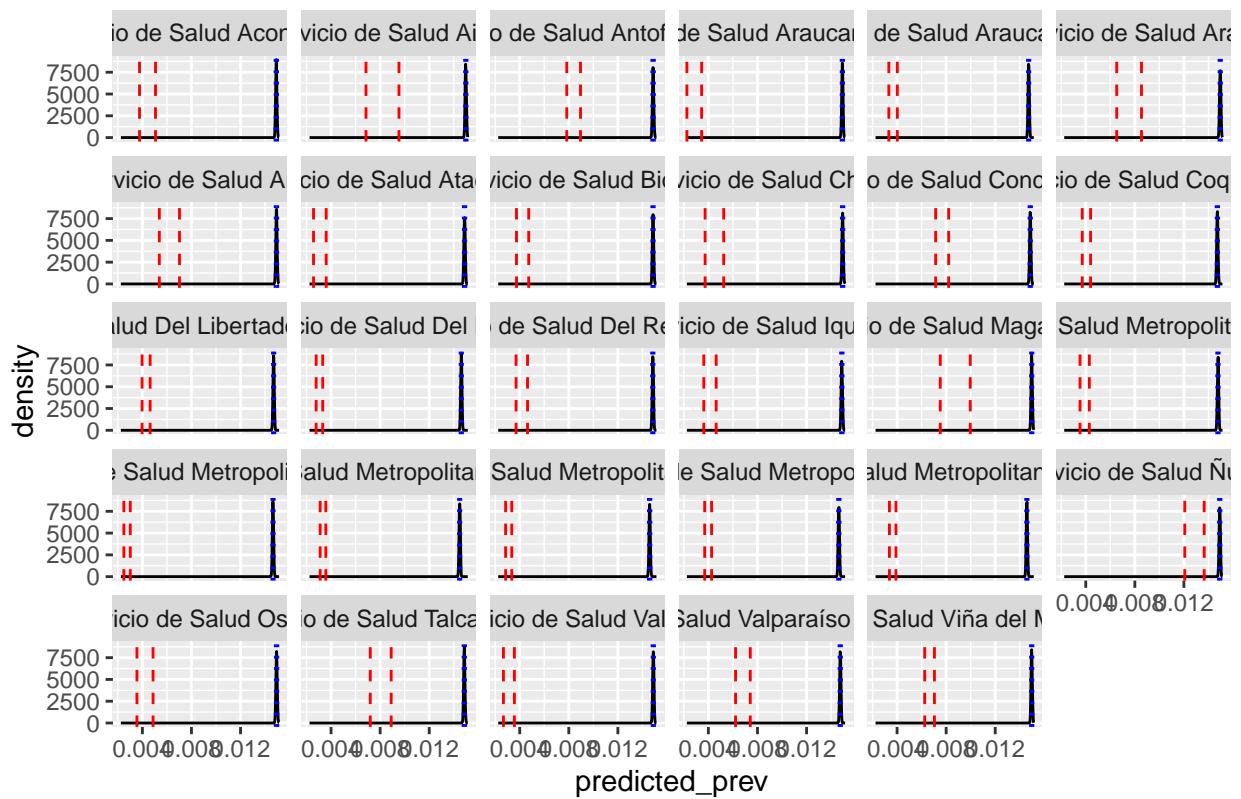
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.01, prior sd = 5.1e-05



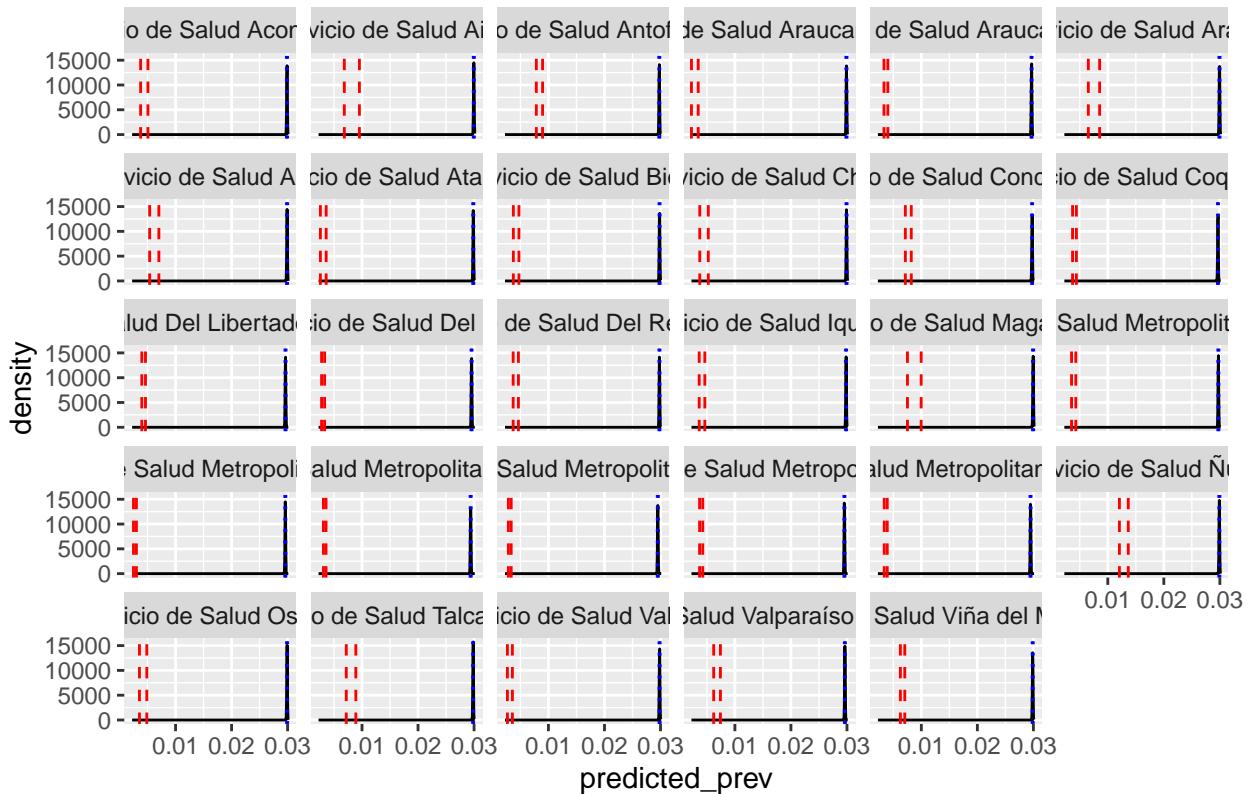
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.015, prior sd = 5.1e-05



```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.03, prior sd = 5.1e-05



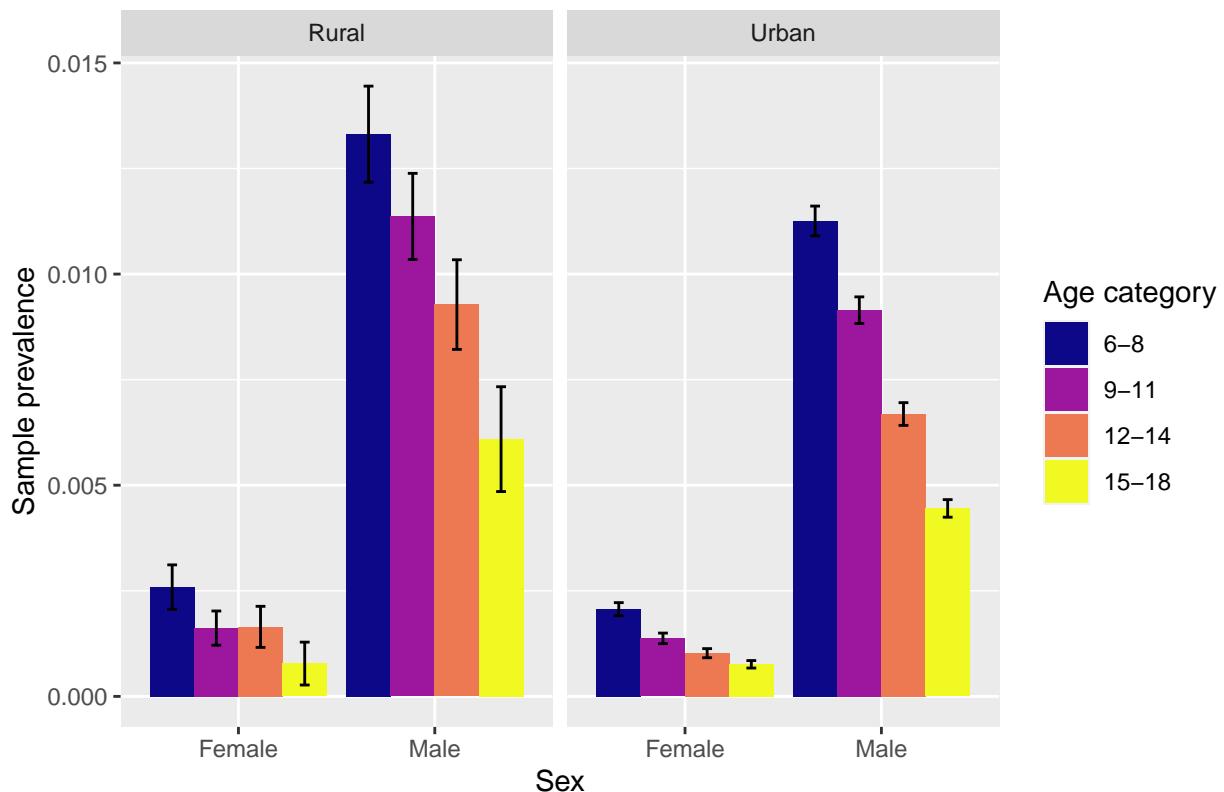
### Random effect on rurality

```
aut_prev_rural.agecat.sex <- get_grouped_prev_plot(x = chile_bayes_aut, c("school_rurality_code", "age_cat_name"),
  mutate(rurality_desc = ifelse(school_rurality_code == 0, "Urban", "Rural"))

## `summarise()` has grouped output by 'school_rurality_code', 'age_cat_name',
## 'sex_desc'. You can override using the `~.groups` argument.

ggplot(data = aut_prev_rural.agecat.sex) +
  geom_col(aes(x = sex_desc, y = sample_prevalence, group = age_cat_name, fill = age_cat_name), position = "dodge") +
  geom_errorbar(aes(x = sex_desc, ymin = ci_lower, ymax = ci_upper, group = age_cat_name), width = 0.2, position = "dodge") +
  scale_fill_viridis_d(option = "plasma") +
  #theme(axis.text.x = element_text(angle = 90, hjust = 1, vjust = 0.2)) +
  facet_wrap(~rurality_desc) +
  labs(title = "Autism prevalence by school rurality",
       x = "Sex",
       y = "Sample prevalence",
       fill = "Age category")
```

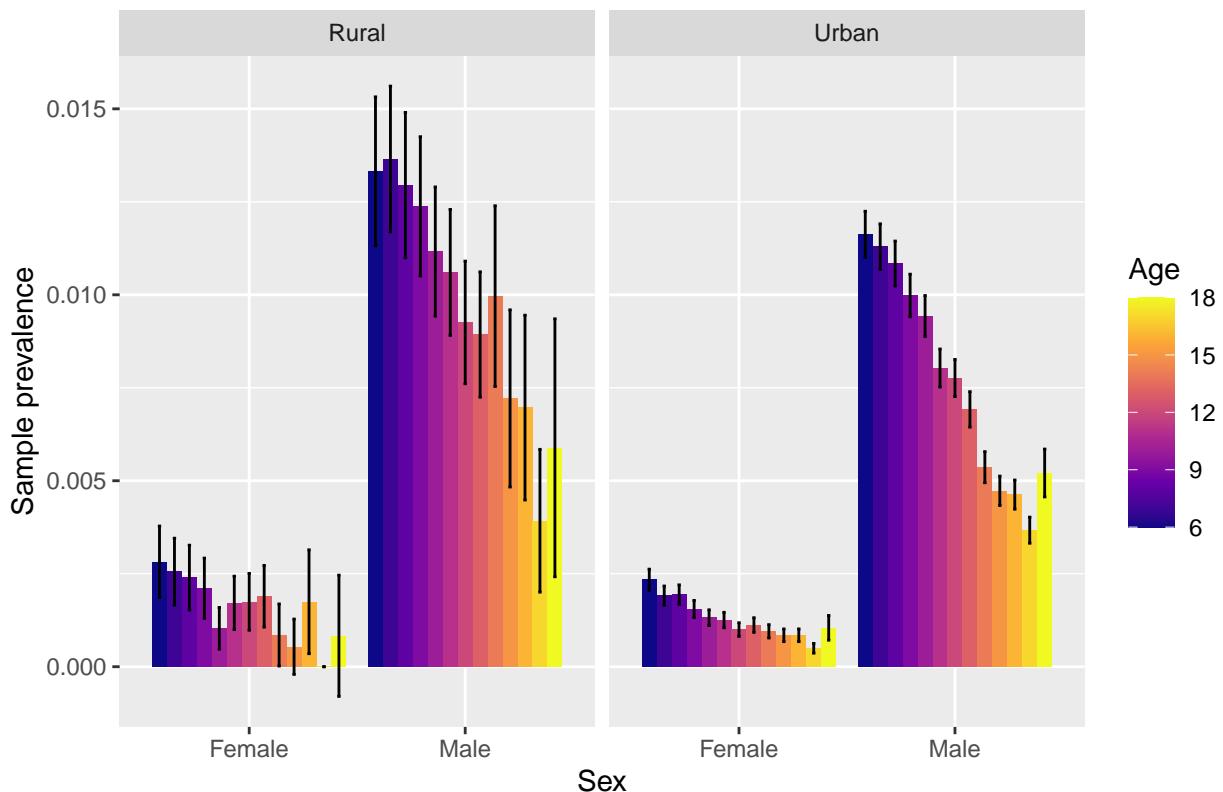
## Autism prevalence by school rurality



```
aut_prev_rural.age.sex <- get_grouped_prev_plot(x = chile_bayes_aut, c("school_rurality_code", "age_june30"))
  mutate(rurality_desc = ifelse(school_rurality_code == 0, "Urban", "Rural"))

## `summarise()` has grouped output by 'school_rurality_code', 'age_june30',
## 'sex_desc'. You can override using the `.groups` argument.
ggplot(data = aut_prev_rural.age.sex) +
  geom_col(aes(x = sex_desc, y = sample_prevalence, group = age_june30, fill = age_june30), position = position_dodge())
  geom_errorbar(aes(x = sex_desc, ymin = ci_lower, ymax = ci_upper, group = age_june30), width = 0.2, position = position_dodge())
  scale_fill_viridis_c(option = "plasma") +
  #theme(axis.text.x = element_text(angle = 90, hjust = 1, vjust = 0.2)) +
  facet_wrap(~rurality_desc) +
  labs(title = "Autism prevalence by school rurality",
       x = "Sex",
       y = "Sample prevalence",
       fill = "Age")
```

## Autism prevalence by school rurality



```
# ggplot(data = aut_prev_rural) +
#   geom_col(aes(x = as.factor(school_rurality_code), y = sample_prevalence, group = age_cat_name, fill =
#   scale_fill_viridis_d() +
#   theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
#   labs(title = "Autism prevalence",
#        x = "Rurality status",
#        y = "Sample prevalence",
#        fill = "Age category")

# ggplot(data = aut_prev_rural) +
#   geom_col(aes(x = as.factor(school_rurality_code), y = sample_prevalence, group = age_cat_name, fill =
#   scale_fill_viridis_d() +
#   theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
#   facet_wrap(~sex_desc) +
#   labs(title = "Autism prevalence by sex",
#        x = "Rurality status",
#        y = "Sample prevalence",
#        fill = "Age category")
#
# ggplot(data = aut_prev_rural) +
#   geom_col(aes(x = as.factor(school_rurality_code), y = sample_prevalence, group = sex, fill = as.factor(
#   scale_fill_manual(values = c("#03CEA4", "#802392")) +
#   theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
#   labs(title = "Autism prevalence",
#        x = "Rurality status",
#        y = "Sample prevalence",
```

```

#           fill = "Sex")

aut_prev_rural <- get_grouped_prev(x = chile_bayes_aut, stdpop = chile_stdpop,
                                    grouping_vars = c("school_rurality_code", "age_june30", "age_cat_name"),
                                    mutate(rurality_desc = ifelse(school_rurality_code == 0, "Urban", "Rural"))

## `summarise()` has grouped output by 'school_rurality_code', 'age_june30',
## 'age_cat_name', 'sex', 'sex_desc'. You can override using the `.groups` argument.
aut_prev_rural_adj <- get_adjusted_prev(aut_prev_rural, grouping_vars = "rurality_desc")

# ggplot(data = aut_prev_rural_adj) +
#   geom_col(aes(x = school_rurality_code, y = adjusted_rate), fill = "lightblue", position = "dodge")
#   geom_errorbar(aes(x = school_rurality_code, ymin = ci_lower, ymax = ci_upper), width = 0.2) +
#   theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
#   labs(title = "Age- and sex-adjusted autism prevalence",
#        x = "Rurality status",
#        y = "Sample prevalence")

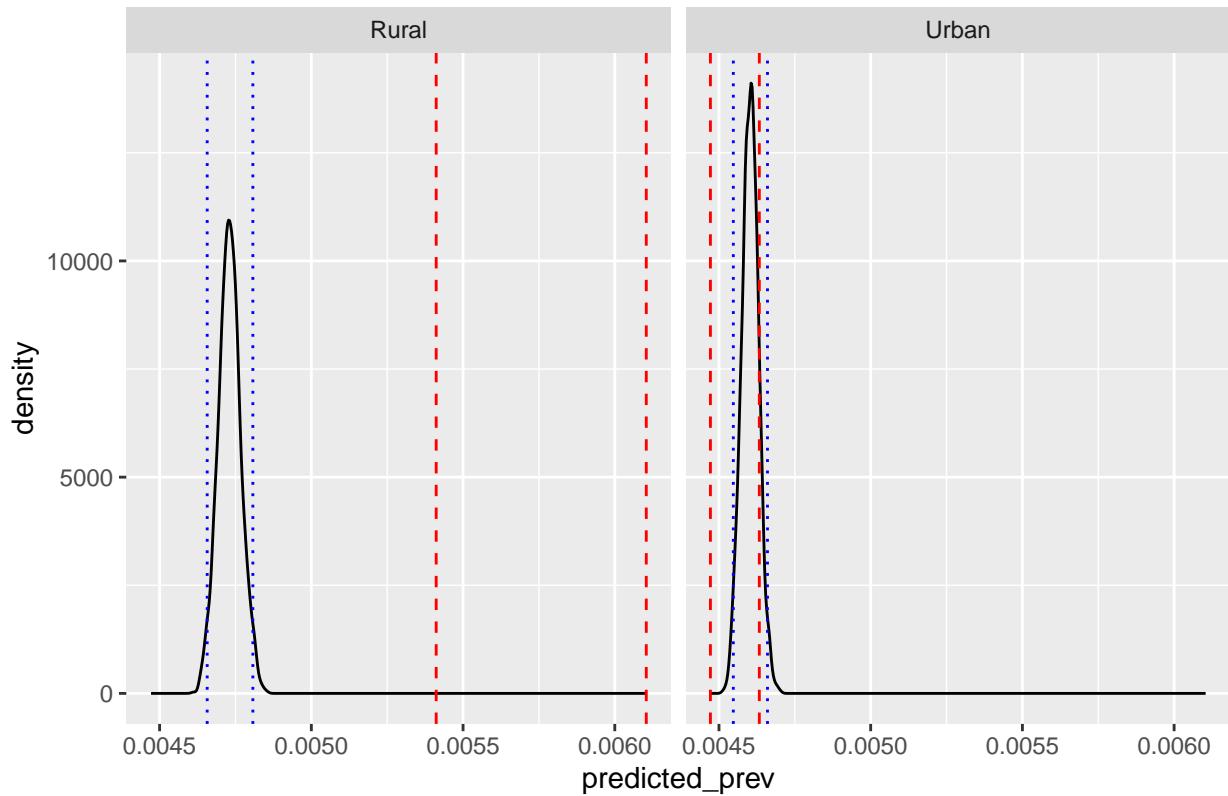
aut_prev_rural_post <- do_jags_rand_model(x = aut_prev_rural_adj,
                                            feat = "rurality_desc",
                                            model = rand_model,
                                            theta_mu = theta_mu_prior,
                                            theta_sigma = theta_sigma_prior,
                                            pars = pars,
                                            convergence_checks = FALSE) %>%
  rename("rurality_desc" = "Feat_names")

plot_post_density(aut_prev_rural_post, aut_prev_rural_adj, feat = "rurality_desc", theta_mu = theta_mu)

## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.

```

Prior mean = 0.00465, prior sd = 3.98e-05



Assuming 0 = city, 1 = rural. Narrower sample CI for city because sample size is bigger

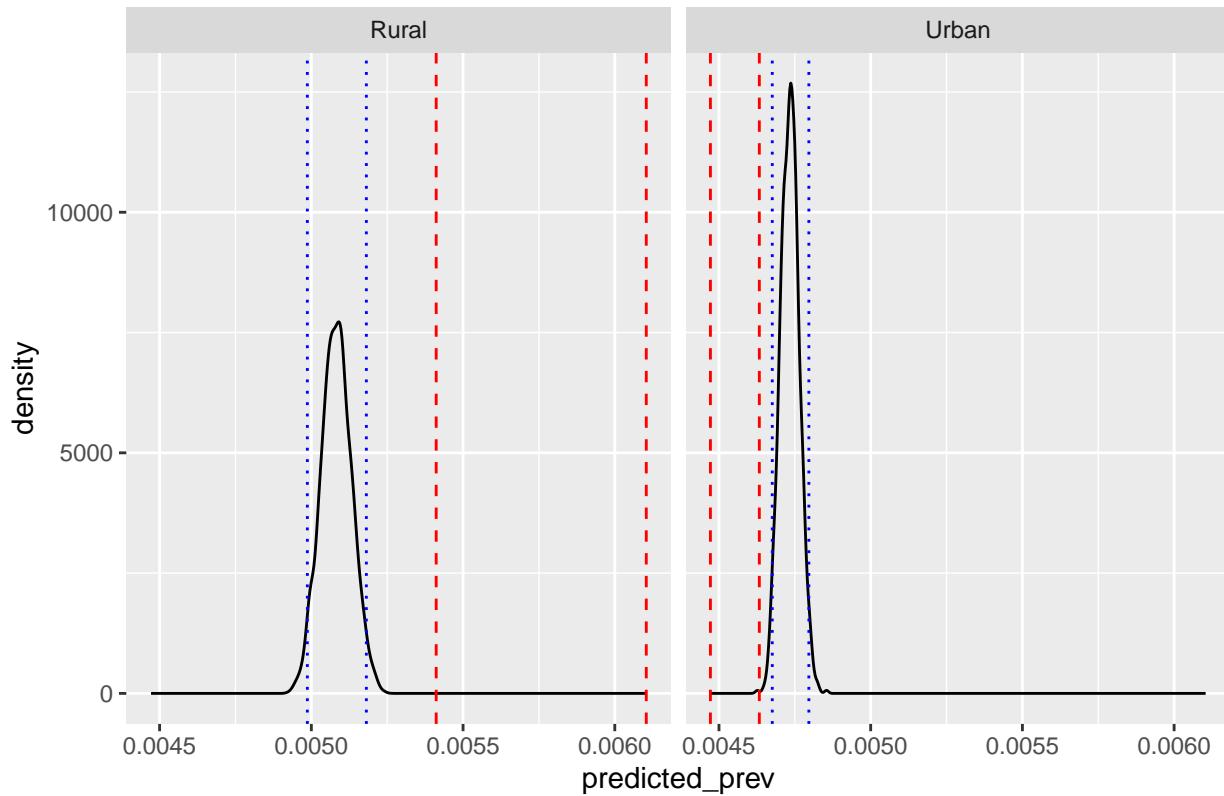
Predictions for higher population prevalence - increase prior mean

```
for(j in 1:length(theta_mu_extrapolate)) {
  aut_prev_rural_post <- do_jags_rand_model(x = aut_prev_rural_adj,
                                              feat = "rurality_desc",
                                              model = rand_model,
                                              theta_mu = theta_mu_extrapolate[j],
                                              theta_sigma = theta_sigma_extrapolate[j],
                                              pars = pars,
                                              convergence_checks = FALSE) %>%
    rename("rurality_desc" = "Feat_names")

  plot_post_density(aut_prev_rural_post,
                    aut_prev_rural_adj,
                    feat = "rurality_desc",
                    theta_mu = theta_mu_extrapolate[j],
                    theta_sigma = theta_sigma_extrapolate[j])
}

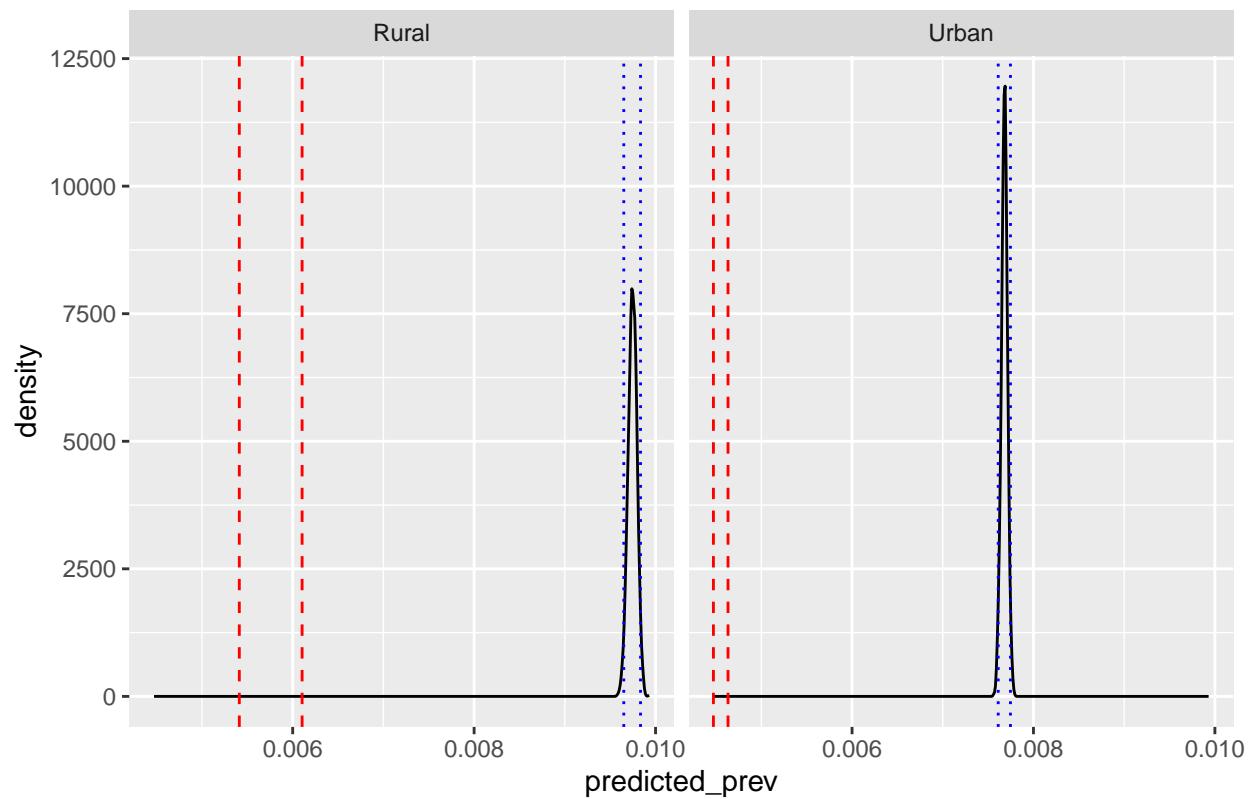
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.005, prior sd = 5.1e-05



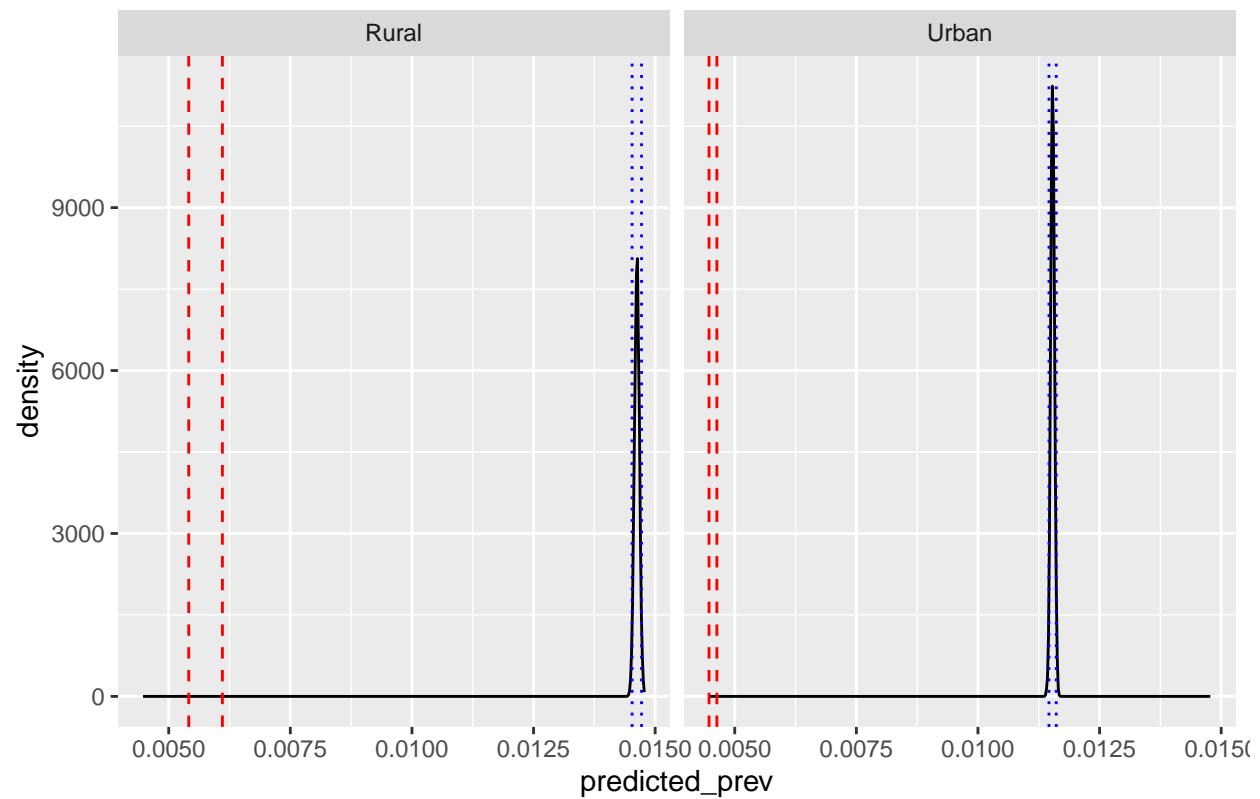
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.01, prior sd = 5.1e-05



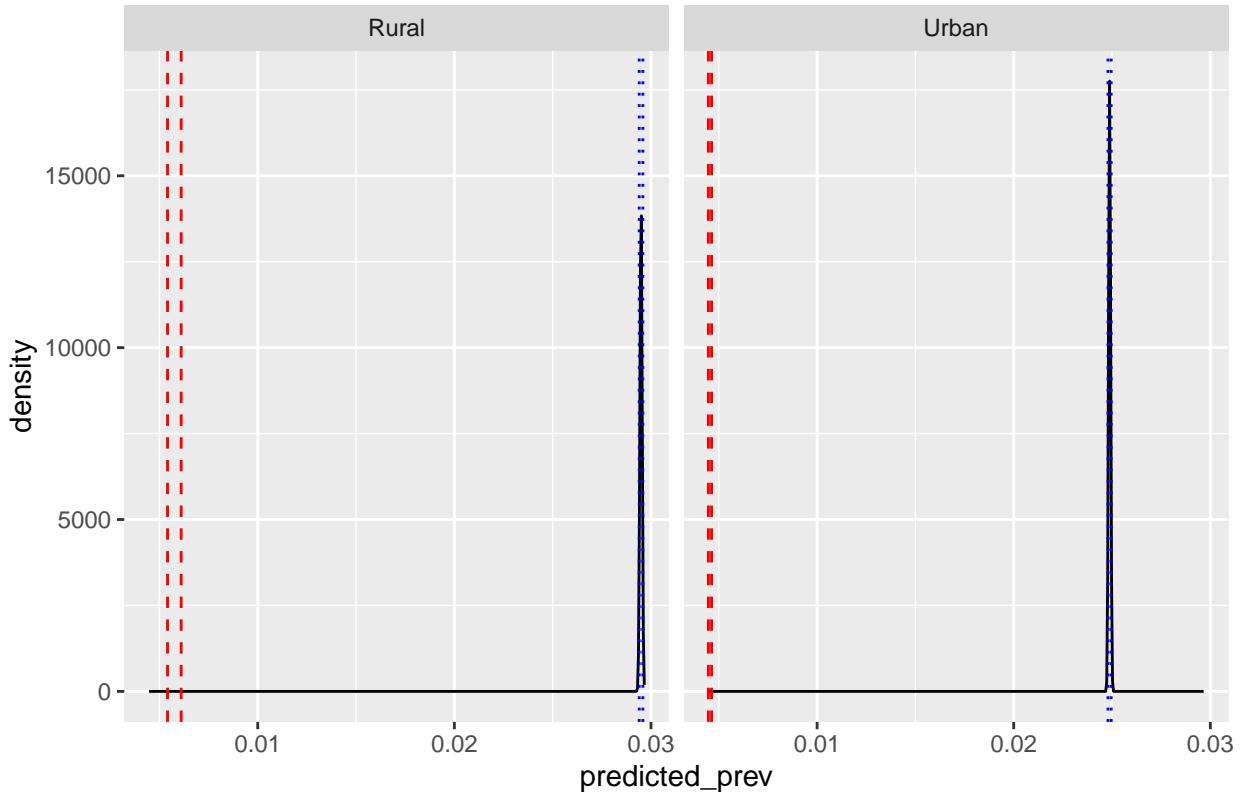
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.015, prior sd = 5.1e-05



```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.03, prior sd = 5.1e-05



### Random effect on ethnicity

Find the regions with high proportion of Mapuche population

```
mapuche_count <- chile_bayes_aut %>%
  group_by(school_region_name_abr, ethnicity) %>%
  summarise(count = n()) %>%
  filter(ethnicity == "Mapuche") %>%
  arrange(desc(count))

## `summarise()` has grouped output by 'school_region_name_abr'. You can override
## using the `.groups` argument.

mapuche_prop <- chile_bayes_aut %>%
  group_by(school_region_name_abr, ethnicity) %>%
  summarise(count = n()) %>%
  mutate(eth_mapuche = ifelse(ethnicity == "Mapuche", "mapuche", "not")) %>%
  group_by(school_region_name_abr, eth_mapuche) %>%
  summarise(count_eth = sum(count)) %>%
  pivot_wider(names_from = eth_mapuche, values_from = count_eth) %>%
  mutate(prop_mapuche = mapuche / (mapuche + not)) %>%
  arrange(desc(prop_mapuche))

## `summarise()` has grouped output by 'school_region_name_abr'. You can override
## using the `.groups` argument.

## `summarise()` has grouped output by 'school_region_name_abr'. You can override
## using the `.groups` argument.
```

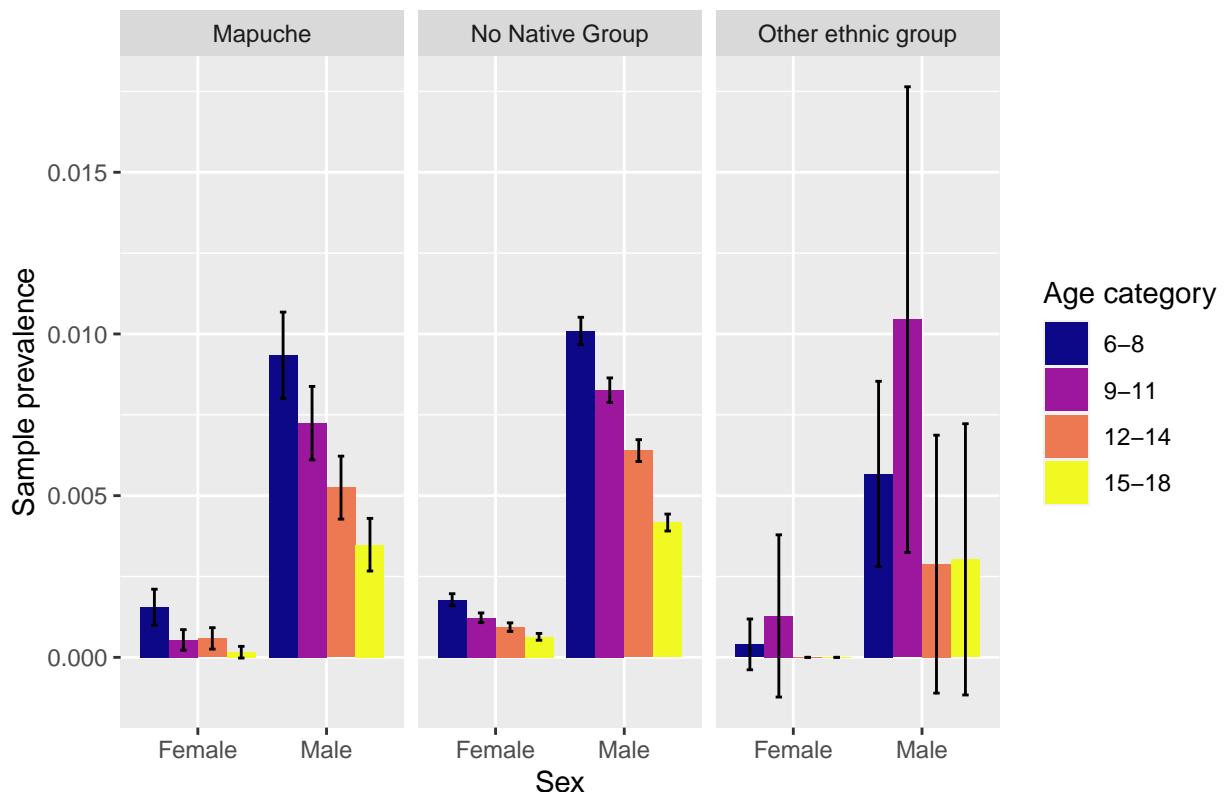
Only use regions with large Mapuche populations - specifically top 5 by count of Mapuche people (ARAUC, RM, LAGOS, BBIO, RIOS) and top 5 by proportion of region's population (ARAUC, LAGOS, RIOS, MAG, AYSEN).

```
aut_prev_ethnic.agecat.sex <- get_grouped_prev_plot(x = filter(chile_bayes_aut, school_region_name_abr %in%
  c("ARAUC", "RM", "LAGOS", "BBIO", "RIOS",
  #c("ARAUC", "BBIO", "LAGOS", "RIOS", "MAG", "AYSEN"),
  grouping_vars = c("ethnic_2_group", "age_cat_name", "sex_desc"))

## `summarise()` has grouped output by 'ethnic_2_group', 'age_cat_name',
## 'sex_desc'. You can override using the `.groups` argument.

ggplot(data = aut_prev_ethnic.agecat.sex) +
  geom_col(aes(x = sex_desc, y = sample_prevalence, group = age_cat_name, fill = age_cat_name), position = "dodge") +
  geom_errorbar(aes(x = sex_desc, ymin = ci_lower, ymax = ci_upper, group = age_cat_name), width = 0.2, position = "dodge") +
  scale_fill_viridis_d(option = "plasma") +
  #theme(axis.text.x = element_text(angle = 90, hjust = 1, vjust = 0.2)) +
  facet_wrap(~ethnic_2_group) +
  labs(title = "Autism prevalence by ethnicity",
       x = "Sex",
       y = "Sample prevalence",
       fill = "Age category")
```

### Autism prevalence by ethnicity



```
aut_prev_ethnic.age.sex <- get_grouped_prev_plot(x = filter(chile_bayes_aut, school_region_name_abr %in%
  c("ARAUC", "RM", "LAGOS", "BBIO", "RIOS",
  #c("ARAUC", "BBIO", "LAGOS", "RIOS", "MAG", "AYSEN"),
  grouping_vars = c("ethnic_2_group", "age_june30", "sex_desc"))
```

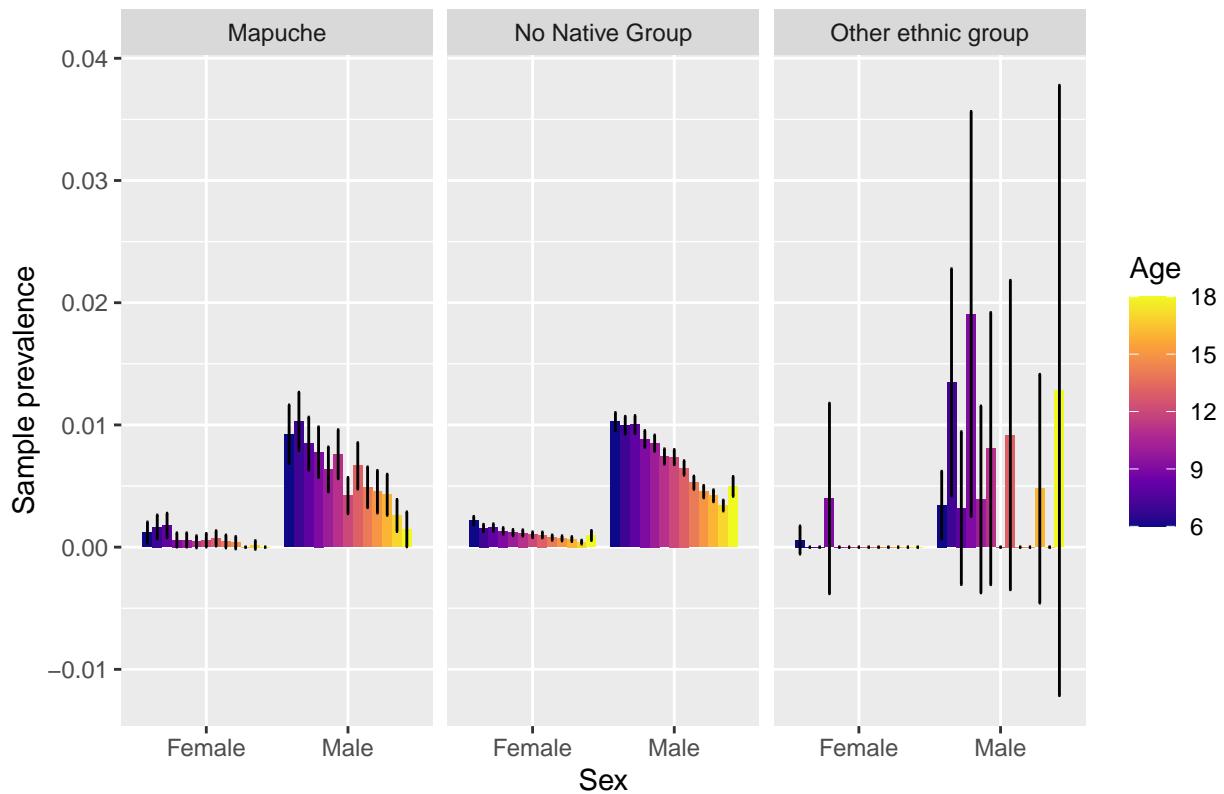
```

## `summarise()` has grouped output by 'ethnic_2_group', 'age_june30', 'sex_desc'.
## You can override using the `groups` argument.

ggplot(data = aut_prev_ethnic.age.sex) +
  geom_col(aes(x = sex_desc, y = sample_prevalence, group = age_june30, fill = age_june30), position = position_dodge())
  geom_errorbar(aes(x = sex_desc, ymin = ci_lower, ymax = ci_upper, group = age_june30), width = 0.2, position = position_dodge())
  scale_fill_viridis_c(option = "plasma") +
  #theme(axis.text.x = element_text(angle = 90, hjust = 1, vjust = 0.2)) +
  facet_wrap(~ethnic_2_group) +
  labs(title = "Autism prevalence by ethnicity",
       x = "Sex",
       y = "Sample prevalence",
       fill = "Age")

```

Autism prevalence by ethnicity



```

#
# ggplot(data = aut_prev_ethnic) +
#   geom_col(aes(x = as.factor(ethnic_2_group), y = sample_prevalence, group = age_cat_name, fill = age),
#            scale_fill_viridis_d() +
#            theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
#            labs(title = "Autism prevalence",
#                 x = "Ethnicity",
#                 y = "Sample prevalence",
#                 fill = "Age category")
#
# ggplot(data = aut_prev_ethnic) +
#   geom_col(aes(x = as.factor(ethnic_2_group), y = sample_prevalence, group = age_cat_name, fill = age),
#            scale_fill_viridis_d() +
#            theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
#            labs(title = "Autism prevalence",
#                 x = "Ethnicity",
#                 y = "Sample prevalence",
#                 fill = "Age category")
# 
```

```

#   theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
#   facet_wrap(~sex_desc) +
#   labs(title = "Autism prevalence by sex",
#        x = "Ethnicity",
#        y = "Sample prevalence",
#        fill = "Age category")
#
# ggplot(data = aut_prev_ethnicic) +
#   geom_col(aes(x = as.factor(ethnic_2_group), y = sample_prevalence, group = sex, fill = as.factor(sex)))
#   scale_fill_manual(values = c("#03CEA4", "#802392")) +
#   theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
#   labs(title = "Autism prevalence",
#        x = "Ethnicity",
#        y = "Sample prevalence",
#        fill = "Sex")

aut_prev_ethnicic <- chile_bayes_aut %>%
  #filter(school_region_name_abr %in% c("ARAUC", "BBIO", "LAGOS", "RIOS", "RM")) %>%
  filter(school_region_name_abr %in% c("ARAUC", "RM", "LAGOS", "BBIO", "RIOS", "MAG", "AYSEN")) %>%
  get_grouped_prev(stdpop = chile_stdpop,
                   grouping_vars = c("ethnic_2_group", "age_june30", "age_cat_name", "sex", "sex_desc",
                                     "sex_desc"))

## `summarise()` has grouped output by 'ethnic_2_group', 'age_june30',
## 'age_cat_name', 'sex', 'sex_desc'. You can override using the `.groups` argument.

aut_prev_ethnicic_adj <- get_adjusted_prev(aut_prev_ethnicic, grouping_vars = "ethnic_2_group")

# ggplot(data = aut_prev_ethnicic_adj) +
#   geom_col(aes(x = ethnic_2_group, y = adjusted_rate), fill = "lightblue", position = "dodge") +
#   geom_errorbar(aes(x = ethnic_2_group, ymin = ci_lower, ymax = ci_upper), width = 0.2) +
#   theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
#   labs(title = "Age- and sex-adjusted autism prevalence",
#        x = "Ethnicity",
#        y = "Sample prevalence")

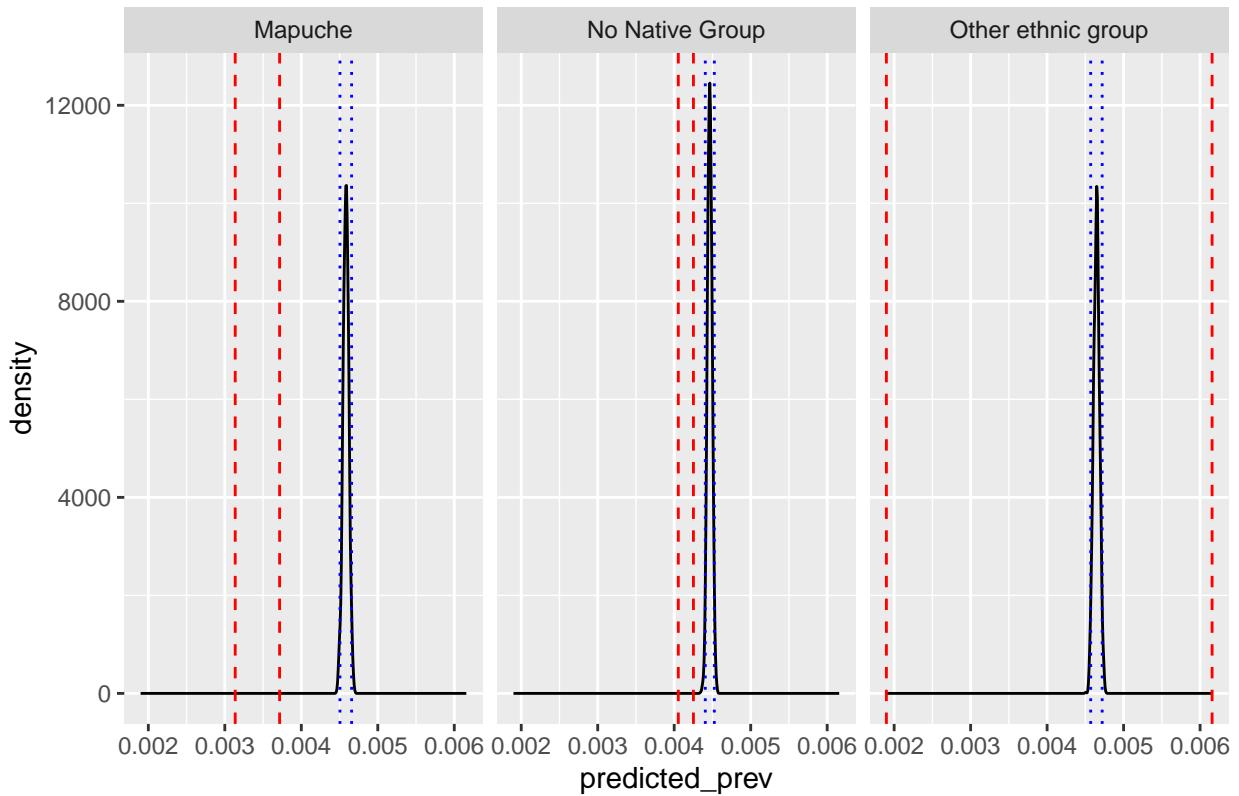
aut_prev_ethnicic_post <- do_jags_rand_model(x = aut_prev_ethnicic_adj,
                                              feat = "ethnic_2_group",
                                              model = rand_model,
                                              theta_mu = theta_mu_prior,
                                              theta_sigma = theta_sigma_prior,
                                              pars = pars,
                                              convergence_checks = FALSE) %>%
  rename("ethnic_2_group" = "Feat_names")

plot_post_density(aut_prev_ethnicic_post, aut_prev_ethnicic_adj, feat = "ethnic_2_group", theta_mu = theta_mu_prior)

## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.

```

Prior mean = 0.00465, prior sd = 3.98e-05



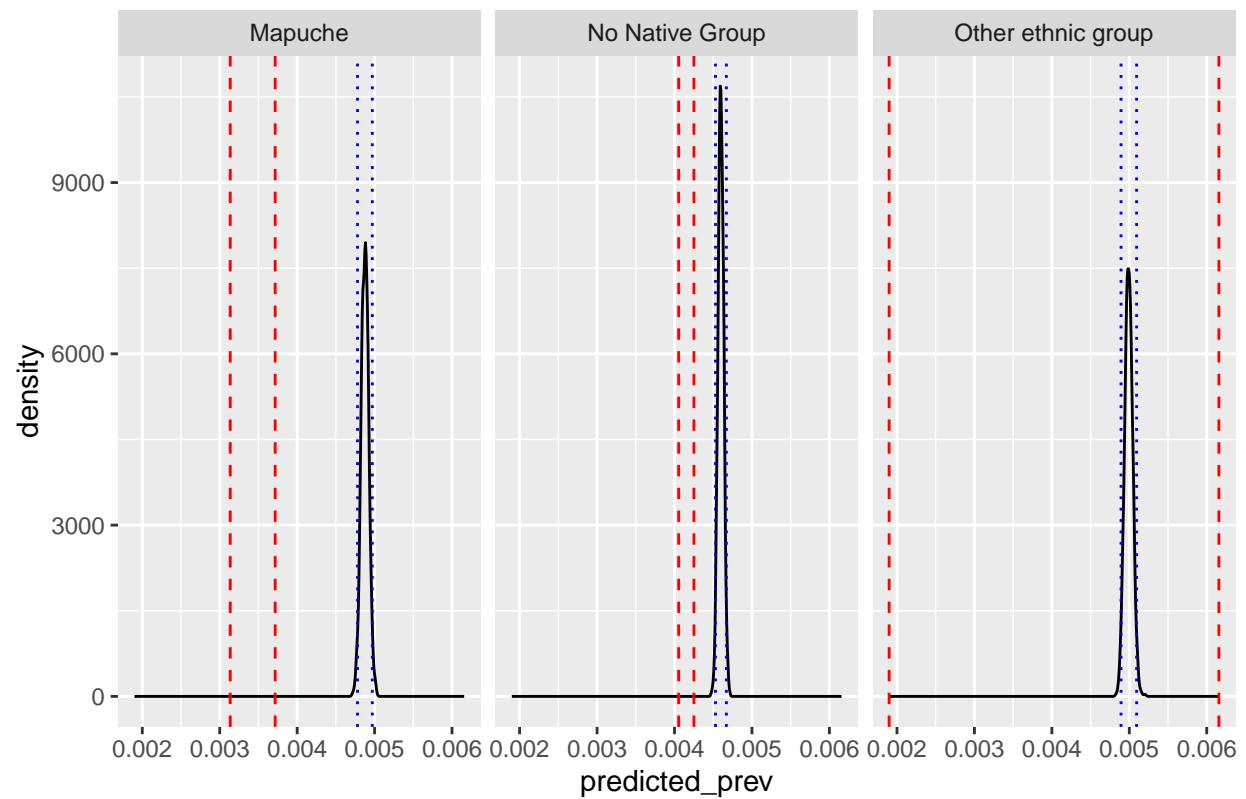
Predictions for higher population prevalence - increase prior mean

```
for(j in 1:length(theta_mu_extrapolate)) {
  aut_prev_ethnic_post <- do_jags_rand_model(x = aut_prev_ethnic_adj,
                                              feat = "ethnic_2_group",
                                              model = rand_model,
                                              theta_mu = theta_mu_extrapolate[j],
                                              theta_sigma = theta_sigma_extrapolate[j],
                                              pars = pars,
                                              convergence_checks = FALSE) %>%
    rename("ethnic_2_group" = "Feat_names")

  plot_post_density(aut_prev_ethnic_post,
                    aut_prev_ethnic_adj,
                    feat = "ethnic_2_group",
                    theta_mu = theta_mu_extrapolate[j],
                    theta_sigma = theta_sigma_extrapolate[j])
}

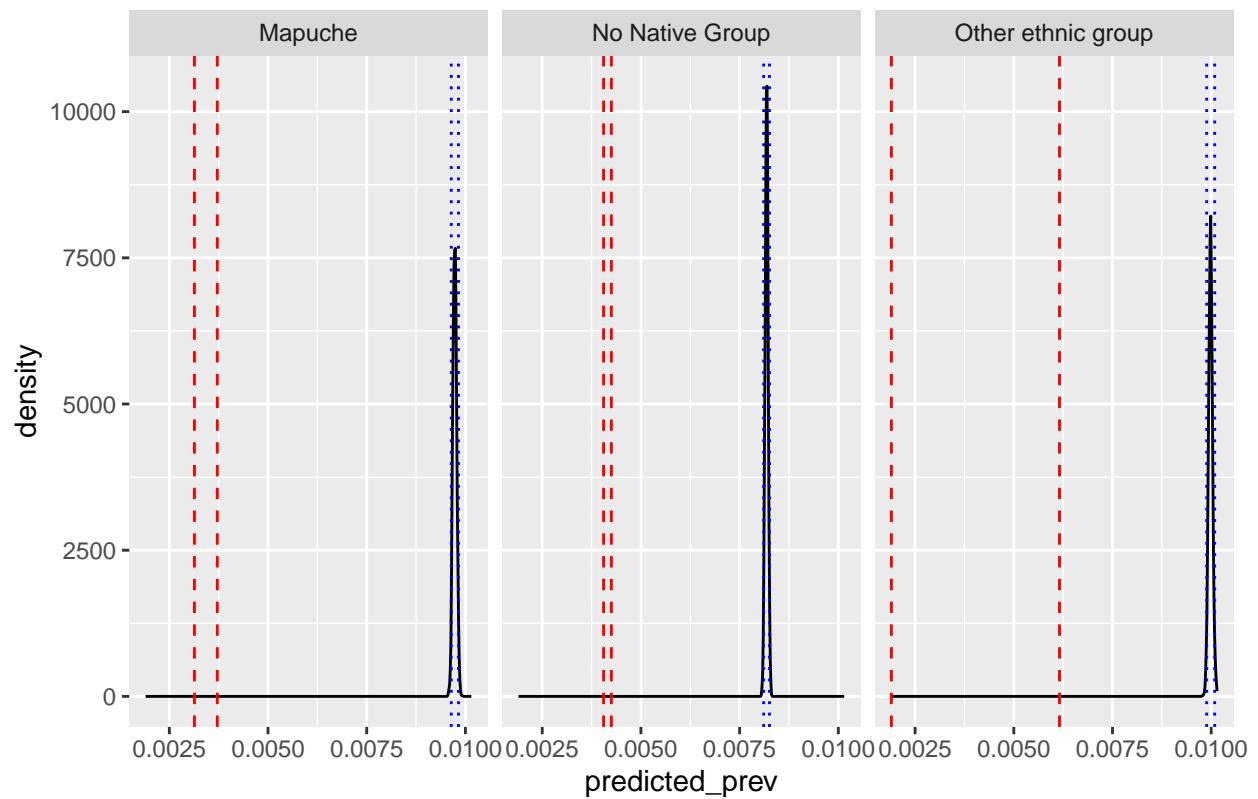
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.005, prior sd = 5.1e-05



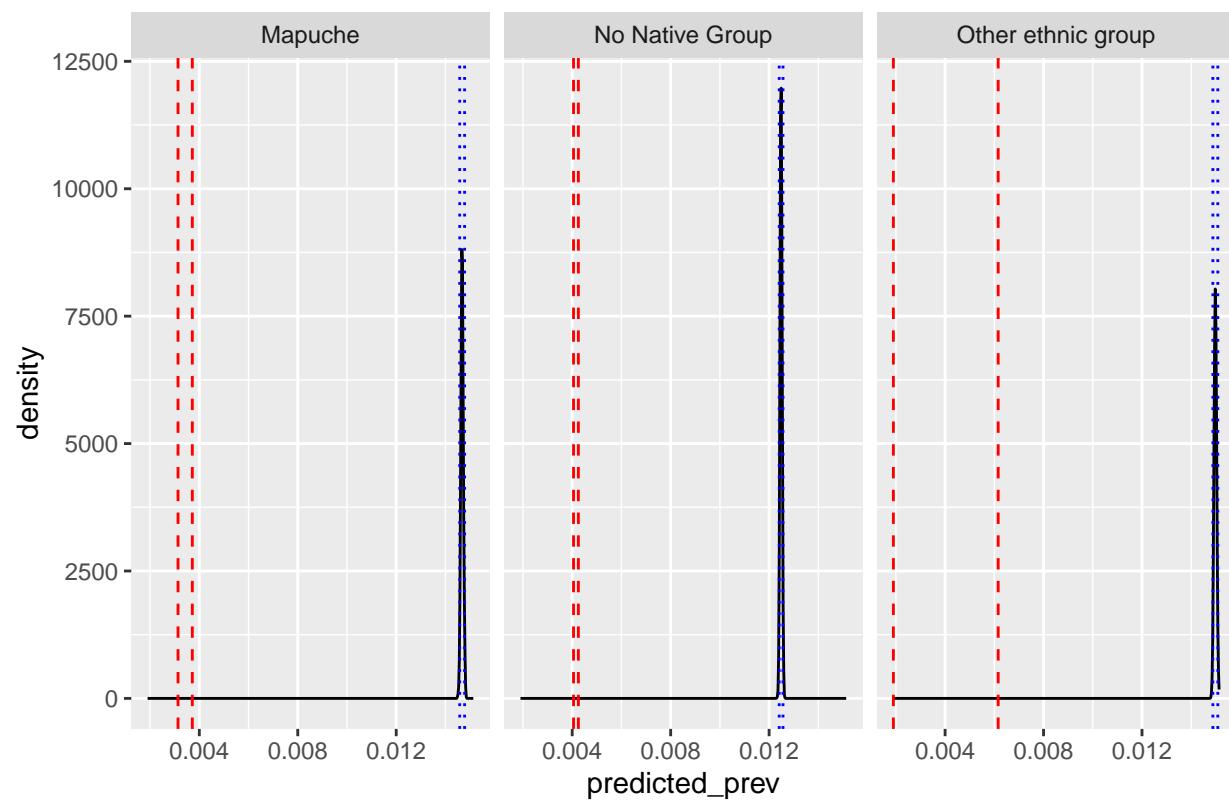
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.01, prior sd = 5.1e-05



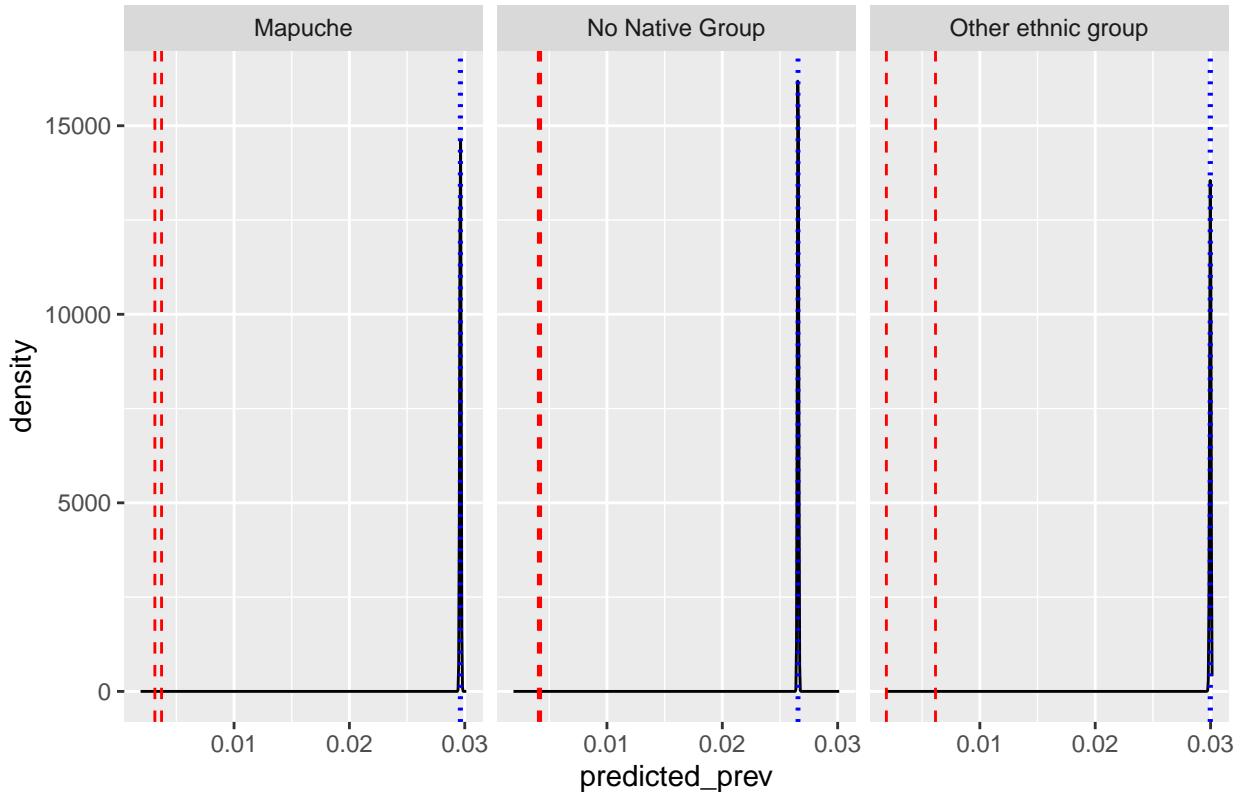
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.015, prior sd = 5.1e-05



```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.03, prior sd = 5.1e-05



### Random effect on ethnicity, sexes separate

```
# Females
aut_prev_ethnic_f <- chile_bayes_aut %>%
  filter(school_region_name_abr %in% c("ARAUC", "RM", "LAGOS", "BBIO", "RIOS", "MAG", "AYSEN")) %>%
  filter(sex == 2) %>%
  get_grouped_prev(stdpop = chile_stdpop_f, grouping_vars = c("ethnic_2_group", "age_june30", "sex", "at"))

## `summarise()` has grouped output by 'ethnic_2_group', 'age_june30', 'sex'. You
## can override using the `.groups` argument.

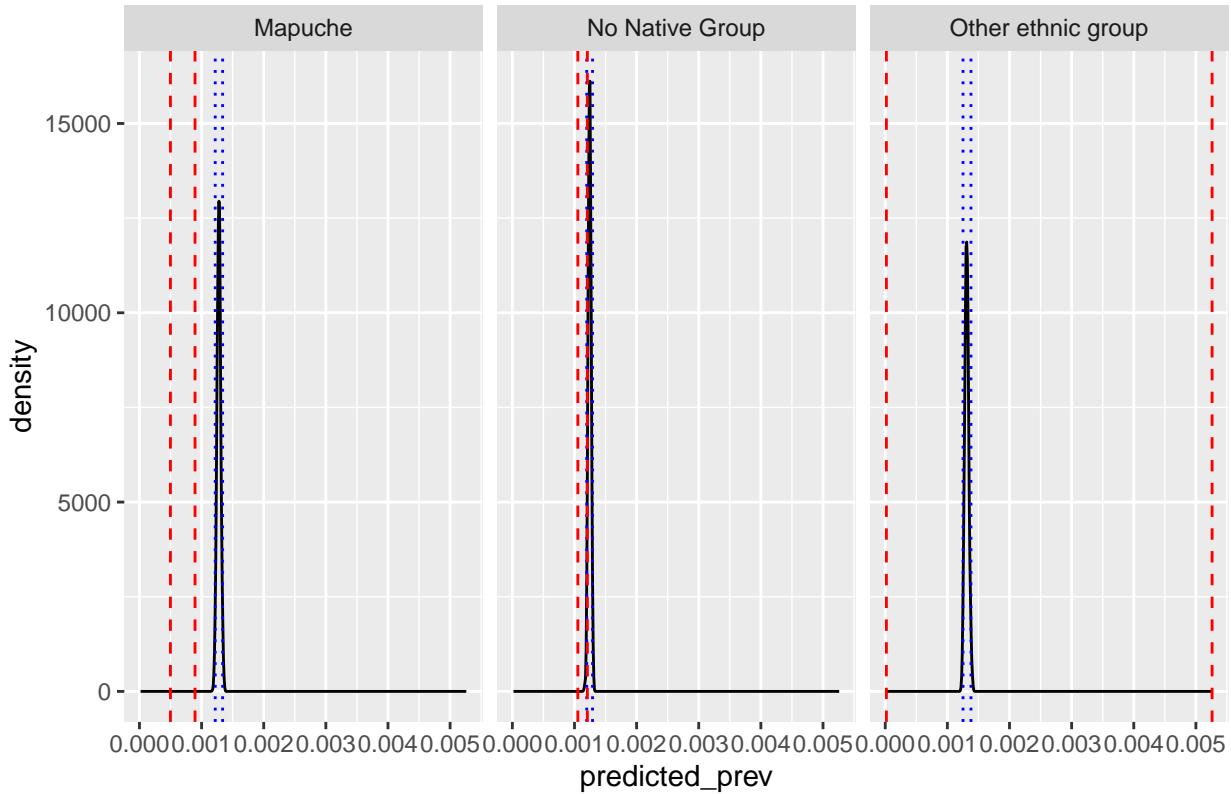
aut_prev_ethnic_adj_f <- get_adjusted_prev(aut_prev_ethnic_f, grouping_vars = "ethnic_2_group")

aut_prev_ethnic_post_f <- do_jags_rand_model(x = aut_prev_ethnic_adj_f,
                                              feat = "ethnic_2_group",
                                              model = rand_model,
                                              theta_mu = theta_mu_prior_f,
                                              theta_sigma = theta_sigma_prior_f,
                                              pars = pars,
                                              convergence_checks = FALSE) %>%
  rename("ethnic_2_group" = "Feat_names")

plot_post_density(aut_prev_ethnic_post_f, aut_prev_ethnic_adj_f, feat = "ethnic_2_group", theta_mu = theta_mu_prior_f)

## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.00131, prior sd = 3.08e-05 (females)



```
# Males
aut_prev_ethnic_m <- chile_bayes_aut %>%
  filter(school_region_name_abr %in% c("ARAUC", "RM", "LAGOS", "BBIO", "RIOS", "MAG", "AYSEN")) %>%
  filter(sex == 1) %>%
  get_grouped_prev(stdpop = chile_stdpop_m, grouping_vars = c("ethnic_2_group", "age_june30", "sex", "a"))

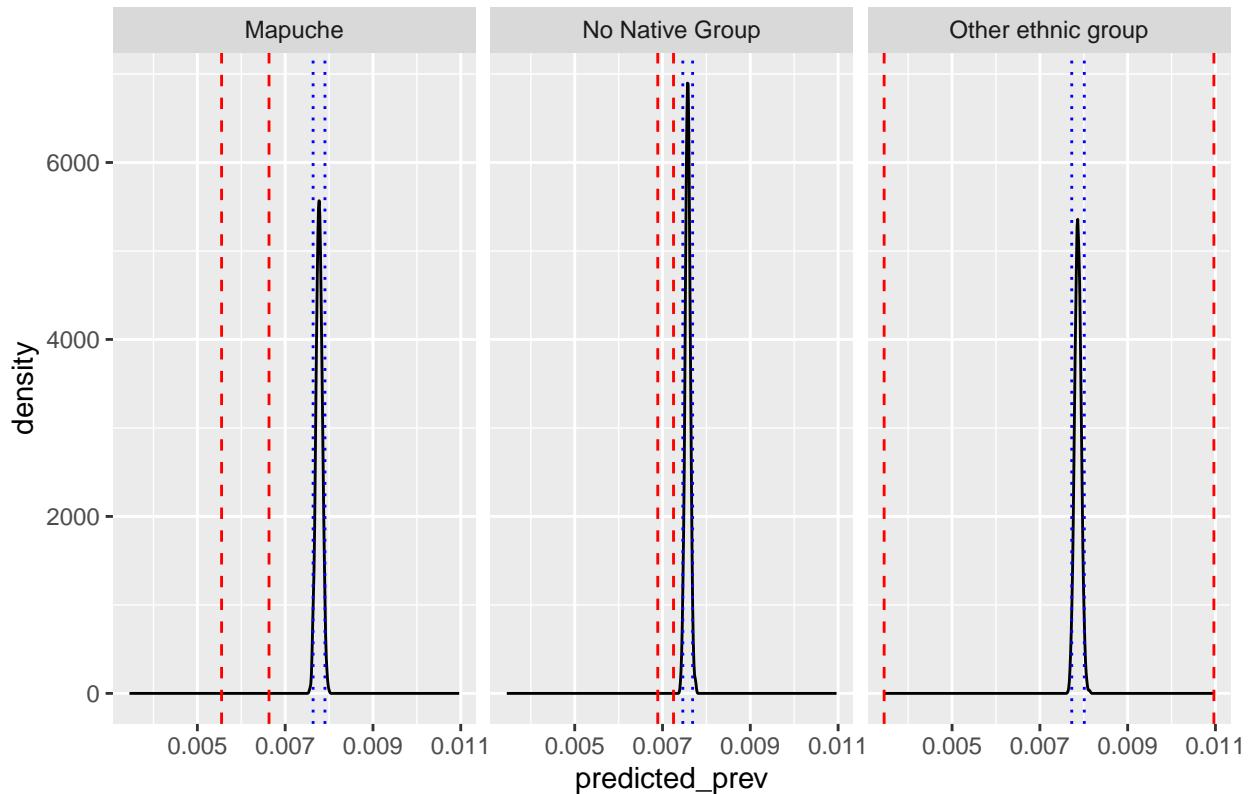
## `summarise()` has grouped output by 'ethnic_2_group', 'age_june30', 'sex'. You
## can override using the ` `.groups` argument.
aut_prev_ethnic_adj_m <- get_adjusted_prev(aut_prev_ethnic_m, grouping_vars = "ethnic_2_group")

aut_prev_ethnic_post_m <- do_jags_rand_model(x = aut_prev_ethnic_adj_m,
                                              feat = "ethnic_2_group",
                                              model = rand_model,
                                              theta_mu = theta_mu_prior_m,
                                              theta_sigma = theta_sigma_prior_m,
                                              pars = pars,
                                              convergence_checks = FALSE) %>%
  rename("ethnic_2_group" = "Feat_names")

plot_post_density(aut_prev_ethnic_post_m, aut_prev_ethnic_adj_m, feat = "ethnic_2_group", theta_mu = the
```

## Don't know how to automatically pick scale for object of type
## <draws\_matrix/draws/matrix>. Defaulting to continuous.

Prior mean = 0.00787, prior sd = 7.17e-05 (males)



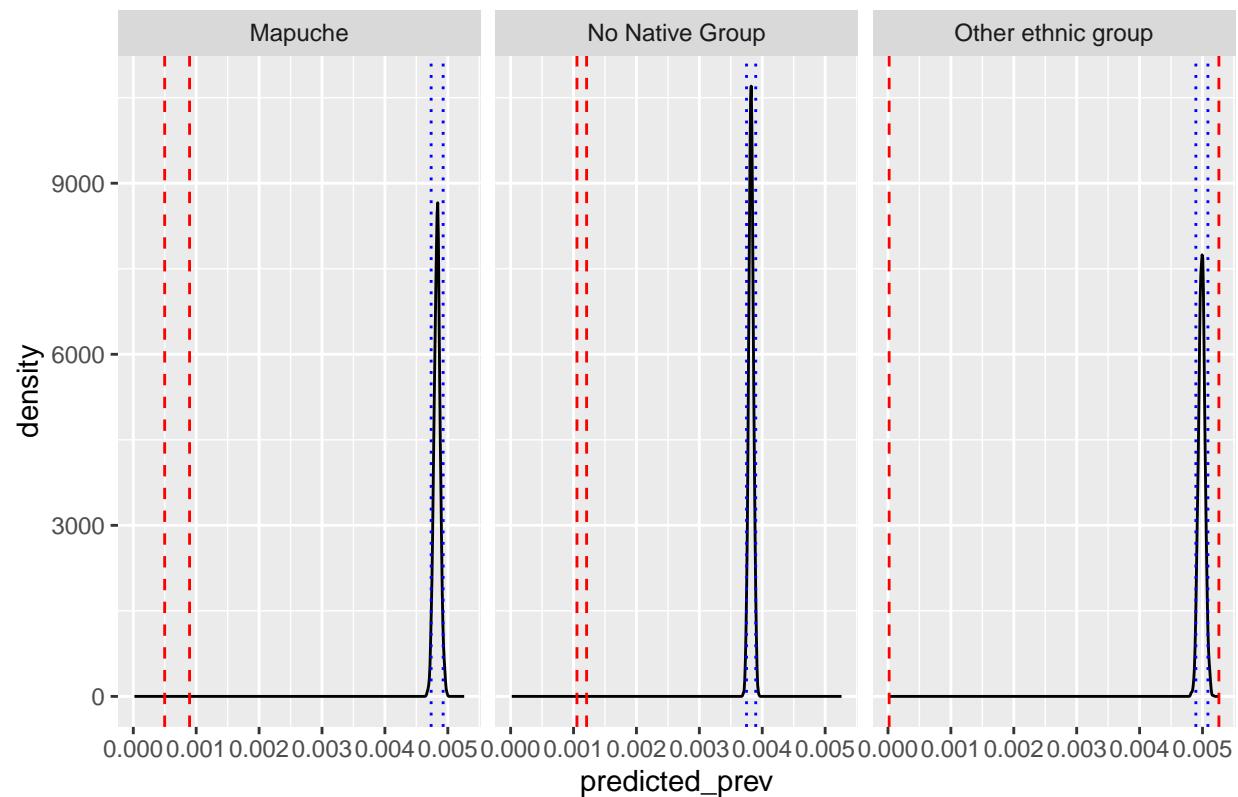
```
# Females
for(j in 1:length(theta_mu_extrapolate)) {
  aut_prev_ethnic_post_f <- do_jags_rand_model(x = aut_prev_ethnic_adj_f,
                                                feat = "ethnic_2_group",
                                                model = rand_model,
                                                theta_mu = theta_mu_extrapolate[j],
                                                theta_sigma = theta_sigma_extrapolate[j],
                                                pars = pars,
                                                convergence_checks = FALSE) %>%
  rename("ethnic_2_group" = "Feat_names")

  plot_post_density(aut_prev_ethnic_post_f,
                    aut_prev_ethnic_adj_f,
                    feat = "ethnic_2_group",
                    theta_mu = theta_mu_extrapolate[j],
                    theta_sigma = theta_sigma_extrapolate[j],
                    title_text = " (females)")

}

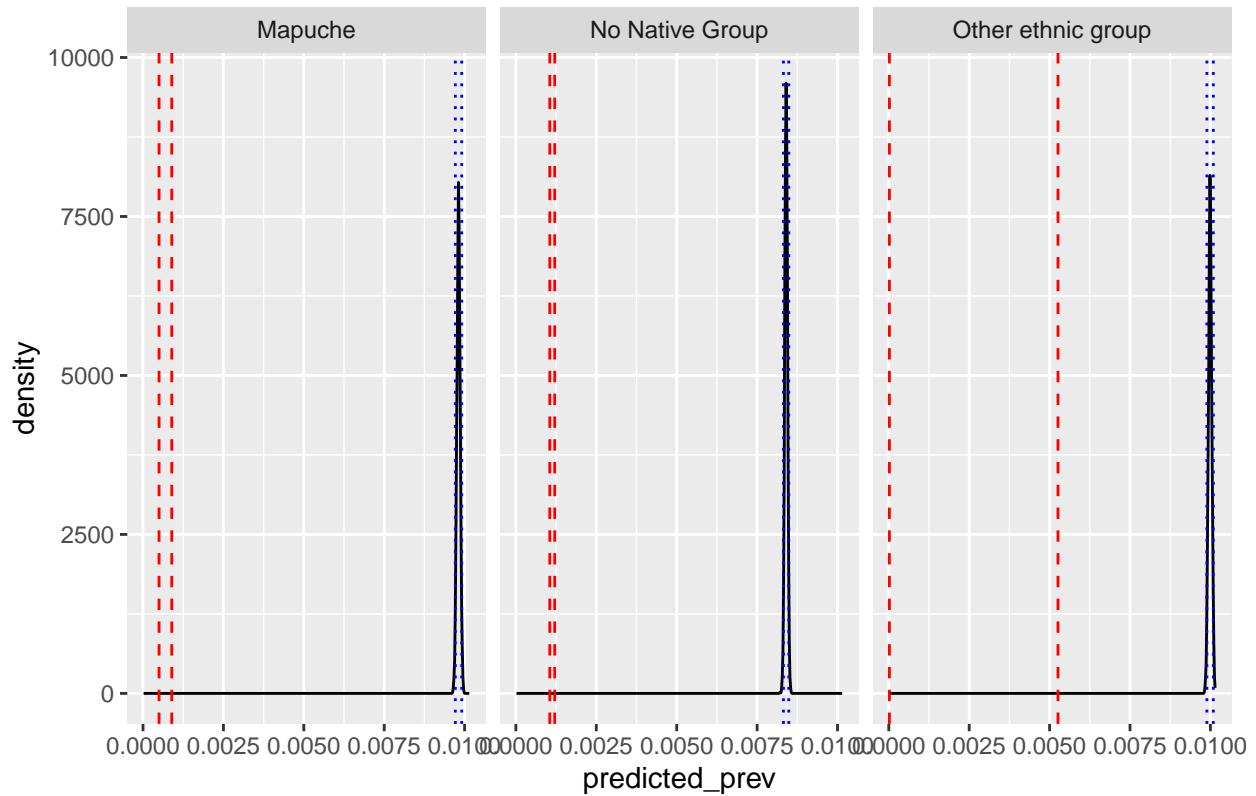
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.005, prior sd = 5.1e-05 (females)



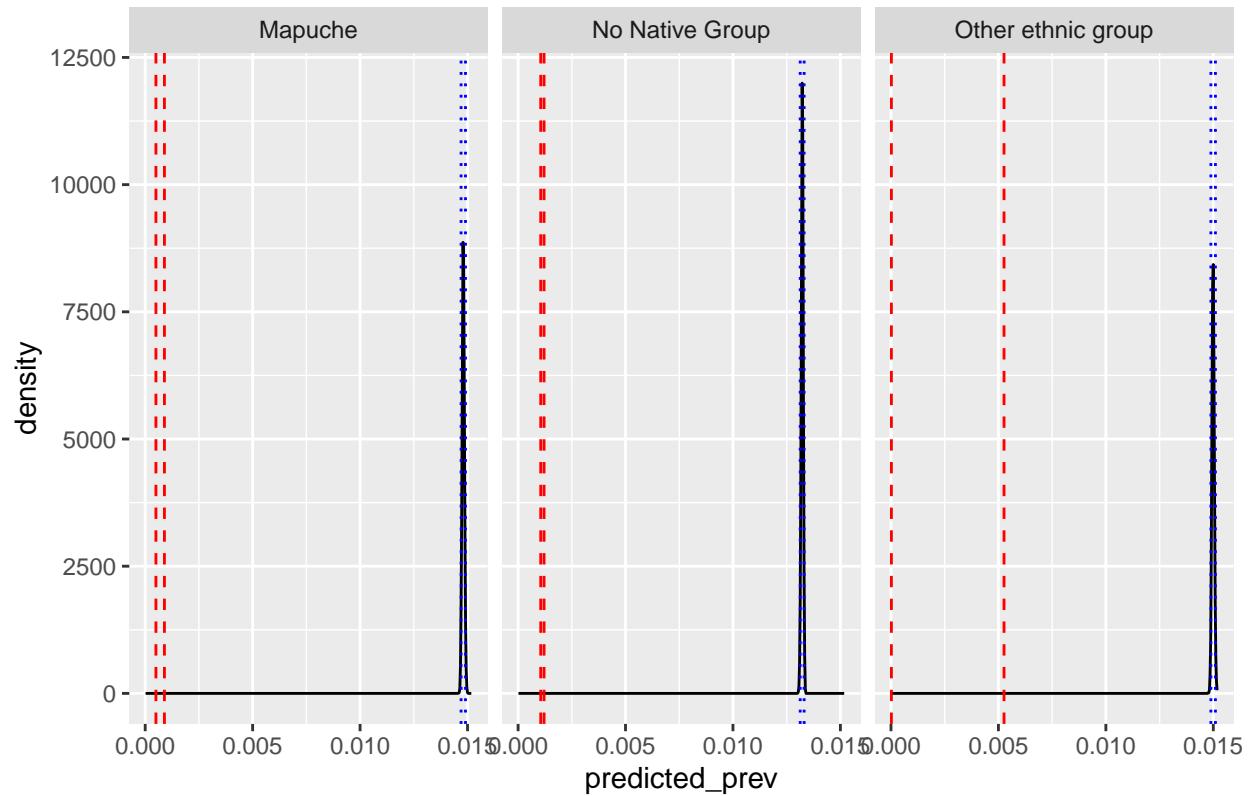
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.01, prior sd = 5.1e-05 (females)



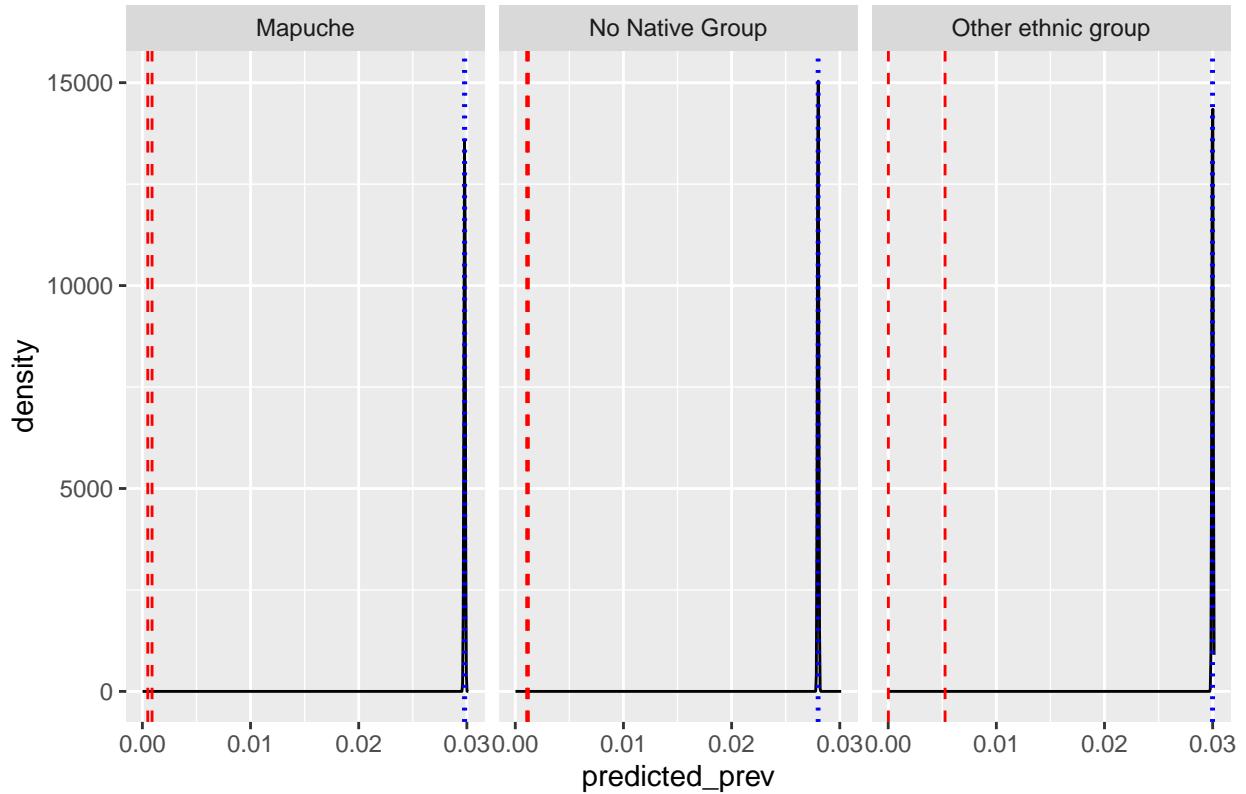
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.015, prior sd = 5.1e-05 (females)



```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.03, prior sd = 5.1e-05 (females)



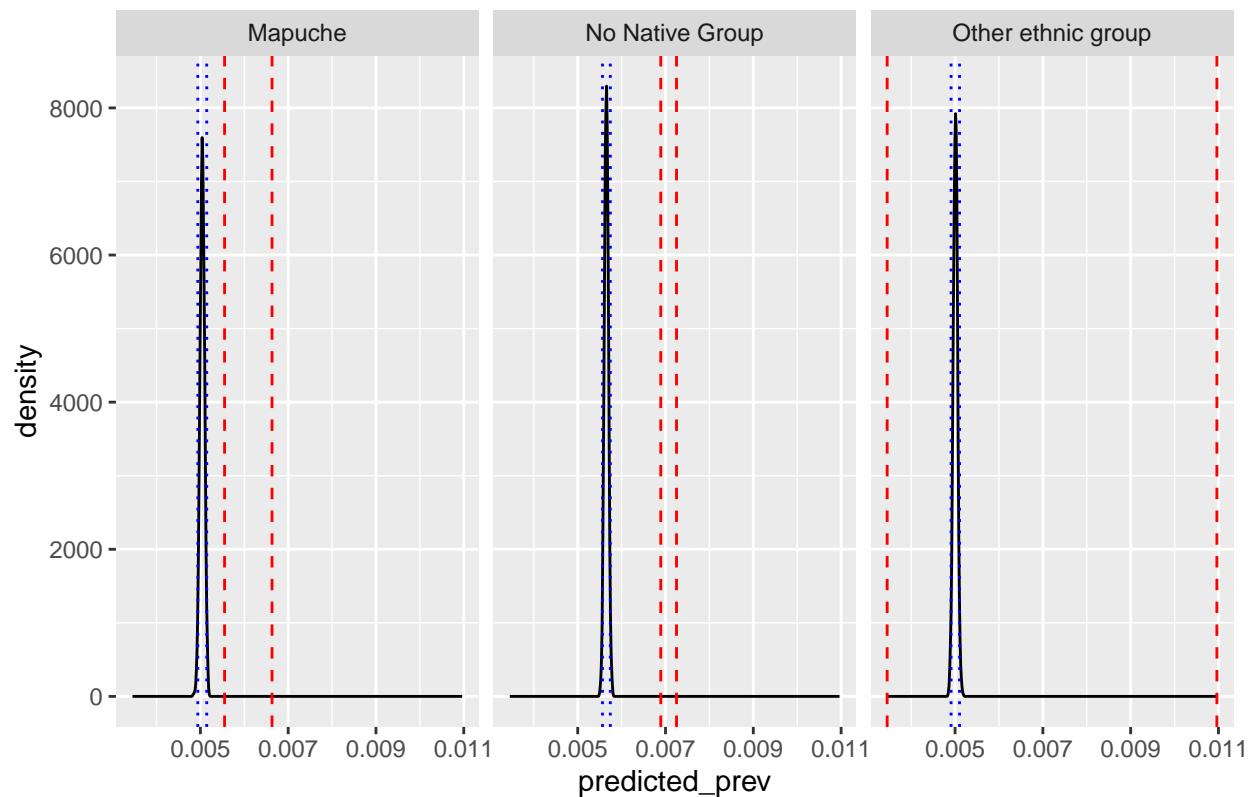
```
# Males
for(j in 1:length(theta_mu_extrapolate)) {
  aut_prev_ethnic_post_m <- do_jags_rand_model(x = aut_prev_ethnic_adj_m,
                                                feat = "ethnic_2_group",
                                                model = rand_model,
                                                theta_mu = theta_mu_extrapolate[j],
                                                theta_sigma = theta_sigma_extrapolate[j],
                                                pars = pars,
                                                convergence_checks = FALSE) %>%
  rename("ethnic_2_group" = "Feat_names")

  plot_post_density(aut_prev_ethnic_post_m,
                    aut_prev_ethnic_adj_m,
                    feat = "ethnic_2_group",
                    theta_mu = theta_mu_extrapolate[j],
                    theta_sigma = theta_sigma_extrapolate[j],
                    title_text = " (males)")

}

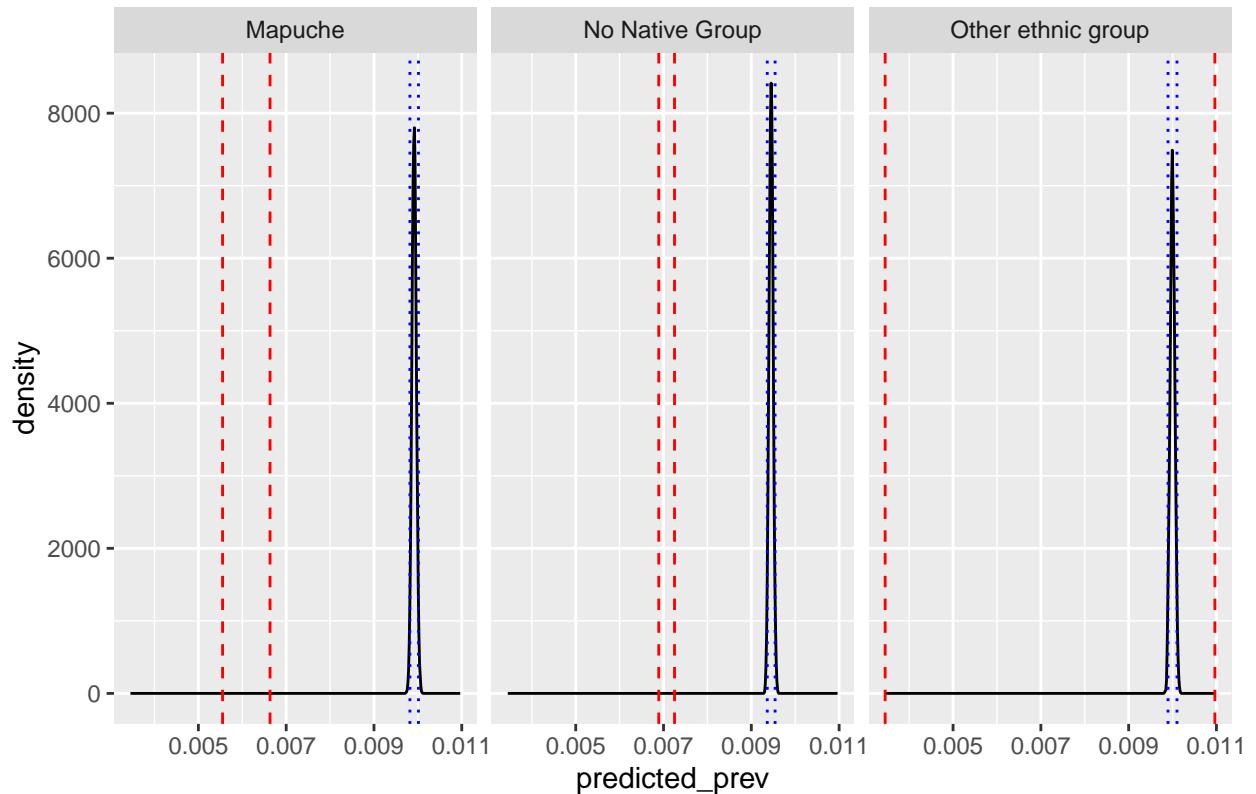
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.005, prior sd = 5.1e-05 (males)



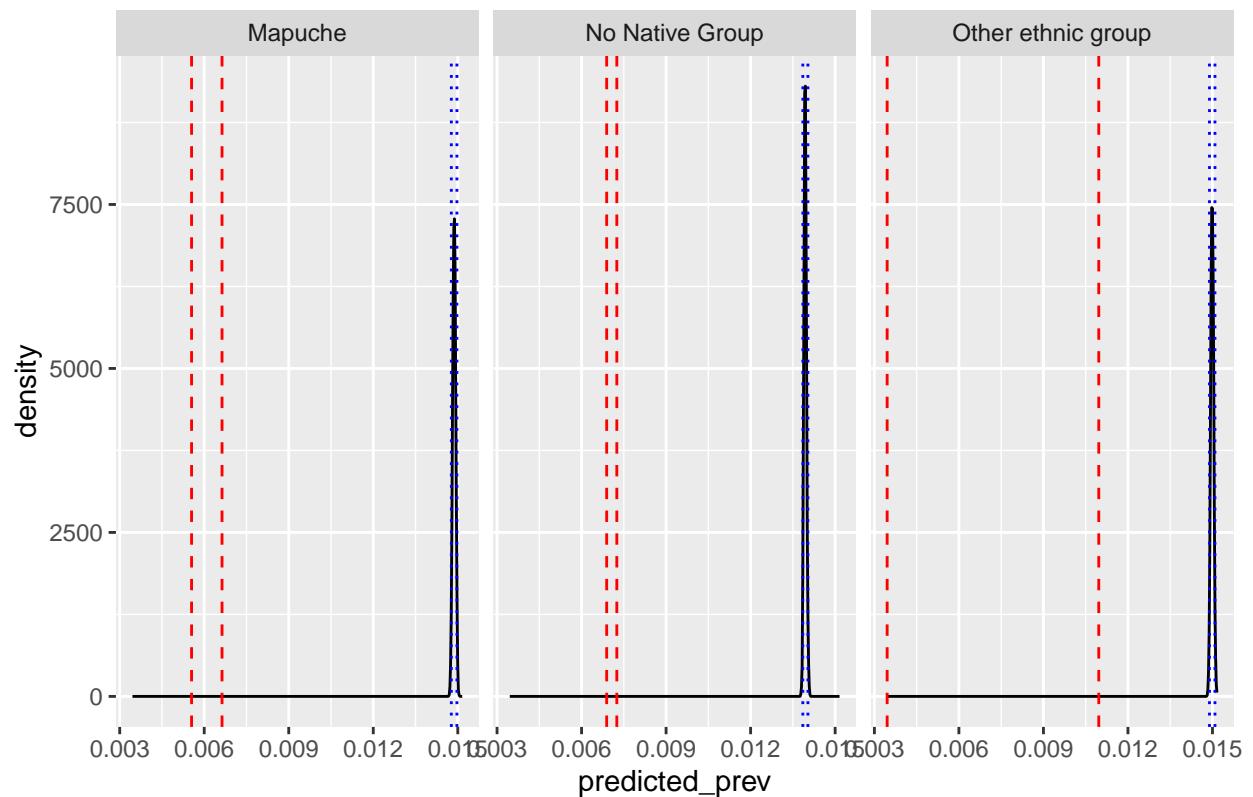
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.01, prior sd = 5.1e–05 (males)



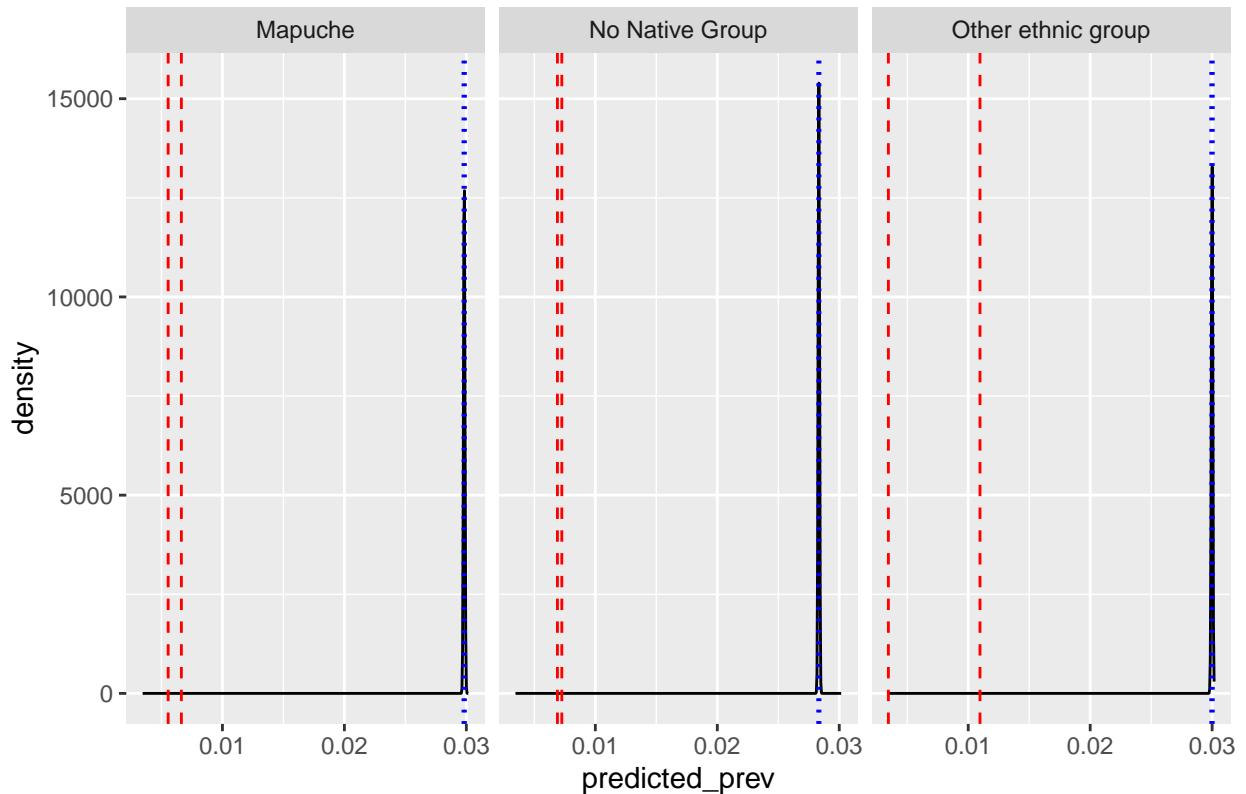
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.015, prior sd = 5.1e-05 (males)



```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.03, prior sd = 5.1e-05 (males)



### Random effect on economic status - all economic groups

```
aut_prev_econA.agecat.sex <- get_grouped_prev_plot(x = chile_bayes_aut, c("school_fee", "age_cat_name"),
## `summarise()` has grouped output by 'school_fee', 'age_cat_name', 'sex_desc'.
## You can override using the `.`groups` argument.
ggplot(data = aut_prev_econA.agecat.sex) +
  geom_col(aes(x = sex_desc, y = sample_prevalence, group = age_cat_name, fill = age_cat_name), position =
  geom_errorbar(aes(x = sex_desc, ymin = ci_lower, ymax = ci_upper, group = age_cat_name), width = 0.2,
  scale_fill_viridis_d(option = "plasma") +
  #theme(axis.text.x = element_text(angle = 90, hjust = 1, vjust = 0.2)) +
  facet_wrap(~school_fee) +
  labs(title = "Autism prevalence by economic status (all)",
  x = "Sex",
  y = "Sample prevalence",
  fill = "Age category")
```

## Autism prevalence by economic status (all)

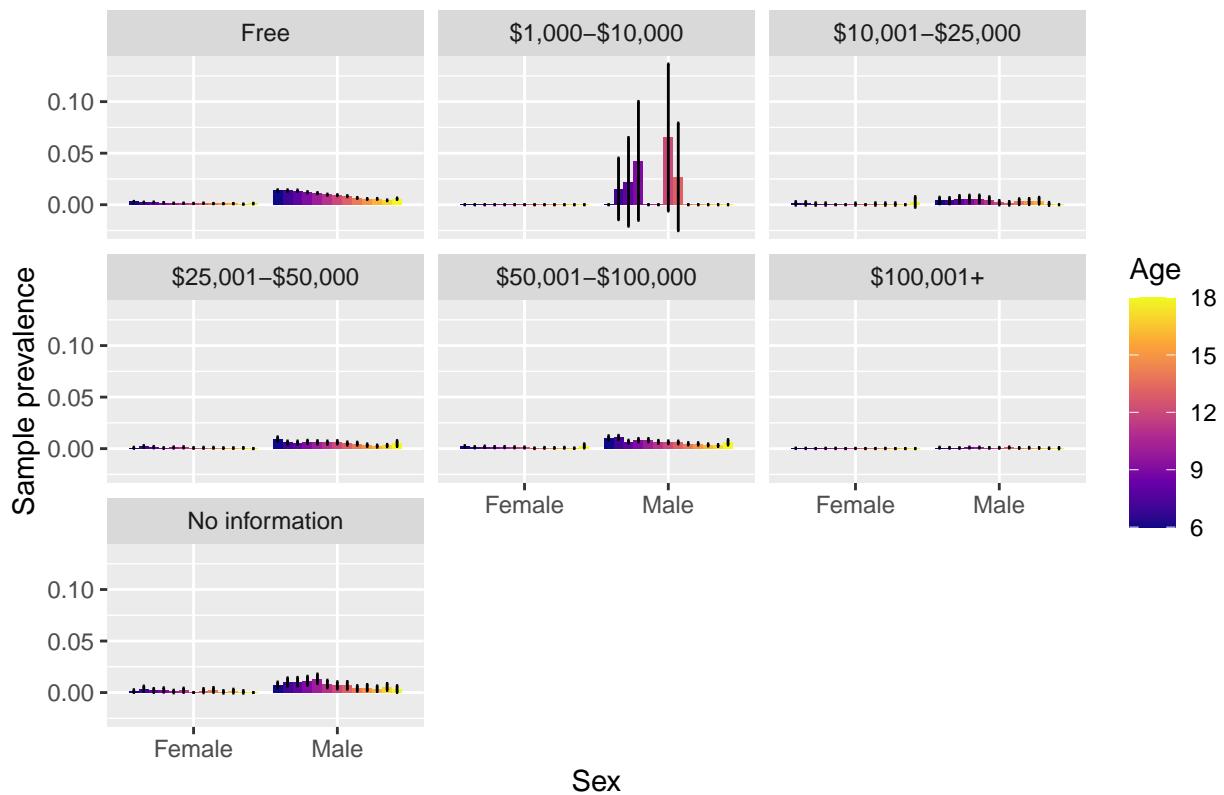


```
aut_prev_econA.age.sex <- get_grouped_prev_plot(x = chile_bayes_aut, c("school_fee", "age_june30", "sex_desc"))

## `summarise()` has grouped output by 'school_fee', 'age_june30', 'sex_desc'. You
## can override using the `.groups` argument.

ggplot(data = aut_prev_econA.age.sex) +
  geom_col(aes(x = sex_desc, y = sample_prevalence, group = age_june30, fill = age_june30), position = position_dodge())
  geom_errorbar(aes(x = sex_desc, ymin = ci_lower, ymax = ci_upper, group = age_june30), width = 0.2, position = position_dodge())
  scale_fill_viridis_c(option = "plasma") +
  #theme(axis.text.x = element_text(angle = 90, hjust = 1, vjust = 0.2)) +
  facet_wrap(~school_fee) +
  labs(title = "Autism prevalence by economic status (all)",
       x = "Sex",
       y = "Sample prevalence",
       fill = "Age")
```

## Autism prevalence by economic status (all)



```
# ggplot(data = aut_prev_econ) +
#   geom_col(aes(x = as.factor(school_fee), y = sample_prevalence, group = age_cat_name, fill = age_cat_name),
#   scale_fill_viridis_d() +
#   theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
#   facet_wrap(~sex_desc) +
#   labs(title = "Autism prevalence by sex",
#       x = "Economic status (all)",
#       y = "Sample prevalence",
#       fill = "Age category")
#
# ggplot(data = aut_prev_econ) +
#   geom_col(aes(x = as.factor(school_fee), y = sample_prevalence, group = sex, fill = as.factor(sex)),
#   scale_fill_manual(values = c("#03CEA4", "#802392")) +
#   theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
#   labs(title = "Autism prevalence",
#       x = "Economic status (all)",
#       y = "Sample prevalence",
#       fill = "Sex")
#
aut_prev_econ <- get_grouped_prev(x = chile_bayes_aut, stdpop = chile_stdpop,
                                    grouping_vars = c("school_fee", "school_fee_group", "age_june30", "age_cat_name"))
## `summarise()` has grouped output by 'school_fee', 'school_fee_group',
## 'age_june30', 'age_cat_name', 'sex', 'sex_desc'. You can override using the
## `.groups` argument.
```

```

aut_prev_econ_adj <- get_adjusted_prev(aut_prev_econ, grouping_vars = "school_fee")

# ggplot(data = aut_prev_econ_adj) +
#   geom_col(aes(x = school_fee, y = adjusted_rate), fill = "lightblue", position = "dodge") +
#   geom_errorbar(aes(x = school_fee, ymin = ci_lower, ymax = ci_upper), width = 0.2) +
#   theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
#   labs(title = "Age- and sex-adjusted autism prevalence",
#        x = "Economic status (all)",
#        y = "Sample prevalence")

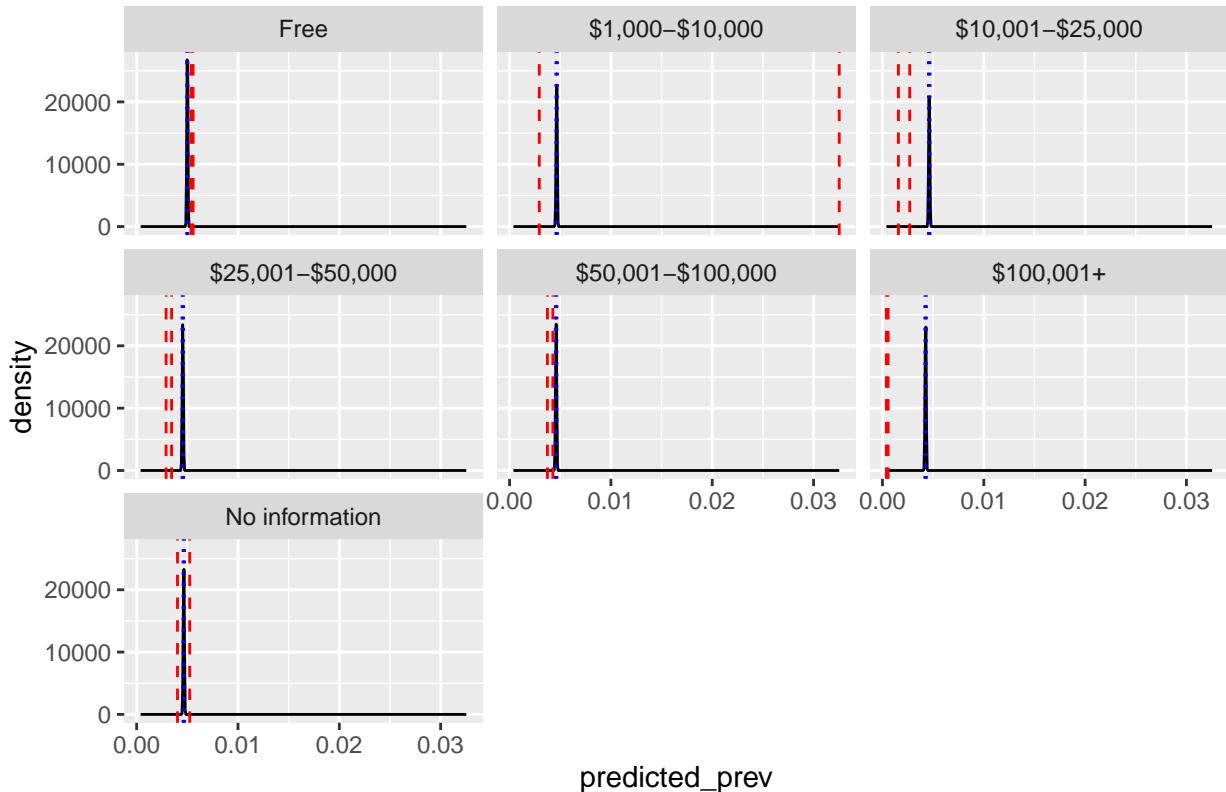
aut_prev_econ_post <- do_jags_rand_model(x = aut_prev_econ_adj,
                                           feat = "school_fee",
                                           model = rand_model,
                                           theta_mu = theta_mu_prior,
                                           theta_sigma = theta_sigma_prior,
                                           pars = pars,
                                           convergence_checks = FALSE) %>%
  rename("school_fee" = "Feat_names")

plot_post_density(aut_prev_econ_post, aut_prev_econ_adj, feat = "school_fee", theta_mu = theta_mu_prior)

## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.

```

Prior mean = 0.00465, prior sd = 3.98e-05



Predictions for higher population prevalence - increase prior mean

```

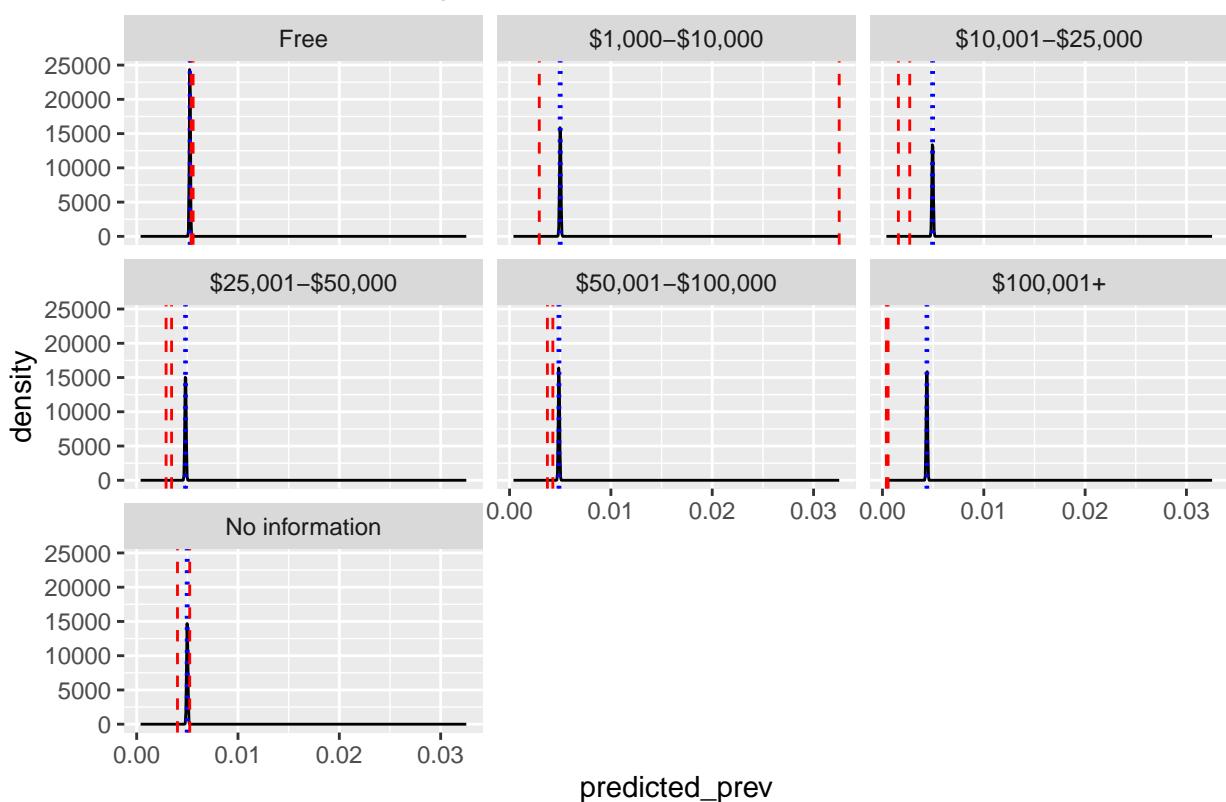
for(j in 1:length(theta_mu_extrapolate)) {
  aut_prev_econ_post <- do_jags_rand_model(x = aut_prev_econ_adj,
                                             feat = "school_fee",
                                             model = rand_model,
                                             theta_mu = theta_mu_extrapolate[j],
                                             theta_sigma = theta_sigma_extrapolate[j],
                                             pars = pars,
                                             convergence_checks = FALSE) %>%
    rename("school_fee" = "Feat_names")

  plot_post_density(aut_prev_econ_post,
                    aut_prev_econ_adj,
                    feat = "school_fee",
                    theta_mu = theta_mu_extrapolate[j],
                    theta_sigma = theta_sigma_extrapolate[j])
}

## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.

```

Prior mean = 0.005, prior sd = 5.1e-05

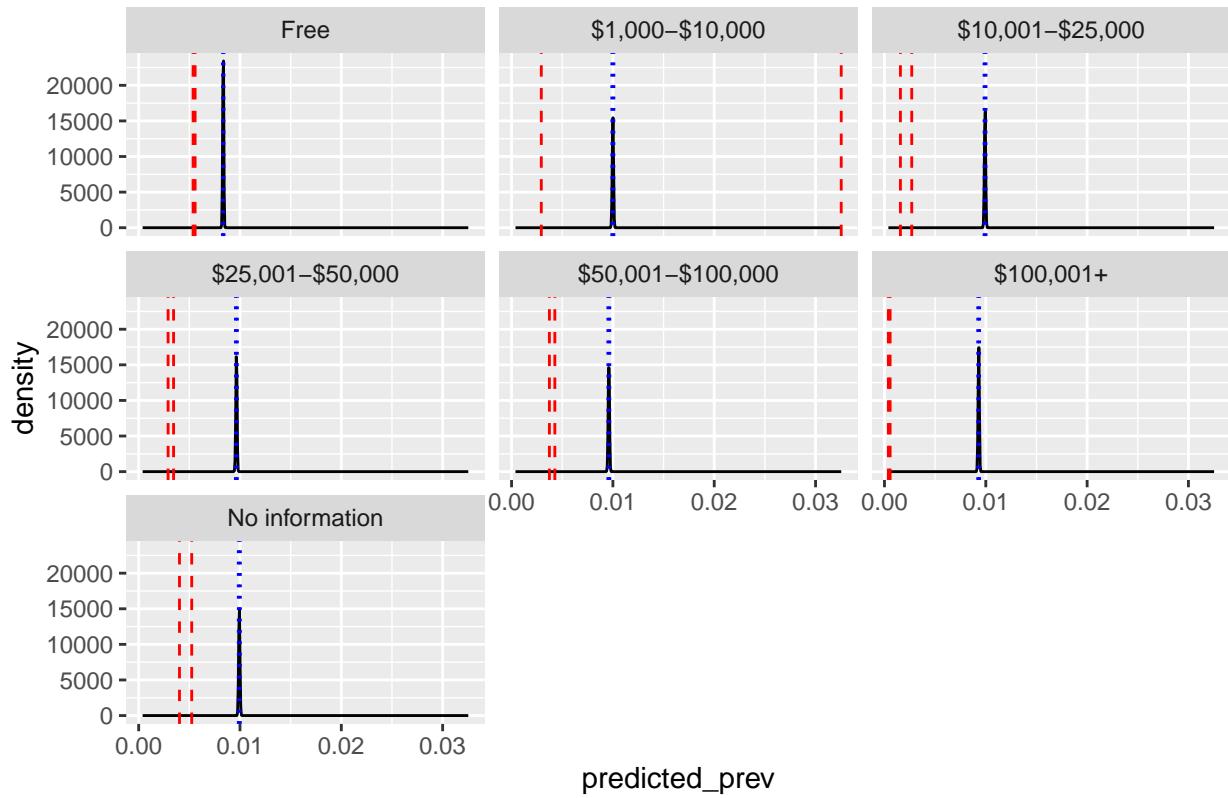


```

## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.

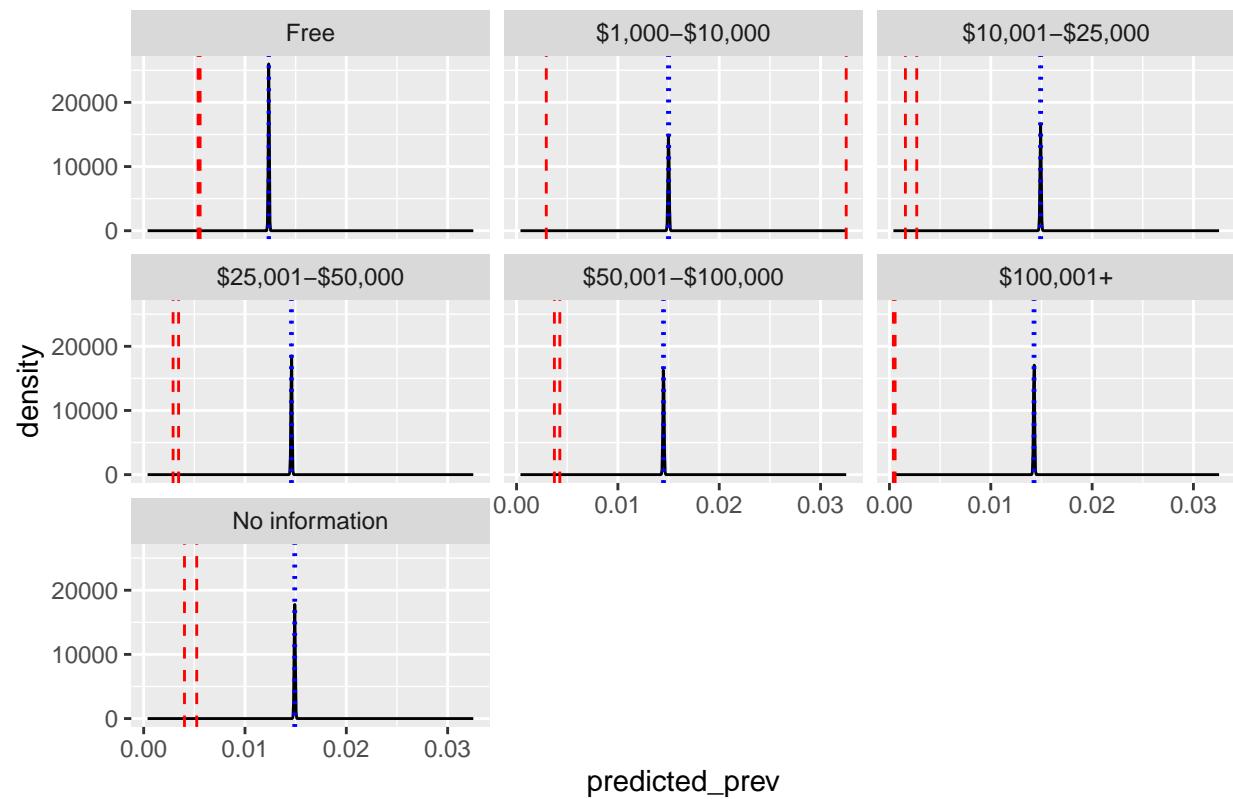
```

Prior mean = 0.01, prior sd = 5.1e-05



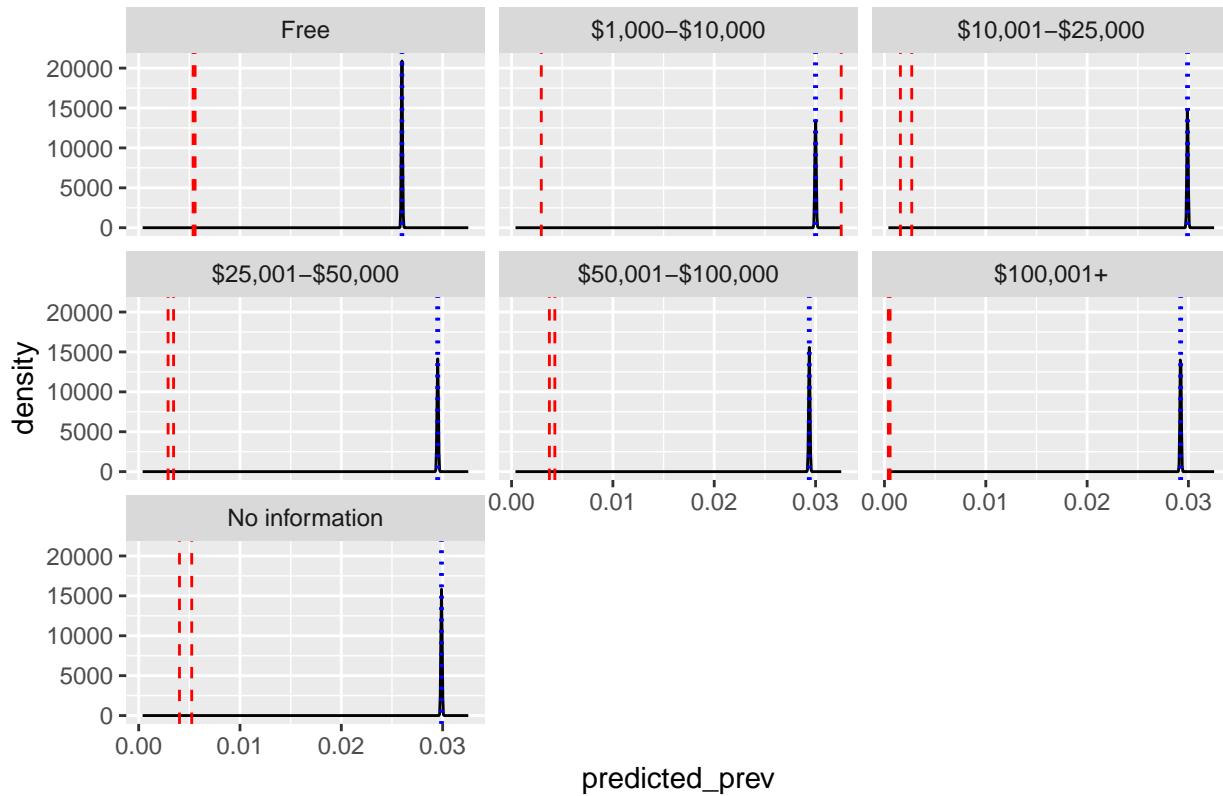
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.015, prior sd = 5.1e-05



```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.03, prior sd = 5.1e-05



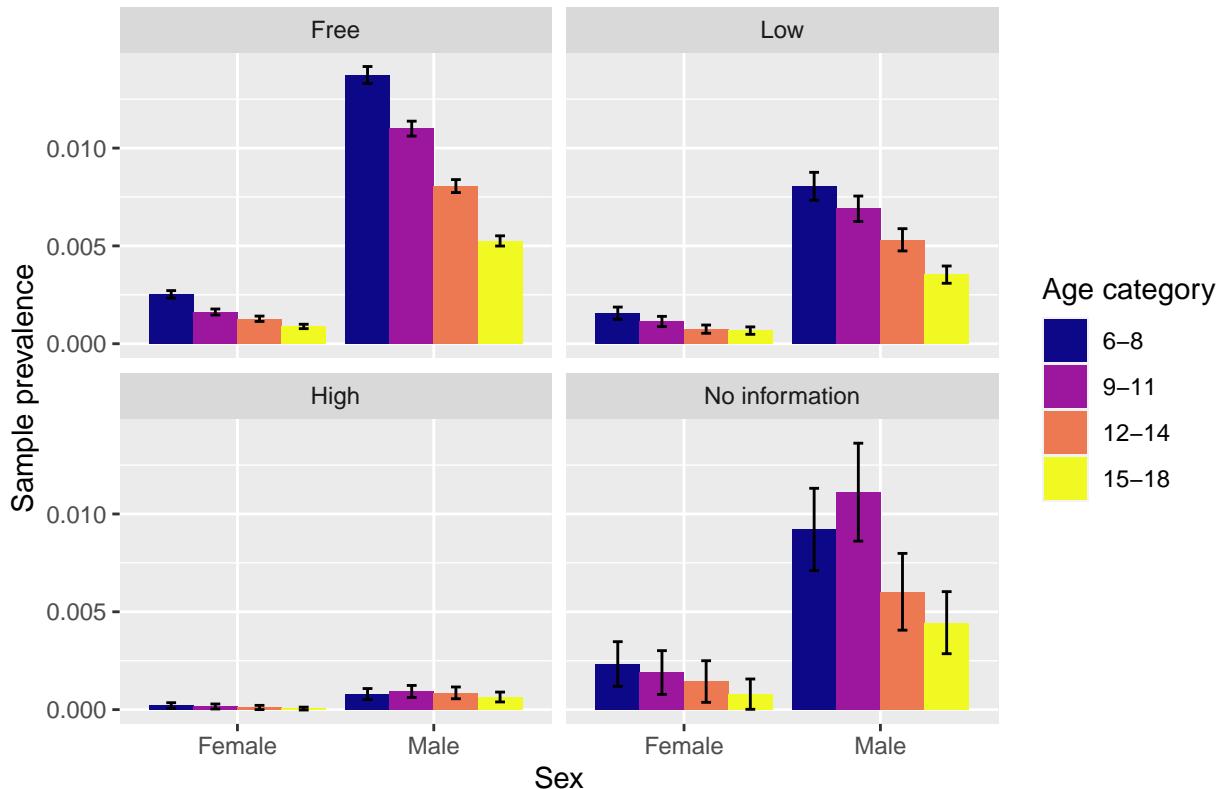
Random effect on economic status - free education, low status, high status and no information

```
aut_prev_econG.agecat.sex <- get_grouped_prev_plot(x = chile_bayes_aut, c("school_fee_group", "age_cat_name"))

## `summarise()` has grouped output by 'school_fee_group', 'age_cat_name',
## 'sex_desc'. You can override using the `~.groups` argument.

ggplot(data = aut_prev_econG.agecat.sex) +
  geom_col(aes(x = sex_desc, y = sample_prevalence, group = age_cat_name, fill = age_cat_name), position = "dodge") +
  geom_errorbar(aes(x = sex_desc, ymin = ci_lower, ymax = ci_upper, group = age_cat_name), width = 0.2, position = "dodge") +
  scale_fill_viridis_d(option = "plasma") +
  #theme(axis.text.x = element_text(angle = 90, hjust = 1, vjust = 0.2)) +
  facet_wrap(~school_fee_group) +
  labs(title = "Autism prevalence by economic status (grouped)",
       x = "Sex",
       y = "Sample prevalence",
       fill = "Age category")
```

## Autism prevalence by economic status (grouped)

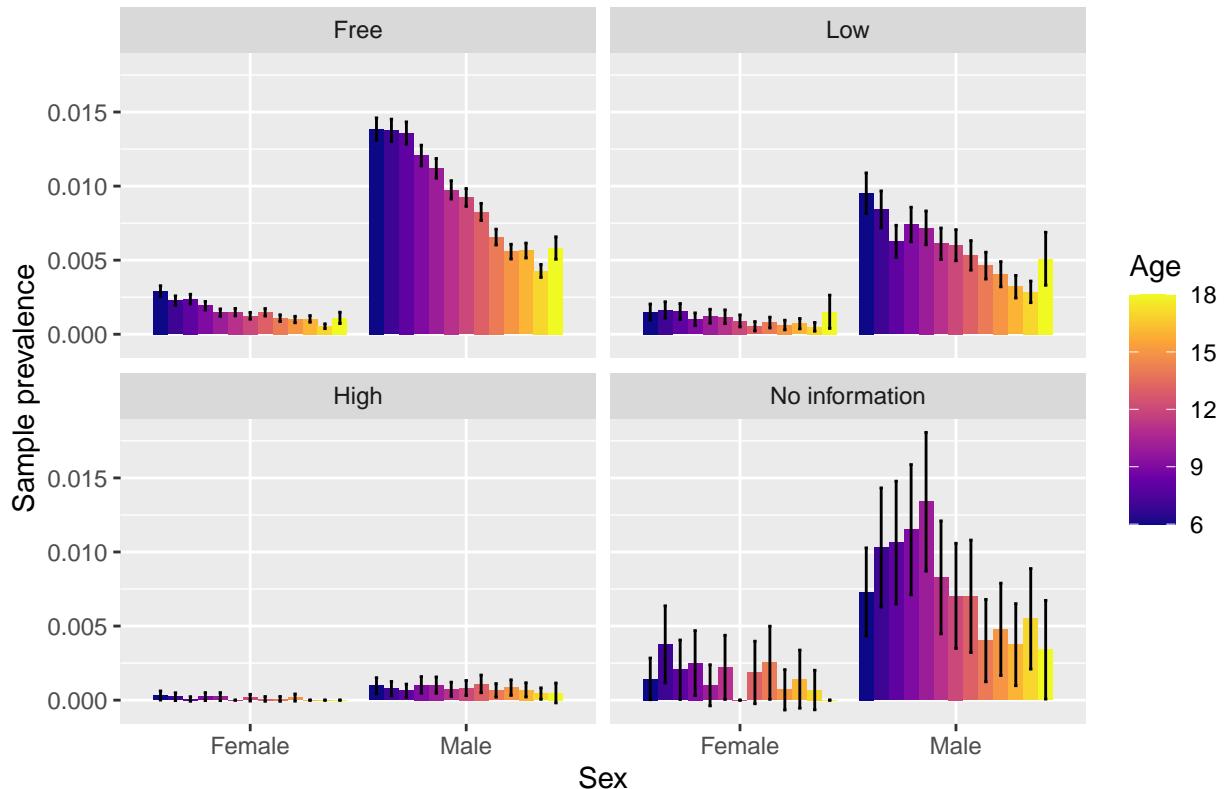


```
aut_prev_econG.age.sex <- get_grouped_prev_plot(x = chile_bayes_aut, c("school_fee_group", "age_june30"))

## `summarise()` has grouped output by 'school_fee_group', 'age_june30',
## 'sex_desc'. You can override using the `.groups` argument.

ggplot(data = aut_prev_econG.age.sex) +
  geom_col(aes(x = sex_desc, y = sample_prevalence, group = age_june30, fill = age_june30), position = position_dodge())
  geom_errorbar(aes(x = sex_desc, ymin = ci_lower, ymax = ci_upper, group = age_june30), width = 0.2, position = position_dodge())
  scale_fill_viridis_c(option = "plasma") +
  #theme(axis.text.x = element_text(angle = 90, hjust = 1, vjust = 0.2)) +
  facet_wrap(~school_fee_group) +
  labs(title = "Autism prevalence by economic status (grouped)",
       x = "Sex",
       y = "Sample prevalence",
       fill = "Age")
```

## Autism prevalence by economic status (grouped)



```
# ggplot(data = aut_prev_econ) +
#   geom_col(aes(x = as.factor(school_fee_group), y = sample_prevalence, group = age_cat_name, fill = age_cat_name),
#   scale_fill_viridis_d() +
#   theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
#   facet_wrap(~sex_desc) +
#   labs(title = "Autism prevalence by sex",
#       x = "Economic status (grouped)",
#       y = "Sample prevalence",
#       fill = "Age category")
#
# ggplot(data = aut_prev_econ) +
#   geom_col(aes(x = as.factor(school_fee_group), y = sample_prevalence, group = sex, fill = sex),
#   scale_fill_manual(values = c("#03CEA4", "#802392")) +
#   theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
#   labs(title = "Autism prevalence",
#       x = "Economic status (grouped)",
#       y = "Sample prevalence",
#       fill = "Sex")
#
aut_prev_econG_adj <- get_adjusted_prev(aut_prev_econ, grouping_vars = "school_fee_group")
#
# ggplot(data = aut_prev_econG_adj) +
#   geom_col(aes(x = school_fee_group, y = adjusted_rate), fill = "lightblue", position = "dodge") +
#   geom_errorbar(aes(x = school_fee_group, ymin = ci_lower, ymax = ci_upper), width = 0.2) +
#   theme(axis.text.x = element_text(angle = 45, hjust = 1)) +
#   labs(title = "Age- and sex-adjusted autism prevalence",
```

```

#           x = "Economic status (grouped)",
#           y = "Sample prevalence")

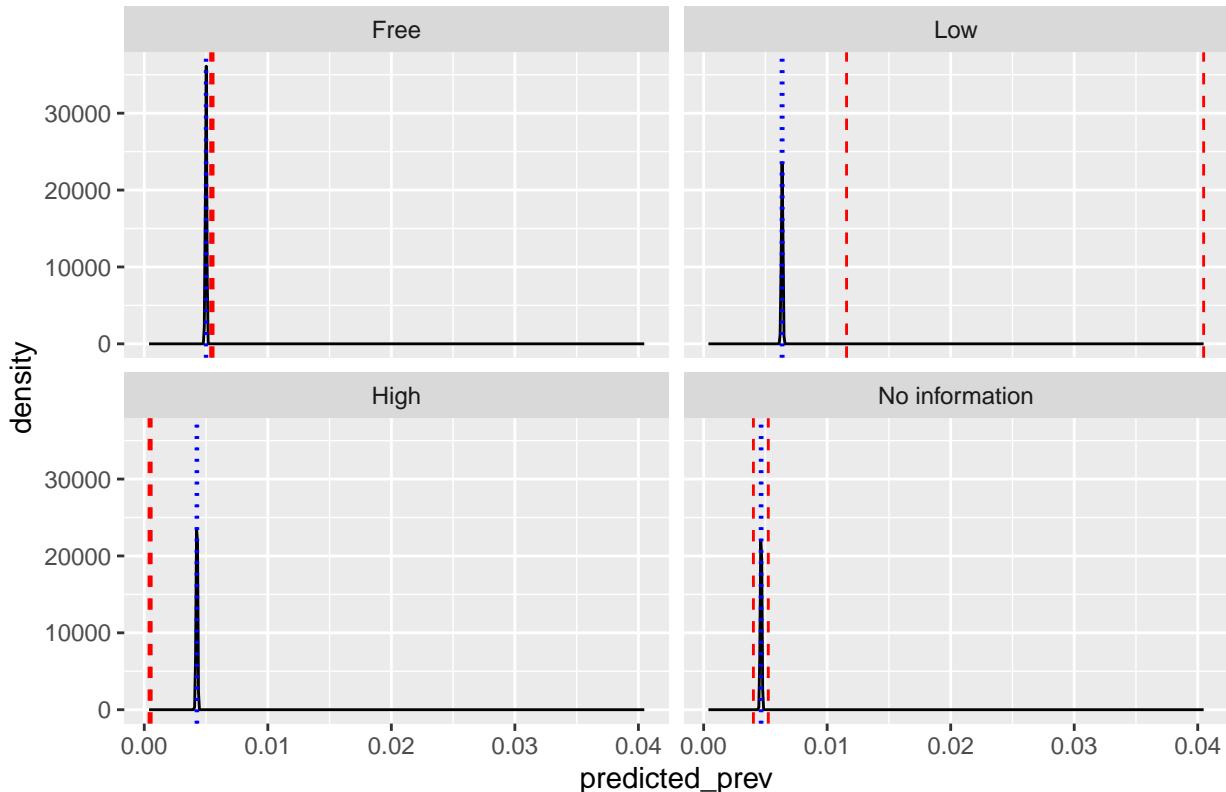
aut_prev_econG_post <- do_jags_rand_model(x = aut_prev_econG_adj,
                                             feat = "school_fee_group",
                                             model = rand_model,
                                             theta_mu = theta_mu_prior,
                                             theta_sigma = theta_sigma_prior,
                                             pars = pars,
                                             convergence_checks = FALSE) %>%
  rename("school_fee_group" = "Feat_names")

plot_post_density(aut_prev_econG_post, aut_prev_econG_adj, feat = "school_fee_group", theta_mu = theta_mu)

## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.

```

Prior mean = 0.00465, prior sd = 3.98e-05



Predictions for higher population prevalence - increase prior mean

```

for(j in 1:length(theta_mu_extrapolate)) {
  aut_prev_econG_post <- do_jags_rand_model(x = aut_prev_econG_adj,
                                              feat = "school_fee_group",
                                              model = rand_model,
                                              theta_mu = theta_mu_extrapolate[j],
                                              theta_sigma = theta_sigma_extrapolate[j],
                                              pars = pars,
                                              convergence_checks = FALSE) %>%

```

```

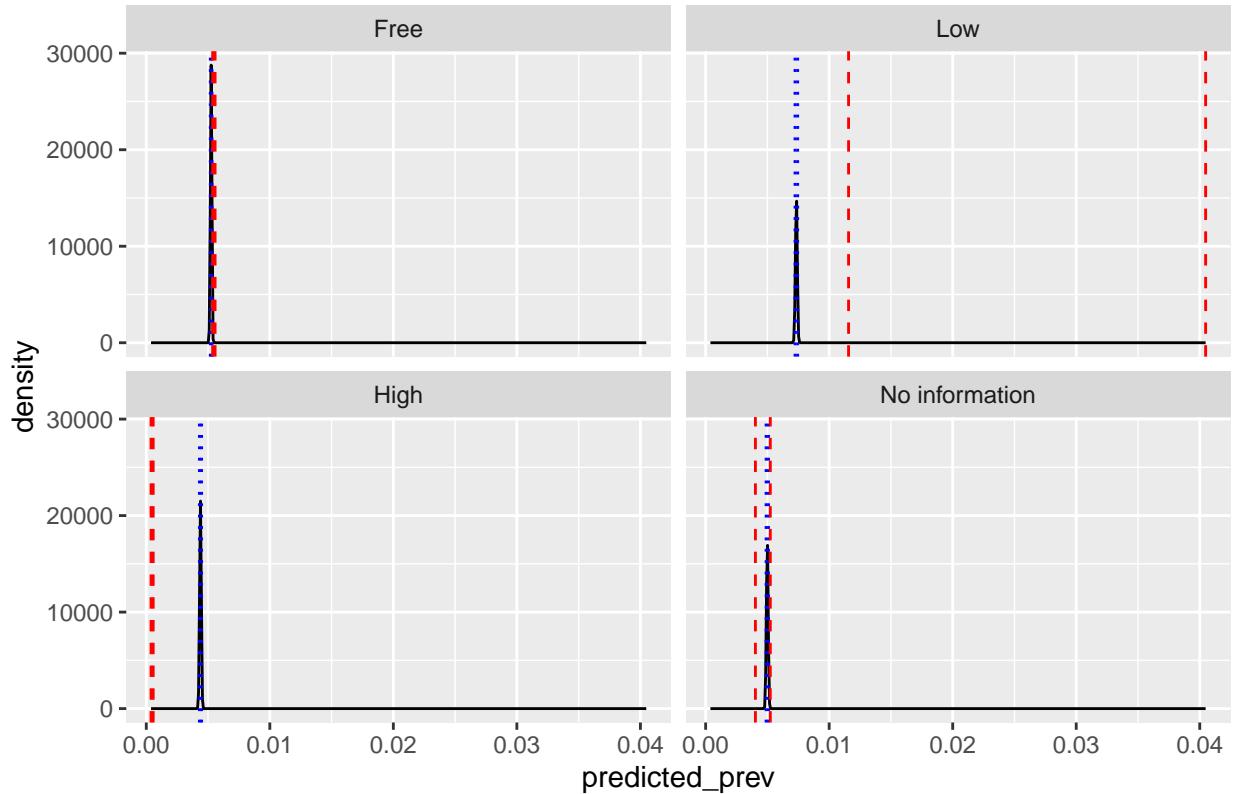
    rename("school_fee_group" = "Feat_names")

    plot_post_density(aut_prev_econG_post,
                      aut_prev_econG_adj,
                      feat = "school_fee_group",
                      theta_mu = theta_mu_extrapolate[j],
                      theta_sigma = theta_sigma_extrapolate[j])
}

## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.

```

Prior mean = 0.005, prior sd = 5.1e-05

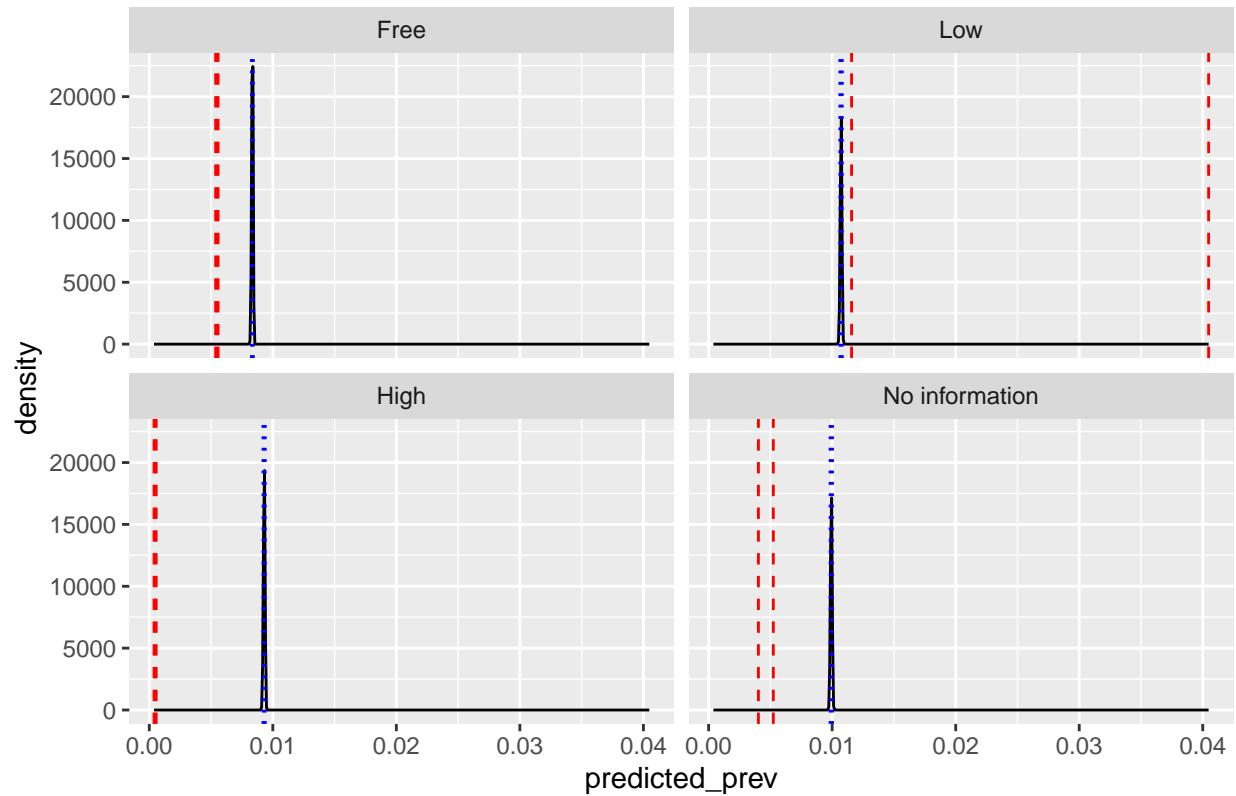


```

## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.

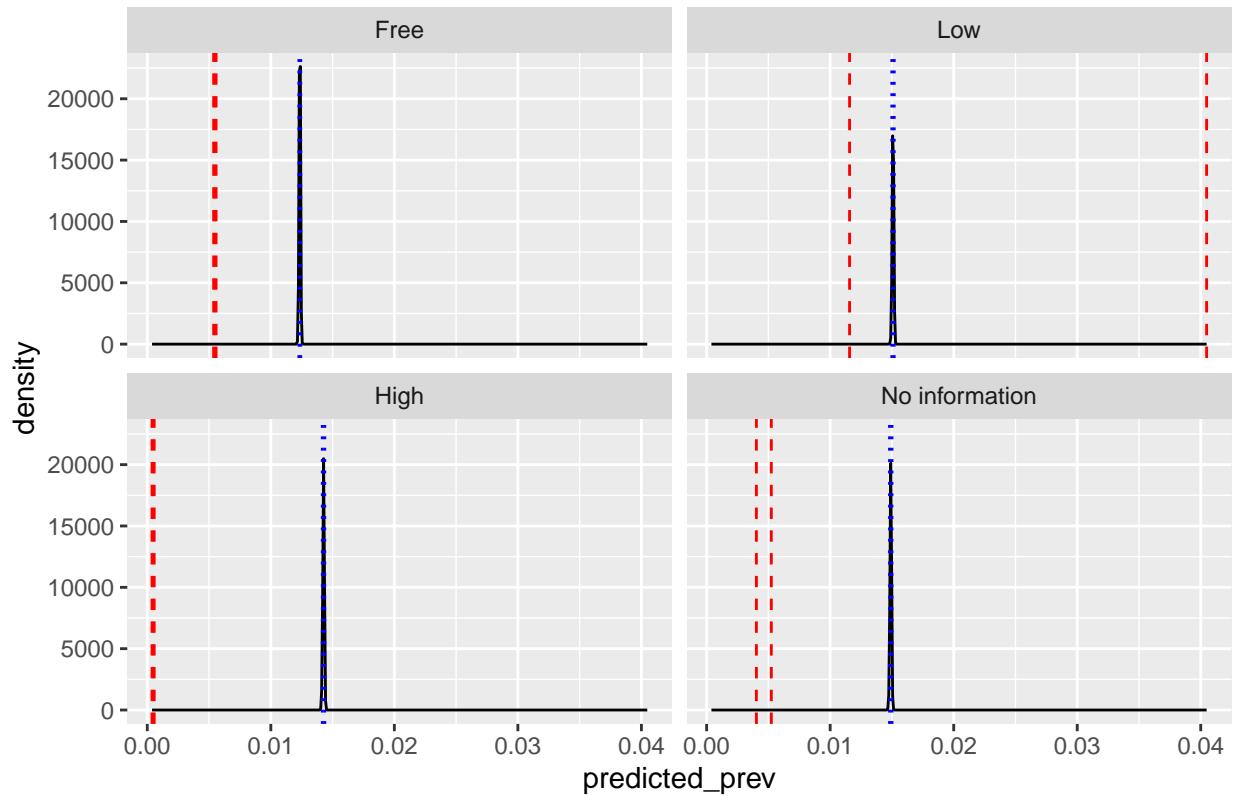
```

Prior mean = 0.01, prior sd = 5.1e-05



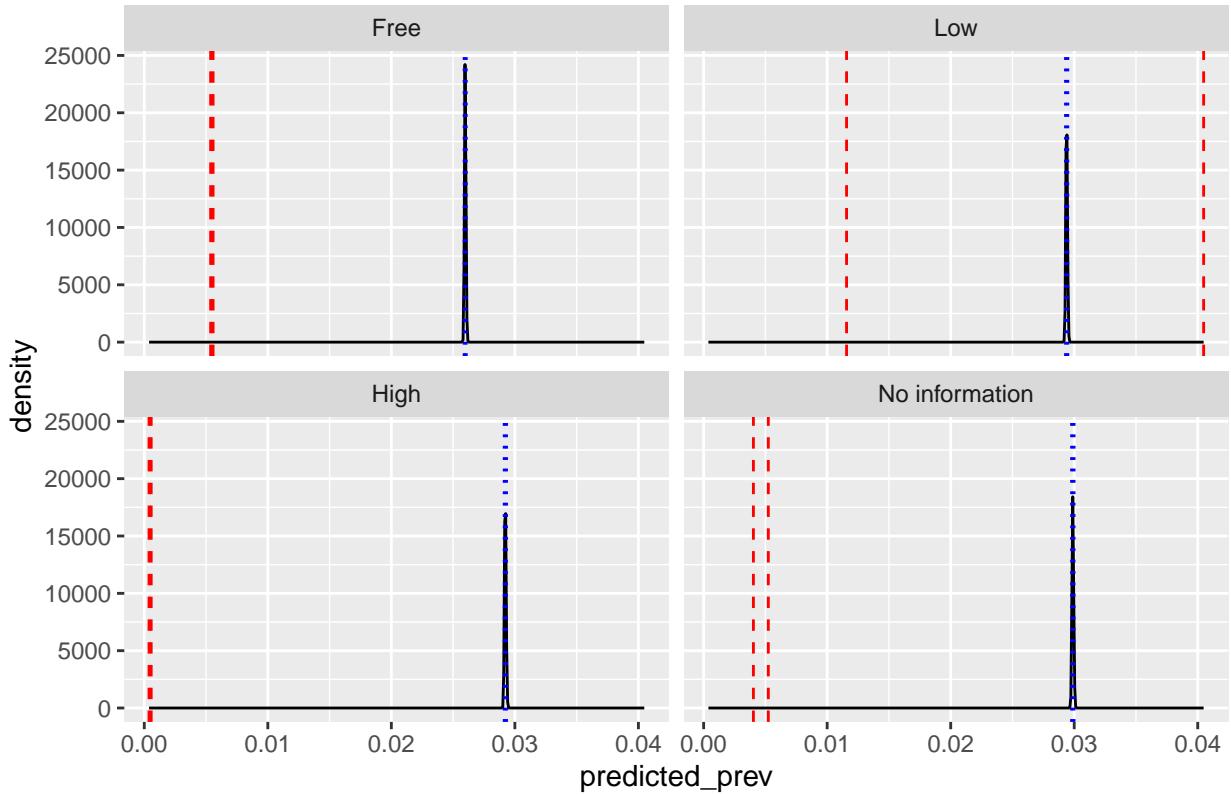
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.015, prior sd = 5.1e-05



```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.03, prior sd = 5.1e-05



### Random effect on economic status, sexes separate

Use grouped fees because they ungrouped classes are too small and there are no females in the 1,000-10,000 group.

```
# Females
aut_prev_econG_f <- chile_bayes_aut %>%
  filter(sex == 2) %>%
  get_grouped_prev(stdpop = chile_stdpop_f, grouping_vars = c("school_fee_group", "age_june30", "sex", "group"))

## `summarise()` has grouped output by 'school_fee_group', 'age_june30', 'sex'.
## You can override using the `.groups` argument.
aut_prev_econG_adj_f <- get_adjusted_prev(aut_prev_econG_f, grouping_vars = "school_fee_group")

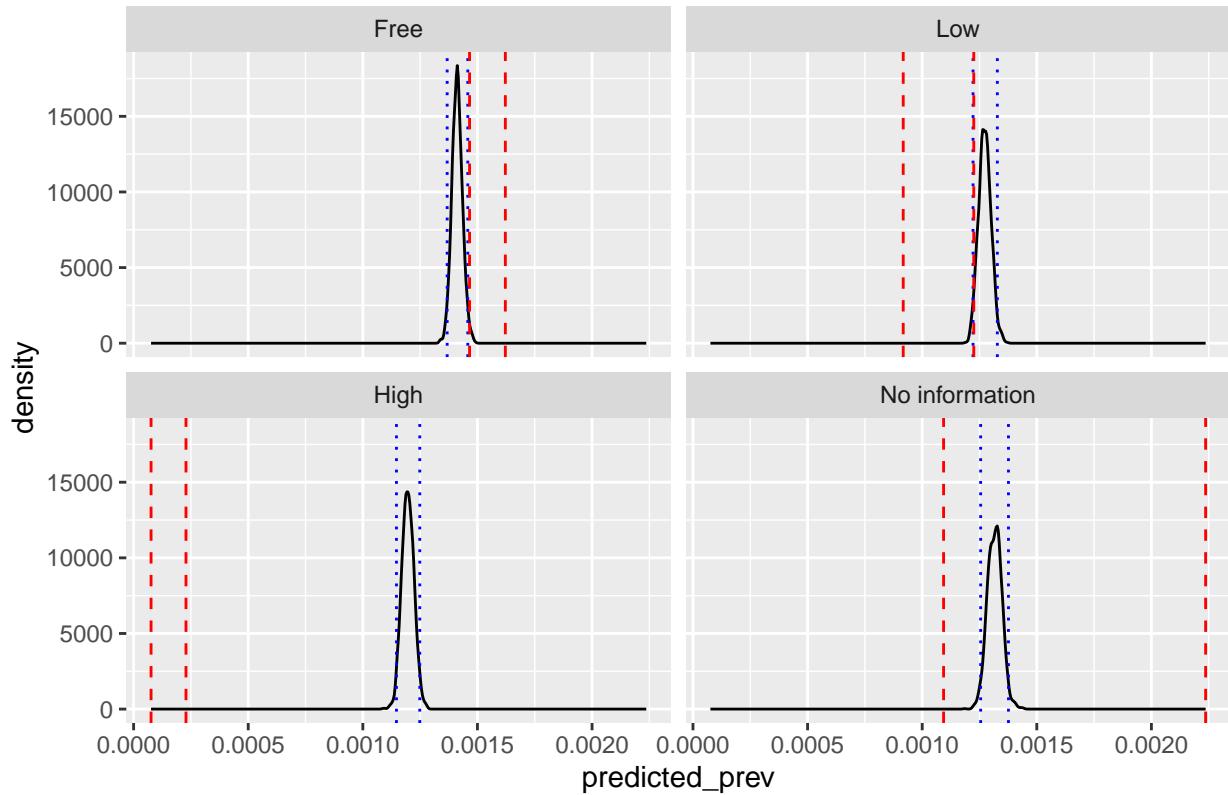
aut_prev_econG_post_f <- do_jags_rand_model(x = aut_prev_econG_adj_f,
                                             feat = "school_fee_group",
                                             model = rand_model,
                                             theta_mu = theta_mu_prior_f,
                                             theta_sigma = theta_sigma_prior_f,
                                             pars = pars,
                                             convergence_checks = FALSE) %>%
  rename("school_fee_group" = "Feat_names")

plot_post_density(aut_prev_econG_post_f, aut_prev_econG_adj_f, feat = "school_fee_group", theta_mu = the
```

## Don't know how to automatically pick scale for object of type

```
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.00131, prior sd = 3.08e-05 (females)



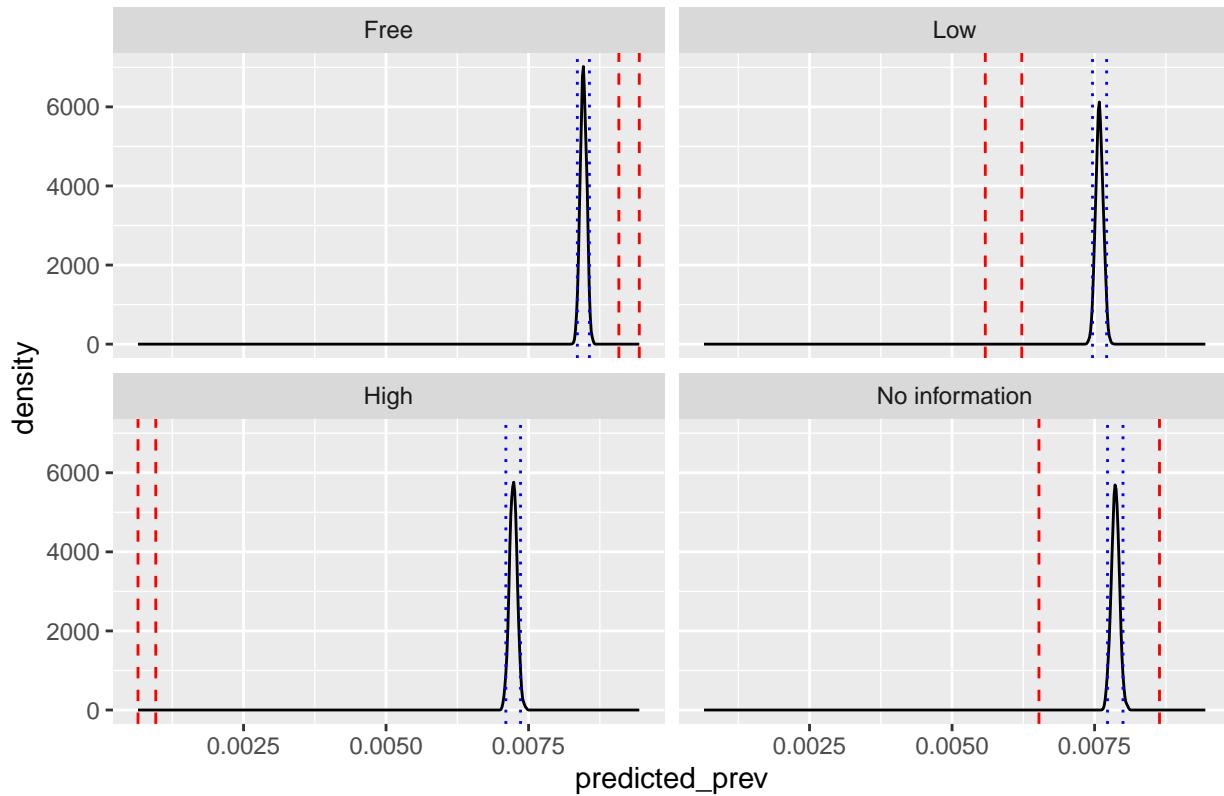
```
# Males
aut_prev_econG_m <- chile_bayes_aut %>%
  filter(sex == 1) %>%
  get_grouped_prev(stdpop = chile_stdpop_m, grouping_vars = c("school_fee_group", "age_june30", "sex"),
  ## `summarise()` has grouped output by 'school_fee_group', 'age_june30', 'sex'.
  ## You can override using the `.groups` argument.
  aut_prev_econG_adj_m <- get_adjusted_prev(aut_prev_econG_m, grouping_vars = "school_fee_group")

aut_prev_econG_post_m <- do_jags_rand_model(x = aut_prev_econG_adj_m,
                                              feat = "school_fee_group",
                                              model = rand_model,
                                              theta_mu = theta_mu_prior_m,
                                              theta_sigma = theta_sigma_prior_m,
                                              pars = pars,
                                              convergence_checks = FALSE) %>%
  rename("school_fee_group" = "Feat_names")

plot_post_density(aut_prev_econG_post_m, aut_prev_econG_adj_m, feat = "school_fee_group", theta_mu = theta_mu_prior_m)

## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.00787, prior sd = 7.17e-05 (males)



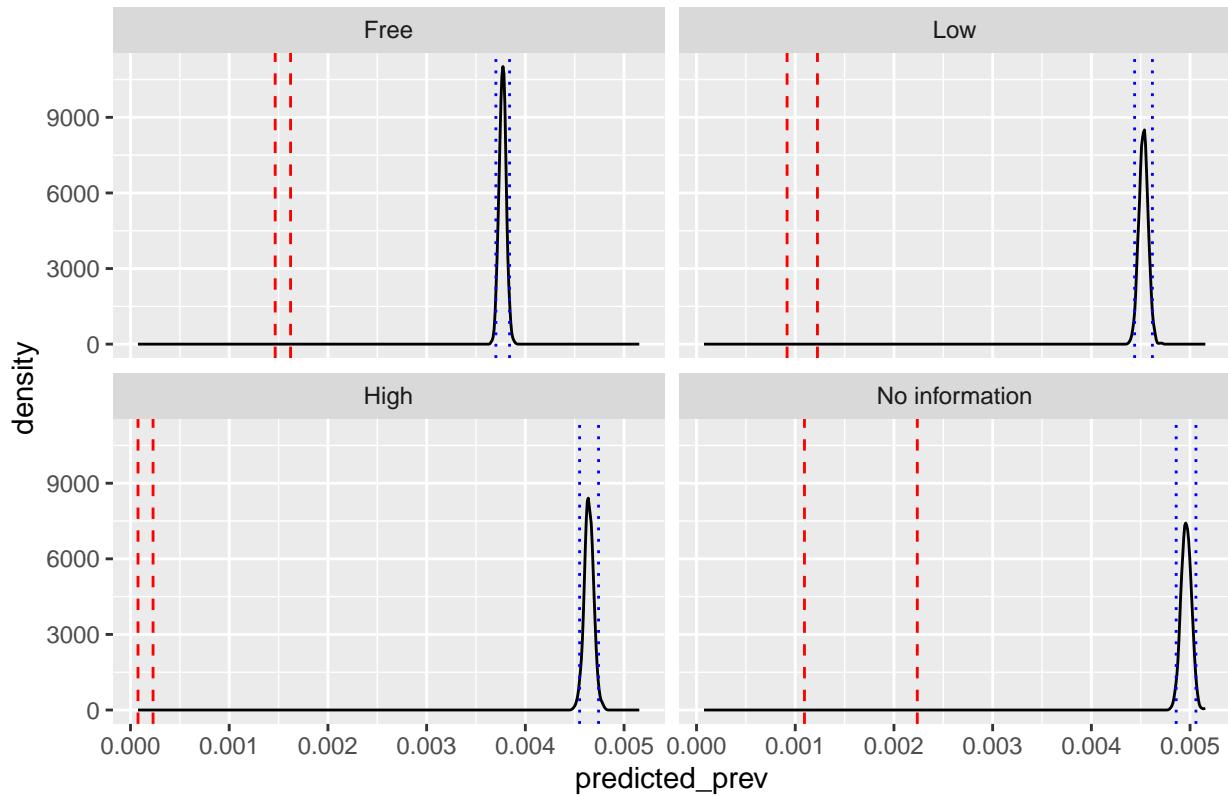
```
# Females
for(j in 1:length(theta_mu_extrapolate)) {
  aut_prev_econG_post_f <- do_jags_rand_model(x = aut_prev_econG_adj_f,
                                                feat = "school_fee_group",
                                                model = rand_model,
                                                theta_mu = theta_mu_extrapolate[j],
                                                theta_sigma = theta_sigma_extrapolate[j],
                                                pars = pars,
                                                convergence_checks = FALSE) %>%
  rename("school_fee_group" = "Feat_names")

  plot_post_density(aut_prev_econG_post_f,
                    aut_prev_econG_adj_f,
                    feat = "school_fee_group",
                    theta_mu = theta_mu_extrapolate[j],
                    theta_sigma = theta_sigma_extrapolate[j],
                    title_text = " (females)")

}

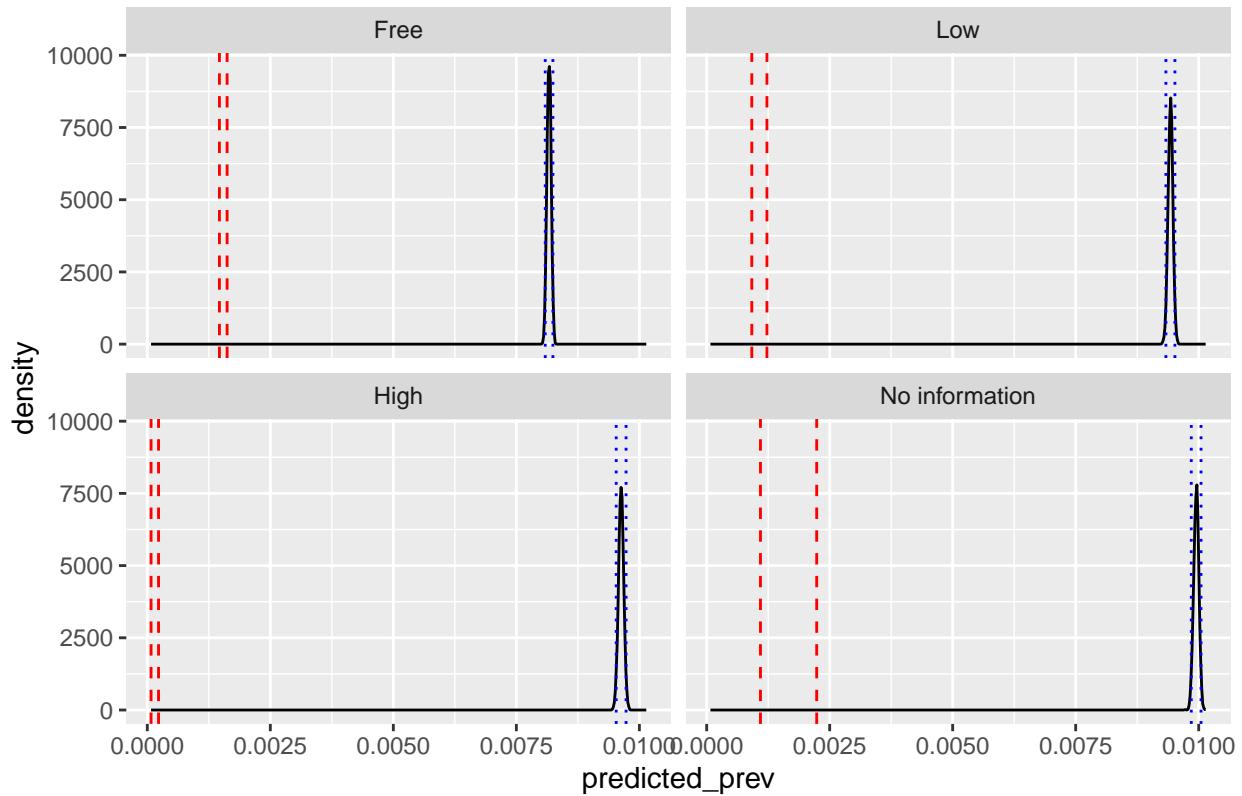
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.005, prior sd = 5.1e-05 (females)



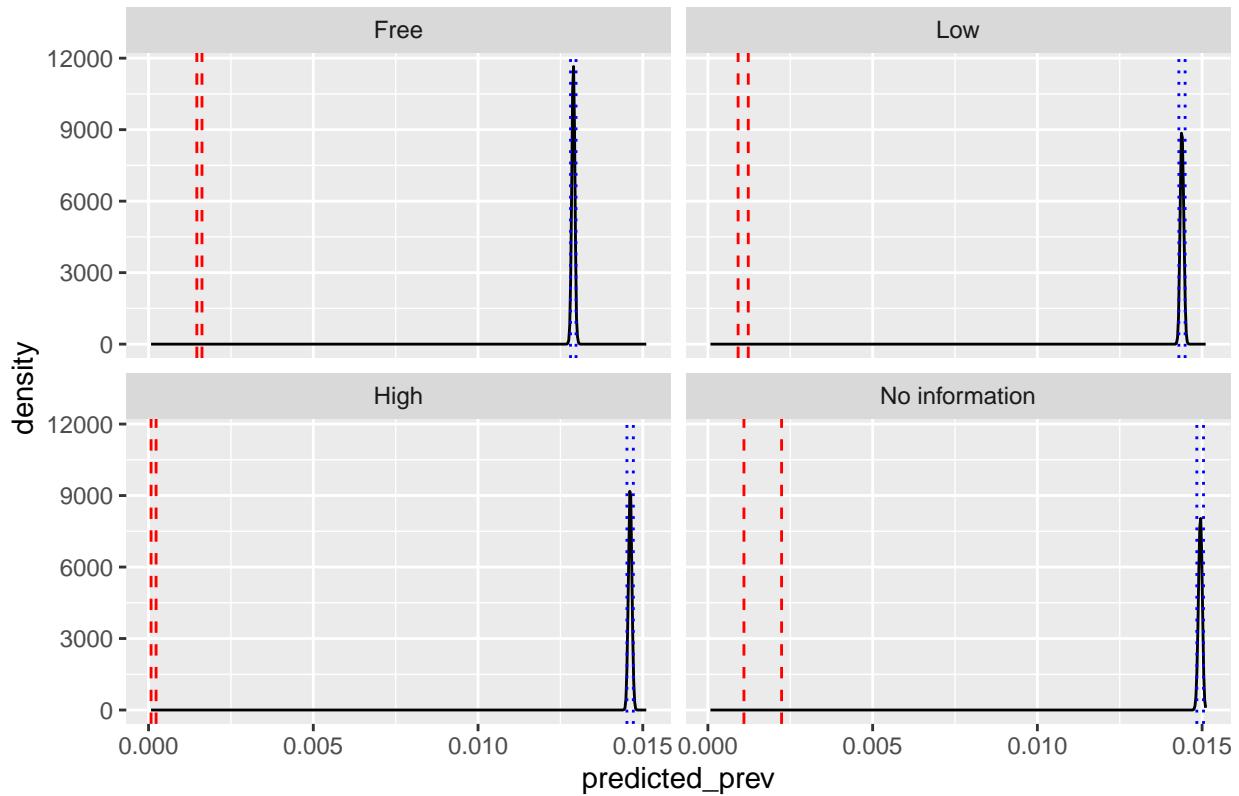
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.01, prior sd = 5.1e-05 (females)



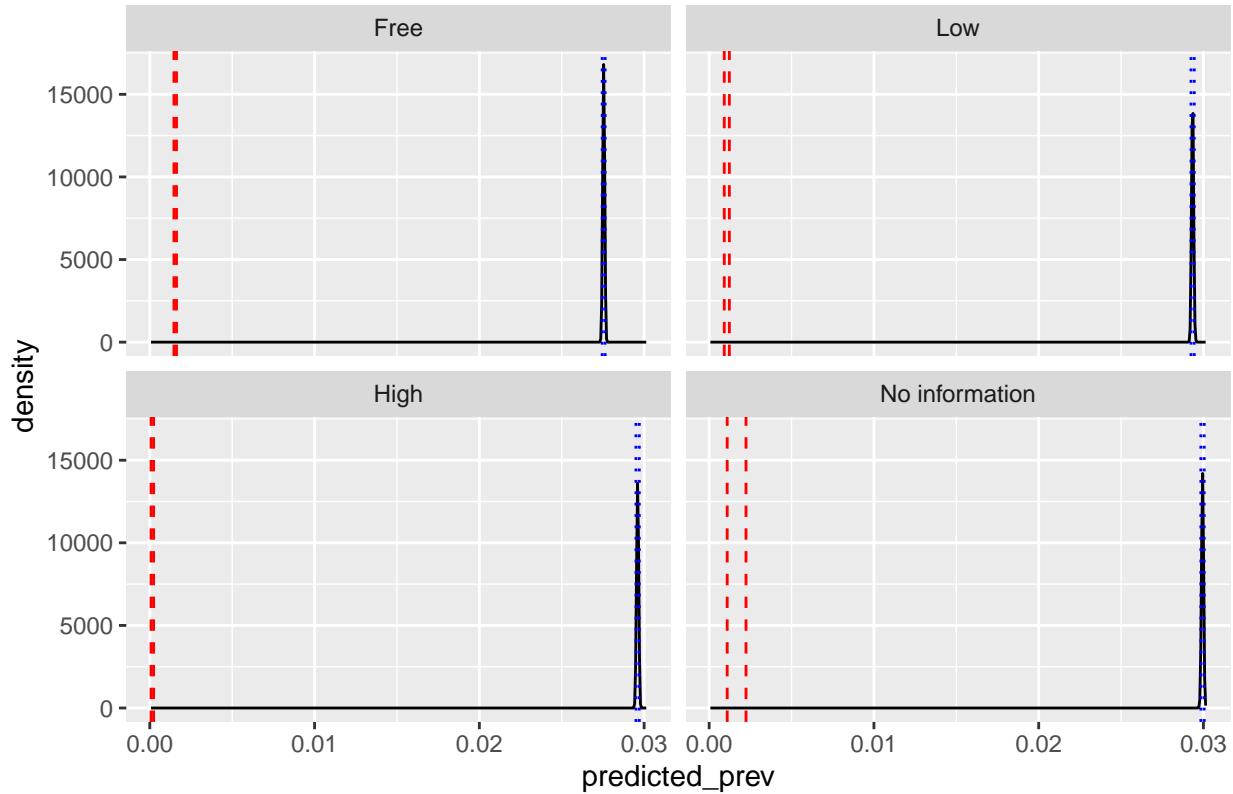
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.015, prior sd = 5.1e-05 (females)



```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.03, prior sd = 5.1e-05 (females)



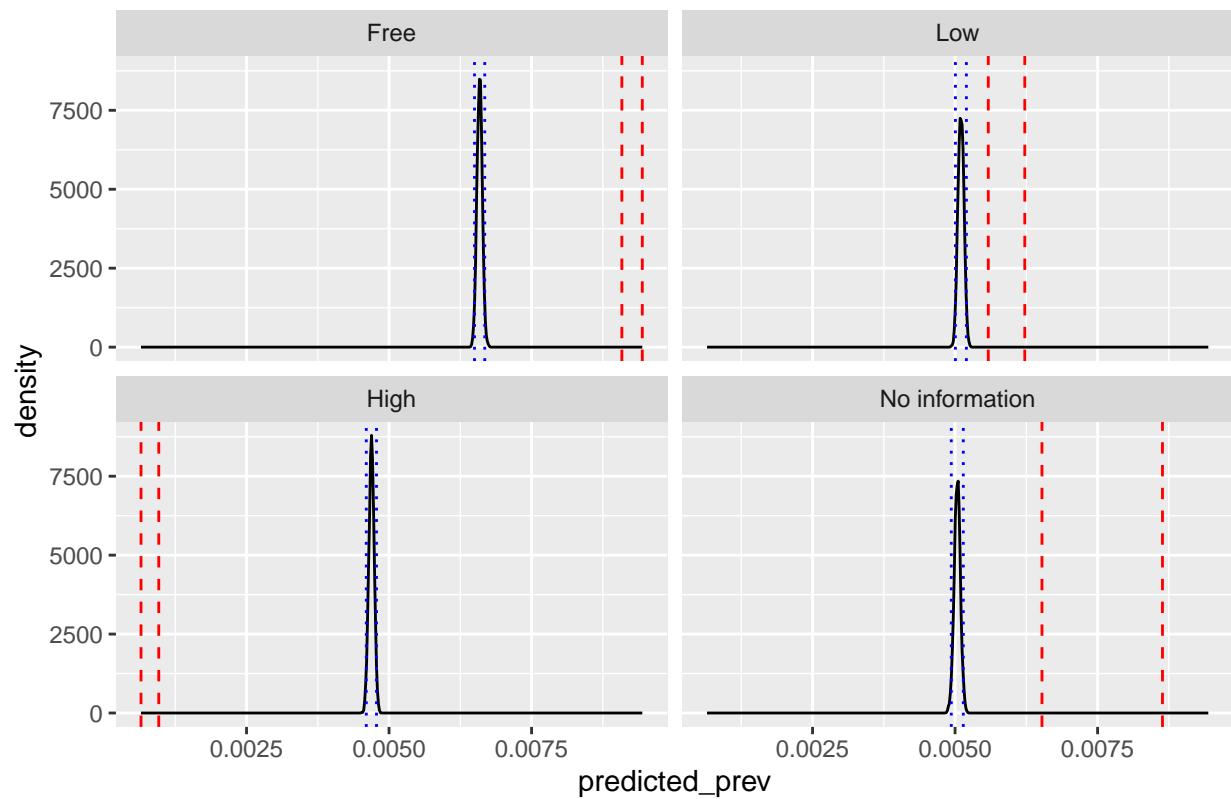
```
# Males
for(j in 1:length(theta_mu_extrapolate)) {
  aut_prev_econG_post_m <- do_jags_rand_model(x = aut_prev_econG_adj_m,
                                                feat = "school_fee_group",
                                                model = rand_model,
                                                theta_mu = theta_mu_extrapolate[j],
                                                theta_sigma = theta_sigma_extrapolate[j],
                                                pars = pars,
                                                convergence_checks = FALSE) %>%
  rename("school_fee_group" = "Feat_names")

  plot_post_density(aut_prev_econG_post_m,
                    aut_prev_econG_adj_m,
                    feat = "school_fee_group",
                    theta_mu = theta_mu_extrapolate[j],
                    theta_sigma = theta_sigma_extrapolate[j],
                    title_text = " (males)")

}

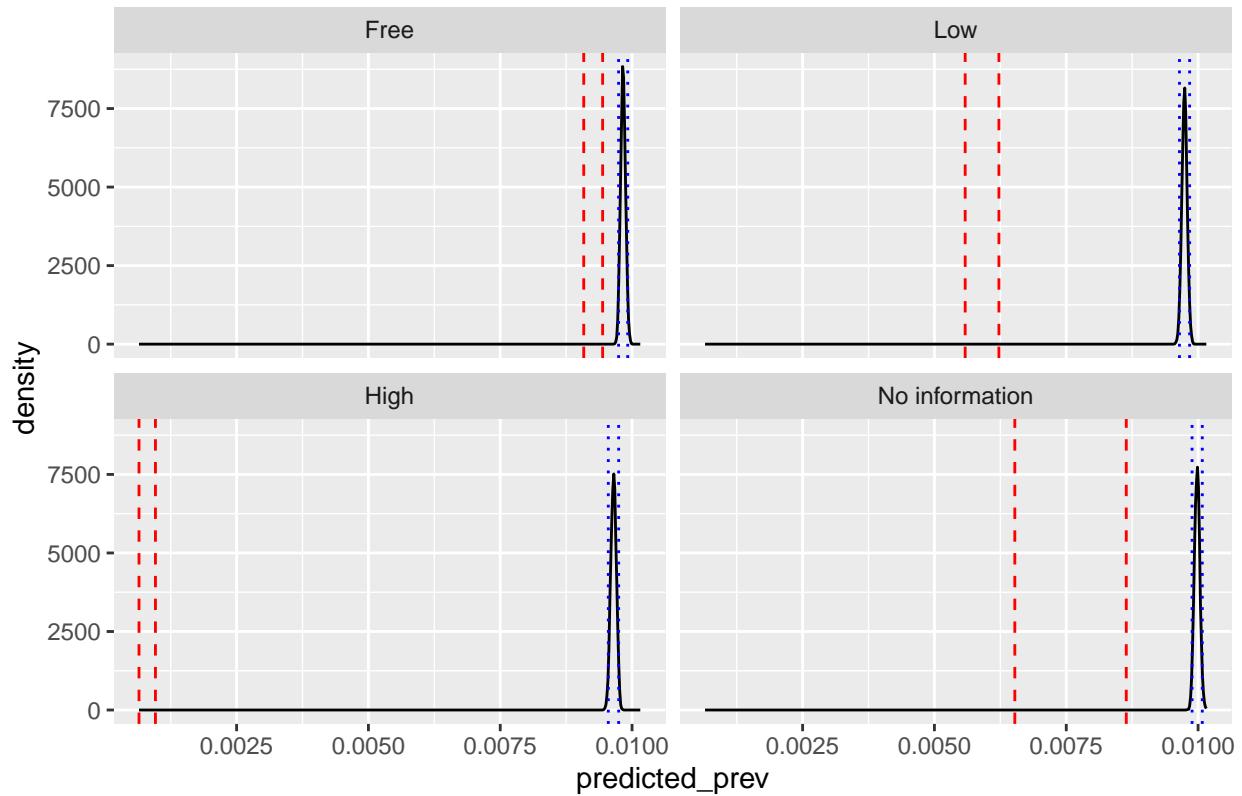
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.005, prior sd = 5.1e-05 (males)



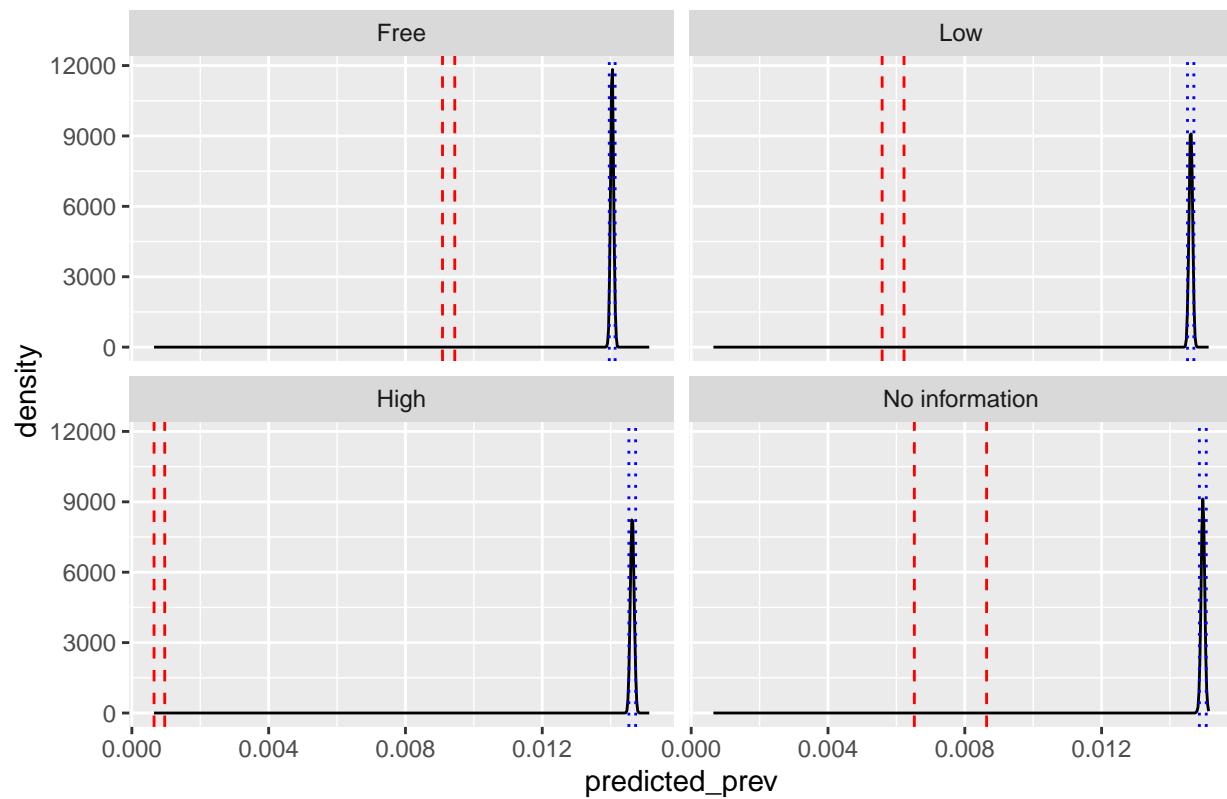
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.01, prior sd = 5.1e-05 (males)



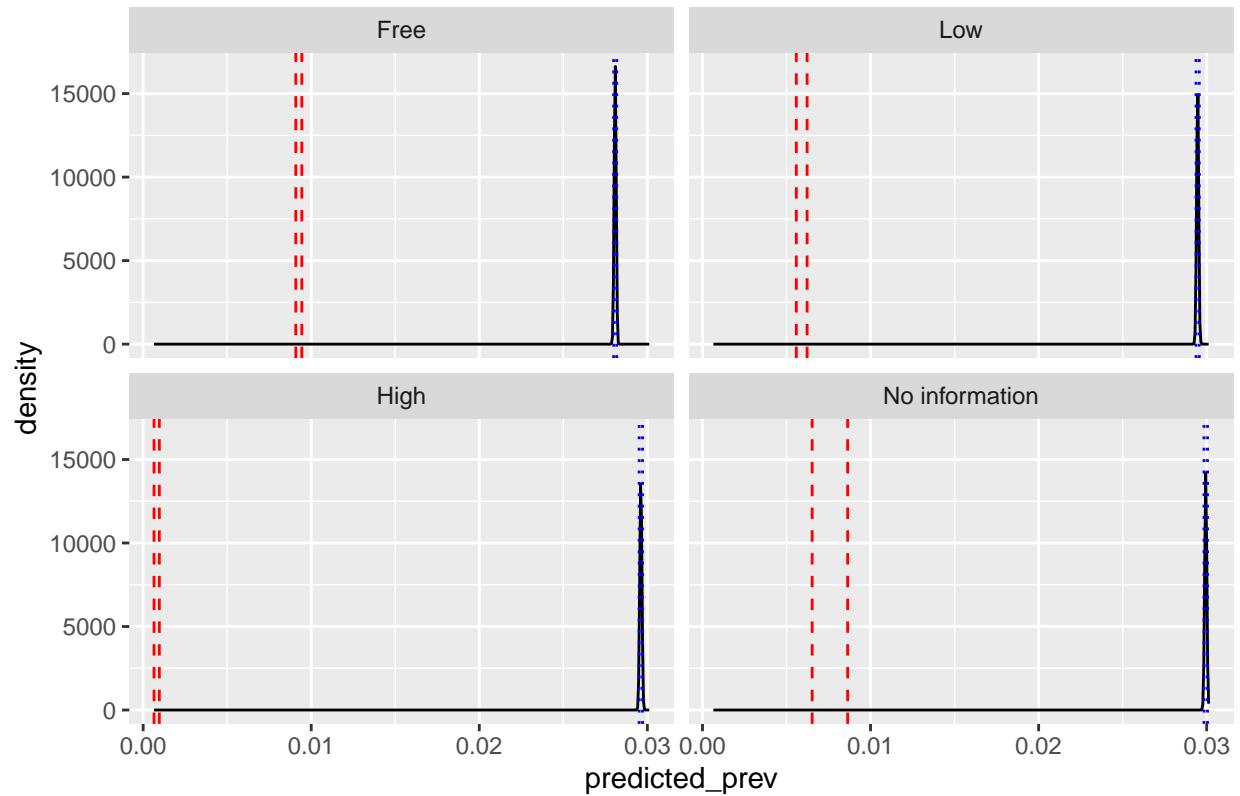
```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.015, prior sd = 5.1e-05 (males)



```
## Don't know how to automatically pick scale for object of type
## <draws_matrix/draws/matrix>. Defaulting to continuous.
```

Prior mean = 0.03, prior sd = 5.1e-05 (males)



Could do random effect on sex and region together