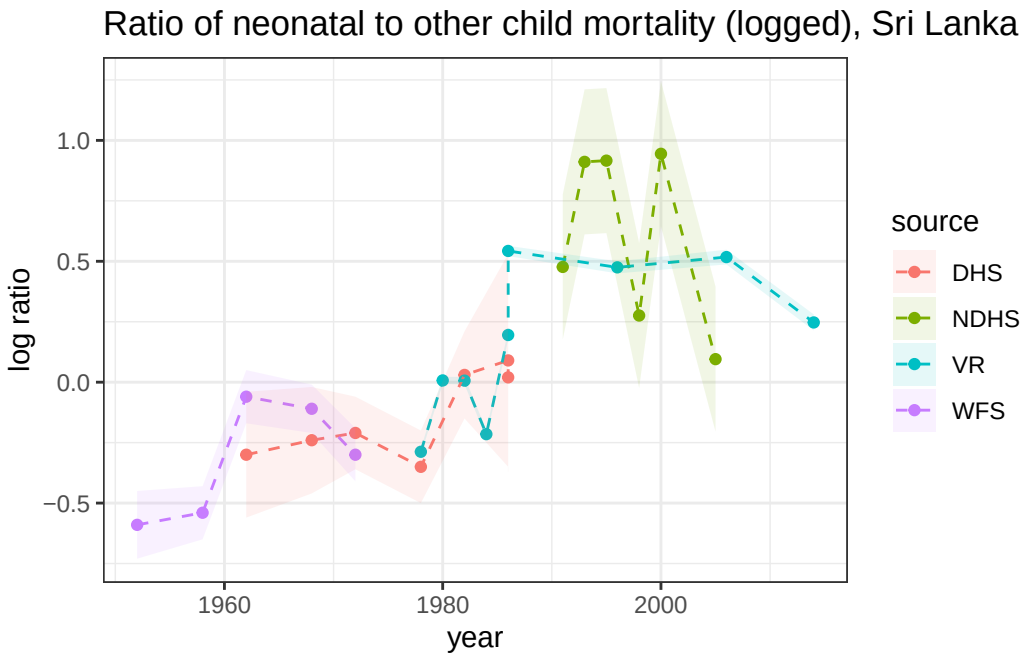
Week 10: Temporal data

23/03/23

Child mortality in Sri Lanka

In this lab you will be fitting a couple of different models to the data about child mortality in Sri Lanka, which was used in the lecture. Here's the data and the plot from the lecture:

```
knitr::opts_chunk$set(results = 'hide')

library(tidyverse)
library(here)
library(rstan)
library(tidybayes)

lka <- read_csv(here("Labs/Lab7/lka.csv"))
ggplot(lka, aes(year, logit_ratio)) +
  geom_point(aes( color = source)) +
  geom_line(aes( color = source), lty = 2) +
  geom_ribbon(aes(ymin = logit_ratio - se,
                  ymax = logit_ratio + se,
                  fill =  source), alpha = 0.1) +
  theme_bw()+
  labs(title = "Ratio of neonatal to other child mortality (logged), Sri Lanka", y = "log
```



Fitting a linear model

Let's firstly fit a linear model in time to these data. Here's the code to do this:

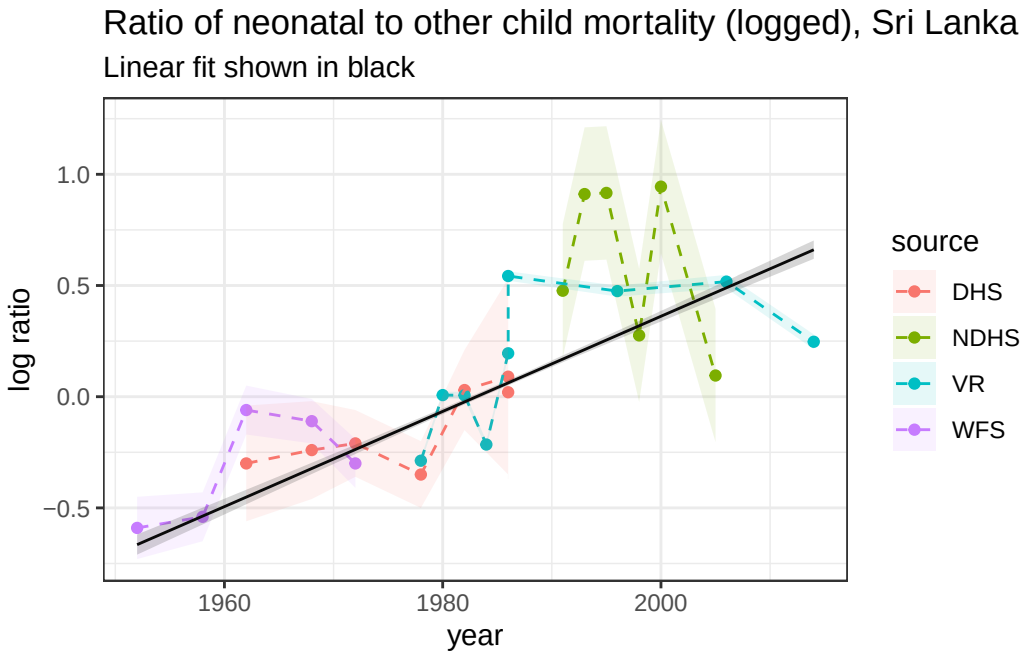
```
observed_years <- lka$year
years <- min(observed_years):max(observed_years)
nyears <- length(years)

stan_data <- list(y = lka$logit_ratio, year_i = observed_years - years[1]+1,
                  T = nyears, years = years, N = length(observed_years),
                  mid_year = mean(years), se = lka$se)

mod <- stan(data = stan_data,
            file = here("Labs/Lab7/lka_linear_me.stan"))
```

Extract the results:

```
res <- mod %>%
  gather_draws(mu[t]) %>%
  median_qi() %>%
  mutate(year = years[t])
```

Plot the results:

```
ggplot(lka, aes(year, logit_ratio)) +
  geom_point(aes( color = source)) +
  geom_line(aes( color = source), lty = 2) +
  geom_ribbon(aes(ymin = logit_ratio - se,
                  ymax = logit_ratio + se,
                  fill =  source), alpha = 0.1) +
  theme_bw()+
  geom_line(data = res, aes(year, .value)) +
  geom_ribbon(data = res, aes(y = .value, ymin = .lower, ymax = .upper), alpha = 0.2)+
  theme_bw()+
  labs(title = "Ratio of neonatal to other child mortality (logged), Sri Lanka",
       y = "log ratio", subtitle = "Linear fit shown in black")
```



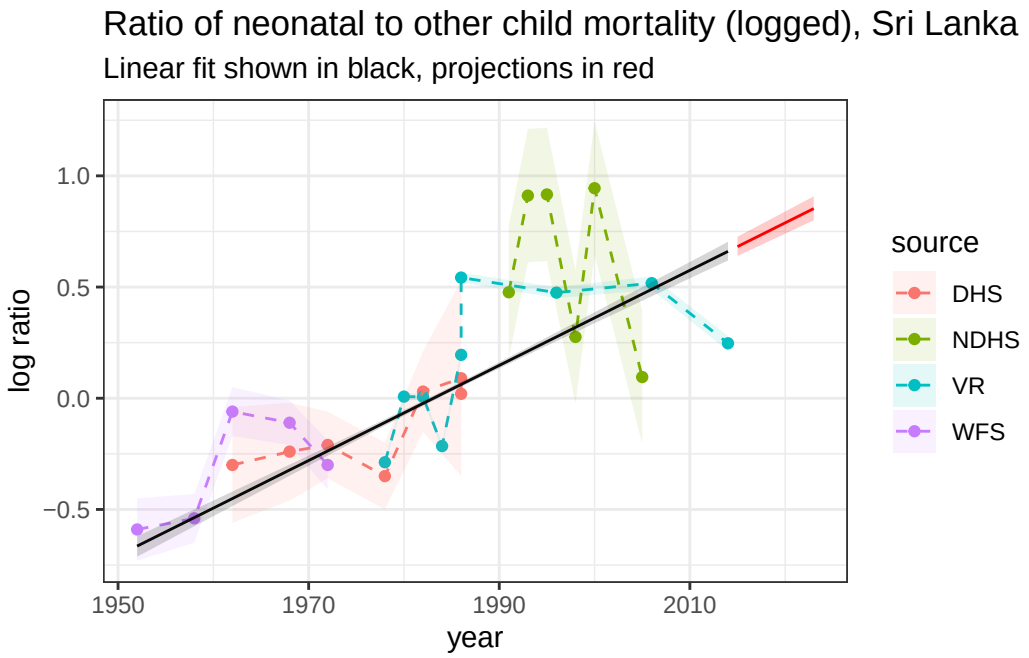
Question 1

Project the linear model above out to 2023 by adding a `generated quantities` block in Stan (do the projections based on the expected value μ). Plot the resulting projections on a graph similar to that above.

```
stan_data <- list(y = lka$logit_ratio, year_i = observed_years - years[1]+1,
                  T = nyears, years = years, N = length(observed_years),
                  mid_year = mean(years), se = lka$se,P=9)

mod2 <- stan(data = stan_data,
             file = here("Labs/Lab7/lka2.stan"))
mod2
```

```
res=mod2 %>%
  gather_draws(mu[t]) %>%
  median_qi() %>%
  mutate(year=years[t])

res_p=mod2 %>%
  gather_draws(mu_p[p]) %>%
  median_qi() %>%
  mutate(year=years[nyears]+p)
```

```
ggplot(lka, aes(year, logit_ratio)) +
  geom_point(aes( color = source)) +
  geom_line(aes( color = source), lty = 2) +
  geom_ribbon(aes(ymin = logit_ratio - se,
                  ymax = logit_ratio + se,
                  fill =  source), alpha = 0.1) +
  theme_bw()+
  geom_line(data = res, aes(year, .value)) +
  geom_ribbon(data = res, aes(y = .value, ymin = .lower, ymax = .upper), alpha = 0.2)+
  geom_line(data = res_p, aes(year, .value),col="red") +
  geom_ribbon(data = res_p, aes(y = .value, ymin = .lower, ymax = .upper),fill="red", alph

  theme_bw()+
  labs(title = "Ratio of neonatal to other child mortality (logged), Sri Lanka",
       y = "log ratio", subtitle = "Linear fit shown in black, projections in red")
```



Random walks

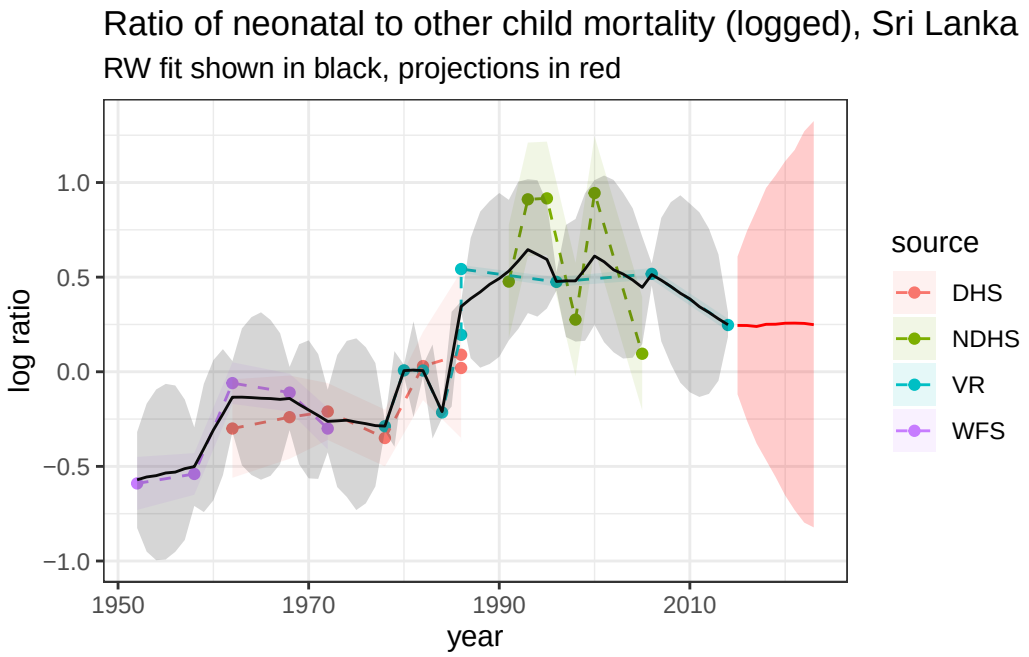
Question 2

Code up and estimate a first order random walk model to fit to the Sri Lankan data, taking into account measurement error, and project out to 2023.

```
mod3 <- stan(data = stan_data,
             file = here("Labs/Lab7/lka3.stan"))
mod3
```

```
res=mod3 %>%
  gather_draws(mu[t]) %>%
  median_qi() %>%
  mutate(year=years[t])

res_p=mod3 %>%
  gather_draws(mu_p[p]) %>%
  median_qi() %>%
  mutate(year=years[nyears]+p)
```

```
ggplot(lka, aes(year, logit_ratio)) +
  geom_point(aes( color = source)) +
  geom_line(aes( color = source), lty = 2) +
  geom_ribbon(aes(ymin = logit_ratio - se,
                  ymax = logit_ratio + se,
                  fill =  source), alpha = 0.1) +
  theme_bw()+
  geom_line(data = res, aes(year, .value)) +
  geom_ribbon(data = res, aes(y = .value, ymin = .lower, ymax = .upper), alpha = 0.2)+
  geom_line(data = res_p, aes(year, .value),col="red") +
  geom_ribbon(data = res_p, aes(y = .value, ymin = .lower, ymax = .upper),fill="red", alph

  theme_bw()+
  labs(title = "Ratio of neonatal to other child mortality (logged), Sri Lanka",
       y = "log ratio", subtitle = "RW fit shown in black, projections in red")
```



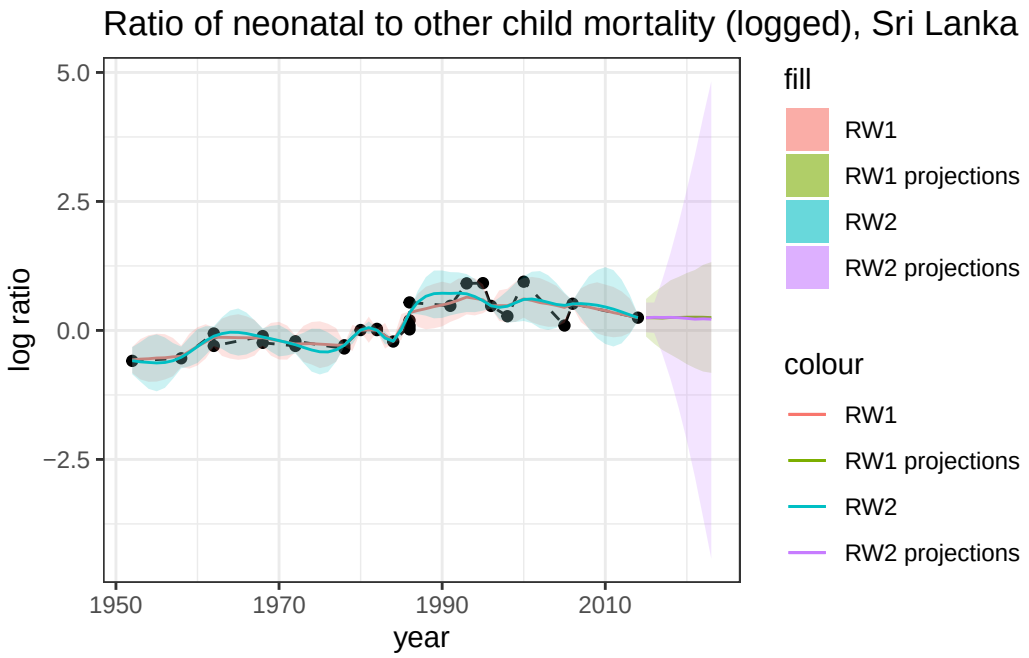
Question 3

Now alter your model above to estimate and project a second-order random walk model (RW2).

Question 4

Run the first order and second order random walk models, including projections out to 2023. Compare these estimates with the linear fit by plotting everything on the same graph.

```
mod4 <- stan(data = stan_data,
             file = here("Labs/Lab7/lka4.stan"))
mod4

# Plot projections
res2=mod4 %>%
  gather_draws(mu[t]) %>%
  median_qi() %>%
  mutate(year=years[t])

res2_p=mod4 %>%
  gather_draws(mu_p[p]) %>%
  median_qi() %>%
  mutate(year=years[nyears]+p)

ggplot(lka, aes(year, logit_ratio)) +
  geom_point() +
  geom_line( lty = 2) +
  #geom_ribbon(aes(ymin = logit_ratio - se,
  #                ymax = logit_ratio + se,
  #                fill =  source), alpha = 0.1) +
  geom_line(data = res, aes(year, .value, col = "RW1")) +
  geom_ribbon(data = res, aes(y = .value, ymin = .lower, ymax = .upper, fill = "RW1"), alp
  geom_line(data = res_p, aes(year, .value,col="RW1 projections")) +
  geom_ribbon(data = res_p, aes(y = .value, ymin = .lower, ymax = .upper,fill="RW1 project

   geom_line(data = res2, aes(year, .value, col = "RW2")) +
  geom_ribbon(data = res2, aes(y = .value, ymin = .lower, ymax = .upper, fill = "RW2"), al

  geom_line(data = res2_p, aes(year, .value,col="RW2 projections")) +
  geom_ribbon(data = res2_p, aes(y = .value, ymin = .lower, ymax = .upper,fill="RW2 projec

  theme_bw()+
  labs(title = "Ratio of neonatal to other child mortality (logged), Sri Lanka",
       y = "log ratio")
```

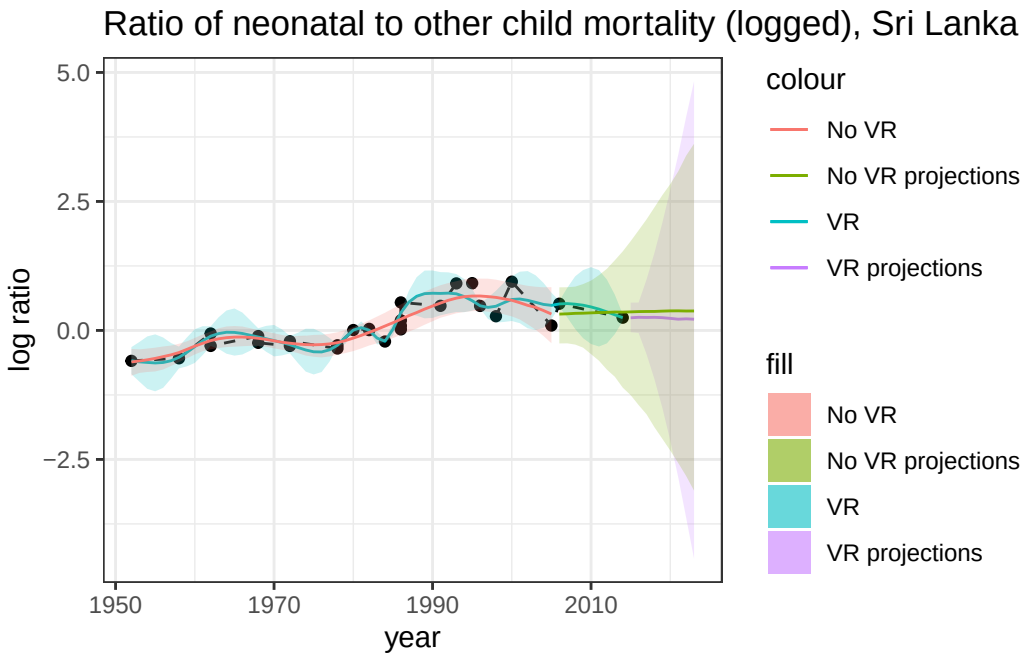


Question 5

Rerun the RW2 model excluding the VR data. Briefly comment on the differences between the two data situations.

```
lka_no_VR <- lka %>% filter(source != "VR")
observed_years <- lka_no_VR$year
years <- min(observed_years):max(observed_years)
nyears <- length(years)

stan_data <- list(y = lka_no_VR$logit_ratio, year_i = observed_years - years[1]+1,
                  T = nyears, years = years, N = length(observed_years),
                  mid_year = mean(years), se = lka_no_VR$se, P = 18)
mod5 <- stan(data = stan_data,
             file = here("Labs/Lab7/lka4.stan"))
mod5

# Plot projections
res3=mod5 %>%
  gather_draws(mu[t]) %>%
  median_qi() %>%
  mutate(year=years[t])
```

```r
res3_p=mod5 %>%
  gather_draws(mu_p[p]) %>%
  median_qi() %>%
  mutate(year=years[nyears]+p)



ggplot(lka, aes(year, logit_ratio)) +
  geom_point() +
  geom_line( lty = 2) +
 # geom_ribbon(aes(ymin = logit_ratio - se,
#                 ymax = logit_ratio + se,
#                 fill =  source), alpha = 0.1) +
  geom_line(data = res2, aes(year, .value, col = "VR")) +
  geom_ribbon(data = res2, aes(y = .value, ymin = .lower, ymax = .upper, fill = "VR"), alp
  geom_line(data = res2_p, aes(year, .value,col="VR projections")) +
  geom_ribbon(data = res2_p, aes(y = .value, ymin = .lower, ymax = .upper,fill="VR project

   geom_line(data = res3, aes(year, .value, col = "No VR")) +
  geom_ribbon(data = res3, aes(y = .value, ymin = .lower, ymax = .upper, fill = "No VR"),

 geom_line(data = res3_p, aes(year, .value,col="No VR projections")) +
 geom_ribbon(data = res3_p, aes(y = .value, ymin = .lower, ymax = .upper,fill="No VR proje

  theme_bw()+
  labs(title = "Ratio of neonatal to other child mortality (logged), Sri Lanka",
       y = "log ratio")
```



Question 6

Briefly comment on which model you think is most appropriate, or an alternative model that would be more appropriate in this context.