EDA

2025-06-15

```
library(readxl)
library(ggplot2)
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(maps)
library(viridis)
```

```
## Loading required package: viridisLite
```

```
##
## Attaching package: 'viridis'
```

```
## The following object is masked from 'package:maps':
##
##     unemp
```

```
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v forcats   1.0.0     v stringr   1.5.1
## v lubridate 1.9.4     v tibble    3.2.1
## v purrr     1.0.4     v tidyr     1.3.1
## v readr     2.1.5
```

```
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## x purrr::map()    masks maps::map()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
library(DataExplorer)
library(corrplot)
```

```
## corrplot 0.95 loaded
```

```
library(ggpubr)
library(GGally)
```

```
## Registered S3 method overwritten by 'GGally':
##   method from
```

```
##   +.gg   ggplot2
```

```
library(reshape2)
```

```
##
## Attaching package: 'reshape2'
##
## The following object is masked from 'package:tidyr':
##
##     smiths
```

```
library(scales)
```

```
##
## Attaching package: 'scales'
##
## The following object is masked from 'package:purrr':
##
##     discard
##
## The following object is masked from 'package:readr':
##
##     col_factor
##
## The following object is masked from 'package:viridis':
##
##     viridis_pal
```

```
data <- read.csv("C:/Users/s19444/Downloads/Nutrition.csv")
```

```
head(data)
```

```
##      Country Year UN_Region UN_sub_region Stunting_survey Stunting_model
## 1 Afganistan 2000      Asia Southern Asia              NA           54.9
## 2 Afganistan 2001      Asia Southern Asia              NA           55.0
## 3 Afganistan 2002      Asia Southern Asia              NA           54.7
## 4 Afganistan 2003      Asia Southern Asia              NA           54.3
## 5 Afganistan 2004      Asia Southern Asia            59.3           53.8
## 6 Afganistan 2005      Asia Southern Asia              NA           53.2
##   Underweight_survey Wasting_survey Overweight_survey Overweight_model
## 1                 NA             NA                NA              6.5
## 2                 NA             NA                NA              6.4
## 3                 NA             NA                NA              6.4
## 4                 NA             NA                NA              6.5
## 5               31.7            9.1               6.5              6.5
## 6                 NA             NA                NA              6.5
##   WHZ_sample_size HAZ_sample_size WAZ_sample_size Under5_population..000.
## 1              NA              NA              NA                       NA
## 2              NA              NA              NA                       NA
## 3              NA              NA              NA                       NA
## 4              NA              NA              NA                       NA
## 5             946             946              NA                  4705.37
## 6              NA              NA              NA                       NA
##   hcpi_a fcpi_a def_a Literacy_female Total_literacy
## 1    0.0     NA    NA              NA             NA
## 2  -43.4     NA    NA              NA             NA
## 3   51.9     NA    NA              NA             NA
```

```
## 4   35.7     NA  13.2              NA             NA
## 5   16.4     NA  11.2              NA             NA
## 6   10.6     NA  10.7              NA             NA
##   Current..health.expenditure....of.GDP.
## 1                                     NA
## 2                                     NA
## 3                               9.443391
## 4                               8.941258
## 5                               9.808474
## 6                               9.948289
##   Urban.population....of.total.population.
## 1                                   22.078
## 2                                   22.169
## 3                                   22.261
## 4                                   22.353
## 5                                   22.500
## 6                                   22.703
##   Rural.population....of.total.population. Mortality_rate_under.5
## 1                                   77.922                  131.6
## 2                                   77.831                  127.4
## 3                                   77.739                  123.0
## 4                                   77.647                  118.5
## 5                                   77.500                  114.0
## 6                                   77.297                  109.5
##   Low.birthweight.babies....of.births.
## 1                                   NA
## 2                                   NA
## 3                                   NA
## 4                                   NA
## 5                                   NA
## 6                                   NA
##   Unemployment..total....of.total.labor.force.
## 1                                        7.955
## 2                                        7.958
## 3                                        7.939
## 4                                        7.922
## 5                                        7.914
## 6                                        7.914
```

```
colSums(is.na(data))
```

```
##                                     Country
##                                           0
##                                        Year
##                                           0
##                                   UN_Region
##                                           0
##                                UN_sub_region
##                                           0
##                              Stunting_survey
##                                         819
##                               Stunting_model
##                                           1
##                           Underweight_survey
##                                         823
```

```
##                                Wasting_survey
##                                           822
##                             Overweight_survey
##                                           846
##                              Overweight_model
##                                             0
##                               WHZ_sample_size
##                                           865
##                               HAZ_sample_size
##                                           860
##                               WAZ_sample_size
##                                           892
##                       Under5_population..000.
##                                           824
##                                      hcpi_a
##                                             0
##                                      fcpi_a
##                                            98
##                                       def_a
##                                            72
##                               Literacy_female
##                                           825
##                                Total_literacy
##                                           834
##       Current..health.expenditure....of.GDP.
##                                            67
##     Urban.population....of.total.population.
##                                             0
##     Rural.population....of.total.population.
##                                             0
##                          Mortality_rate_under.5
##                                             0
##         Low.birthweight.babies....of.births.
##                                           365
## Unemployment..total....of.total.labor.force.
##                                           194
```

```
colnames(data)[1:18] <- c("Country", "Year","UN_Region", "UN_sub_region", "Stunting_survey","Stunting_m
```

```
## Warning in colnames(data)[1:18] <- c("Country", "Year", "UN_Region",
## "UN_sub_region", : number of items to replace is not a multiple of replacement
## length
```

#Selected countries

```
selected_countries <- c("Afghanistan", "Bangladesh", "Bolvia", "Botswana", "Brazil", "Chilie", "Colombi
```

```
library(ggplot2)
library(rnaturalearth)
library(rnaturalearthdata)
```

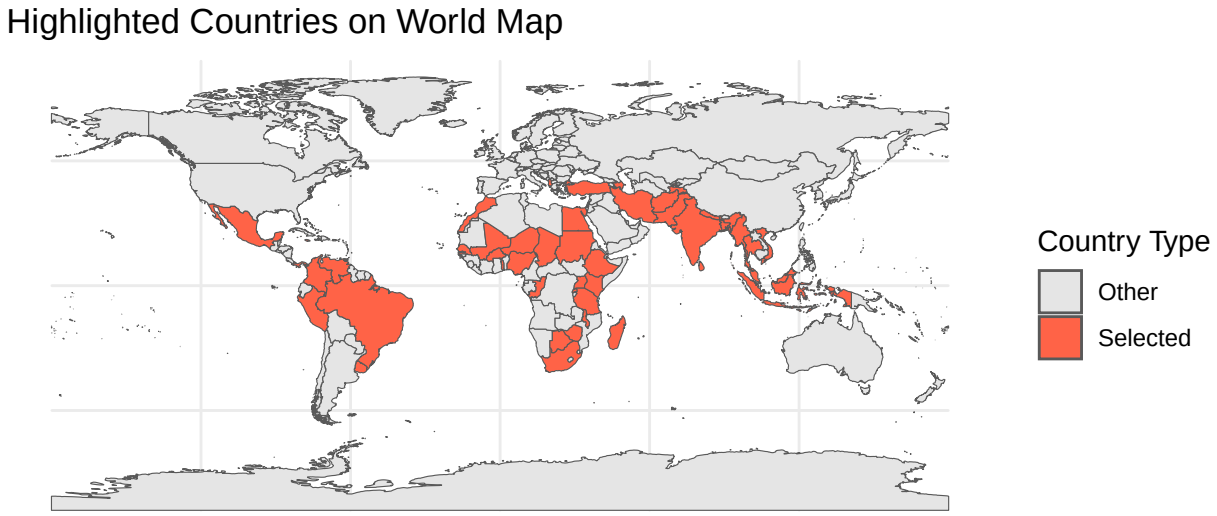
```
##
## Attaching package: 'rnaturalearthdata'
```

```
## The following object is masked from 'package:rnaturalearth':
##
##     countries110
```

```r
library(sf)
```

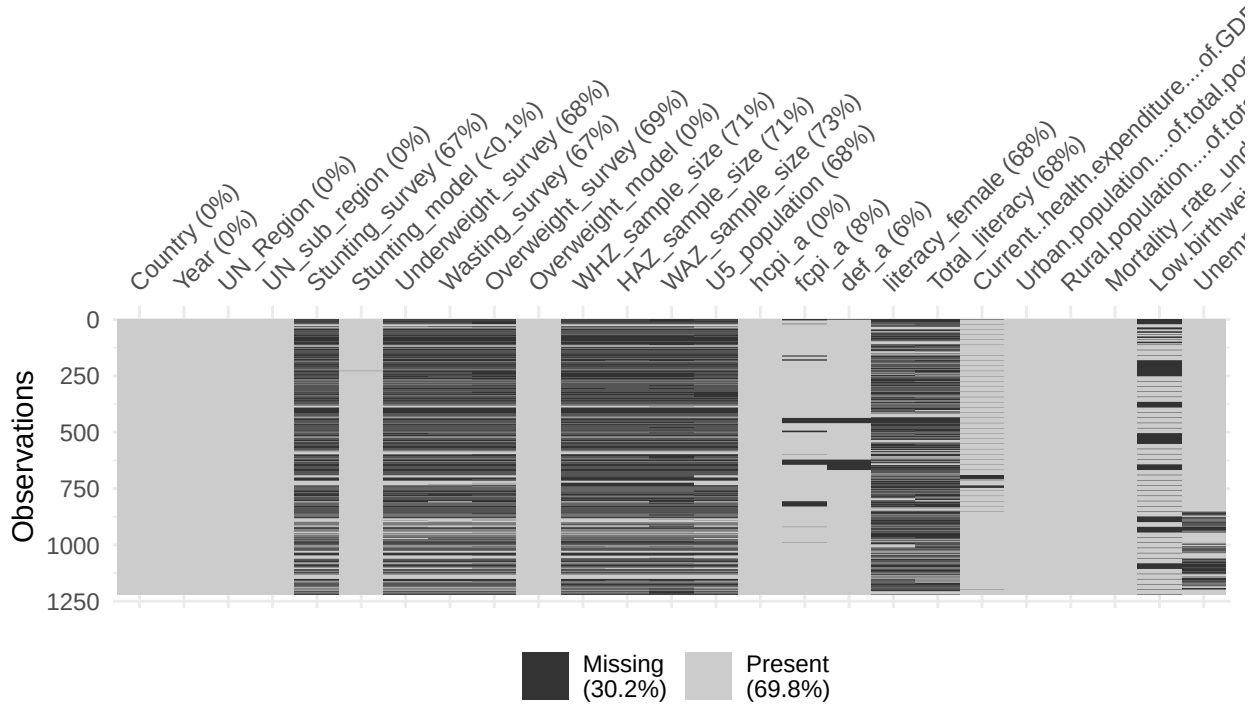
```
## Linking to GEOS 3.13.0, GDAL 3.10.1, PROJ 9.5.1; sf_use_s2() is TRUE
```

```r
world <- ne_countries(scale = "medium", returnclass = "sf")


world$highlight <- ifelse(world$name %in% selected_countries, "Selected", "Other")


ggplot(data = world) +
  geom_sf(aes(fill = highlight)) +
  scale_fill_manual(values = c("Selected" = "tomato", "Other" = "gray90")) +
  theme_minimal() +
  labs(title = "Highlighted Countries on World Map",
       fill = "Country Type")
```



#Missing values

```r
library(naniar)
vis_miss(data)
```




```
miss_var_summary(data)
```

```
## # A tibble: 25 x 3
##    variable           n_miss pct_miss
##    <chr>               <int>    <num>
##  1 WAZ_sample_size       892     73.2
##  2 WHZ_sample_size       865     71.0
##  3 HAZ_sample_size       860     70.5
##  4 Overweight_survey     846     69.4
##  5 Total_literacy        834     68.4
##  6 literacy_female       825     67.7
##  7 U5_population         824     67.6
##  8 Underweight_survey    823     67.5
##  9 Wasting_survey        822     67.4
## 10 Stunting_survey       819     67.2
## # i 15 more rows
```

```
colMeans(is.na(data)) * 100
```

```
##                                 Country
##                              0.00000000
##                                    Year
##                              0.00000000
##                               UN_Region
##                              0.00000000
##                             UN_sub_region
##                              0.00000000
```

```
##                                Stunting_survey
##                                    67.18621821
##                                Stunting_model
##                                     0.08203445
##                              Underweight_survey
##                                    67.51435603
##                                Wasting_survey
##                                    67.43232158
##                               Overweight_survey
##                                    69.40114848
##                               Overweight_model
##                                     0.00000000
##                                WHZ_sample_size
##                                    70.95980312
##                                HAZ_sample_size
##                                    70.54963084
##                                WAZ_sample_size
##                                    73.17473339
##                                  U5_population
##                                    67.59639048
##                                         hcpi_a
##                                     0.00000000
##                                         fcpi_a
##                                     8.03937654
##                                          def_a
##                                     5.90648072
##                                literacy_female
##                                    67.67842494
##                                 Total_literacy
##                                    68.41673503
##       Current..health.expenditure....of.GDP.
##                                     5.49630845
##     Urban.population....of.total.population.
##                                     0.00000000
##     Rural.population....of.total.population.
##                                     0.00000000
##                         Mortality_rate_under.5
##                                     0.00000000
##         Low.birthweight.babies....of.births.
##                                    29.94257588
## Unemployment..total....of.total.labor.force.
##                                    15.91468417
```

By omitting the predictor variables more than 50% of missing values, the selected socioeconomic factors are:

hcpi_a fcpi_a def_a Current health expenditure(% if GDP) urban population(% of total population) mortality rate under 5 Low birth weight babies unemployment rate

Distribution of response variables

Stunting

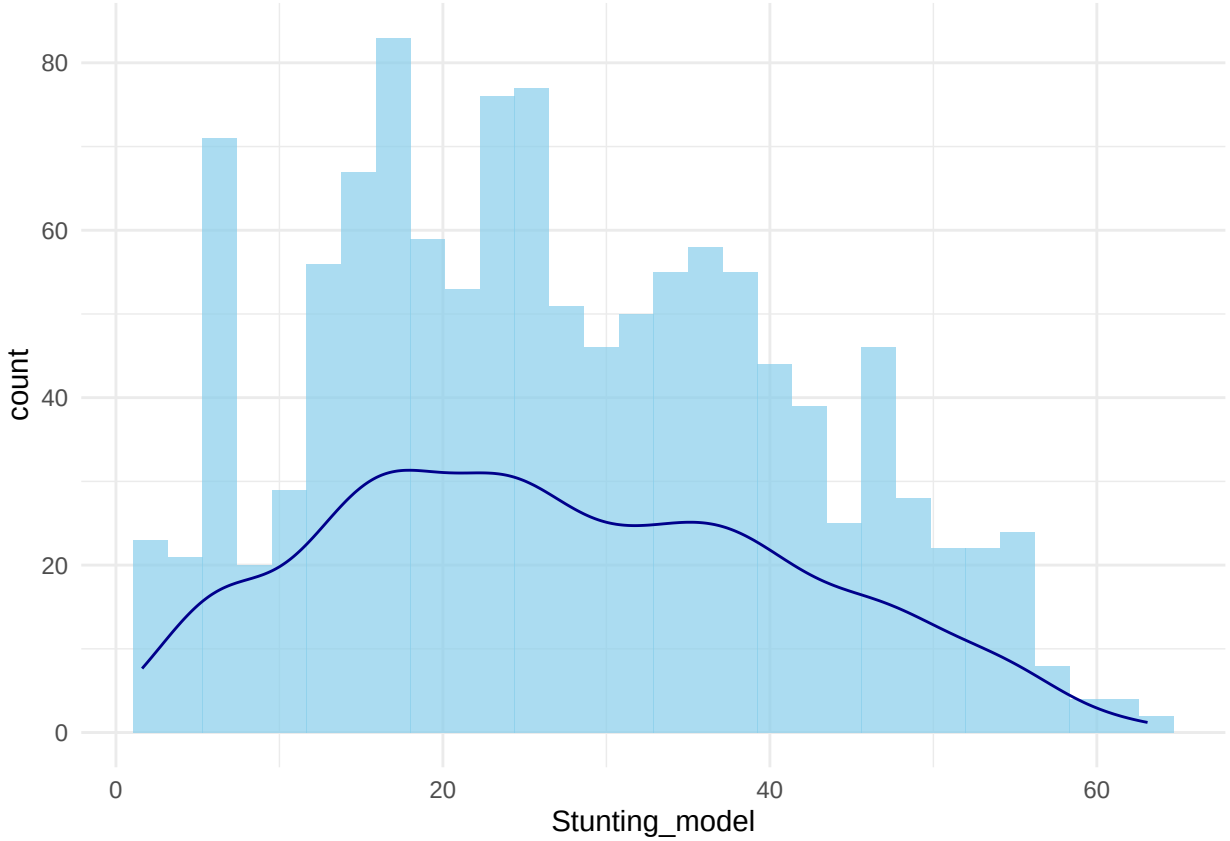
```
# Histograms & density
ggplot(data, aes(x = Stunting_model)) +
  geom_histogram(bins = 30, fill = "skyblue", alpha = 0.7) +
```

```
  geom_density(aes(y = ..count..), color = "darkblue") +
  theme_minimal()
```

```
## Warning: The dot-dot notation (`..count..`) was deprecated in ggplot2 3.4.0.
## i Please use `after_stat(count)` instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```

```
## Warning: Removed 1 row containing non-finite outside the scale range
## (`stat_bin()`).
```

```
## Warning: Removed 1 row containing non-finite outside the scale range
## (`stat_density()`).
```



The distribution is multi-modal (Multiple peaks) This indicates that different countries or time periods may cluster around different stunting levels.

The highest concentrations of observations appear between 10% and 40% with several mini-peaks

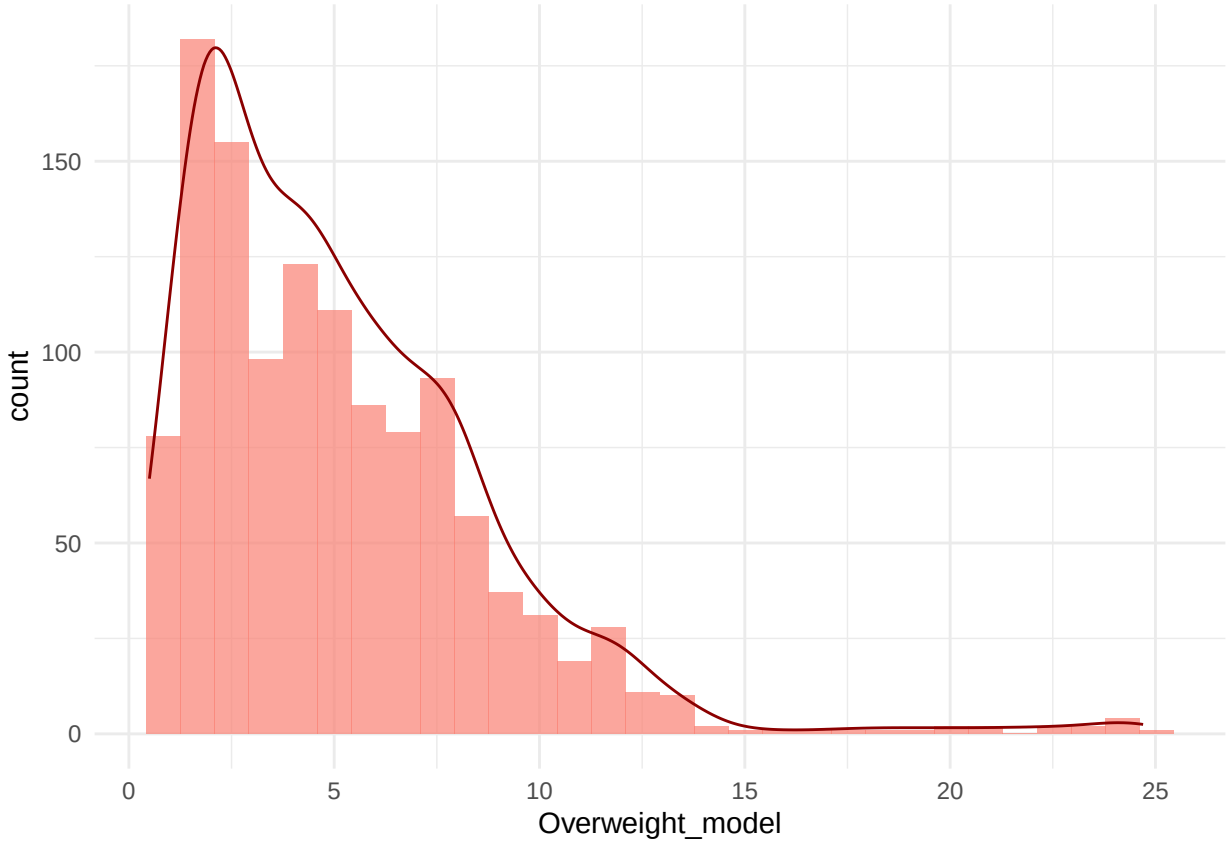
The distribution has a slightly right skew: there are some countries or years with very high stunting percentages, though most values are in the lower-to-mid range.

Long tail extending beyond 50%: high stunting in certain countries or time periods, which might act as outliers in modeling.

overweight

```
ggplot(data, aes(x = Overweight_model)) +
  geom_histogram(bins = 30, fill = "salmon", alpha = 0.7) +
```

```
  geom_density(aes(y = ..count..), color = "darkred") +
  theme_minimal()
```

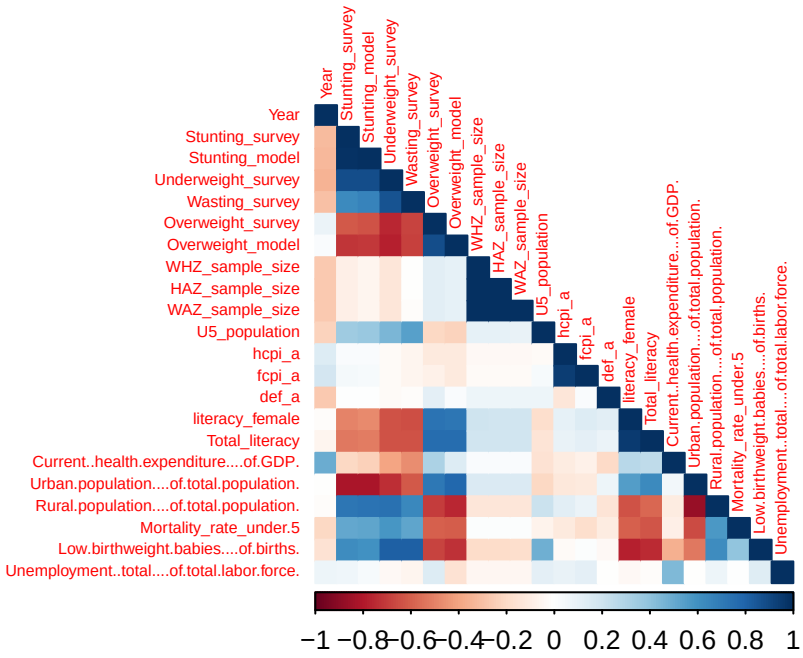


Right skewed

There is one clear peak around 0-2% overweight prevalence. (unimodal) not normally distributed the most values appear to be around 0-2%

#Correlation Analysis

```
df_numeric <- data %>%
  select(where(is.numeric)) %>%
  drop_na()


cor_matrix <- cor(df_numeric, use = "complete.obs")
corrplot(cor_matrix, method = "color", type = "lower", tl.cex = 0.5)
```



According to the correlation plot,

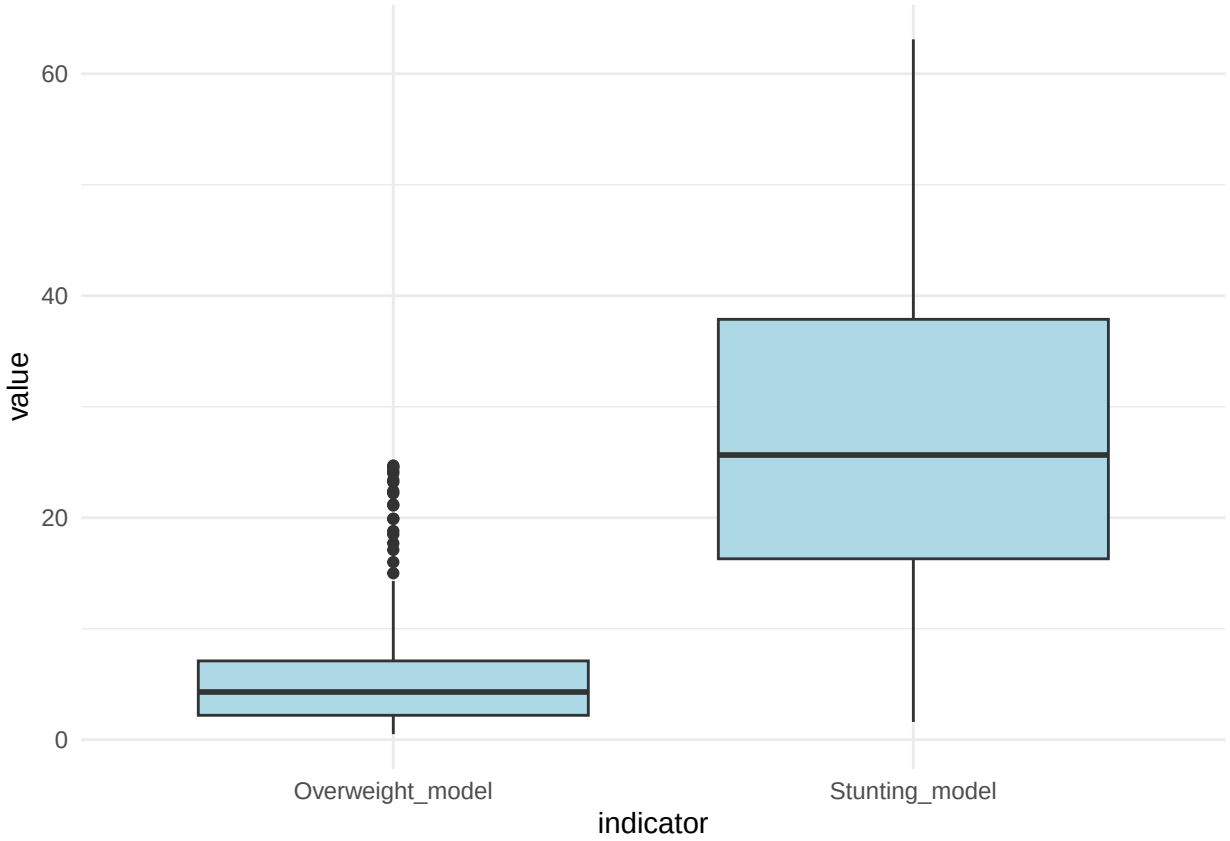
Overweight modeled values are positively correlated with socioeconomic indicators literacy rate, current health expenditure, urban population and negatively correlated with the variables hcpi_a, fcpi_a, def_a, mortality rate under 5, rural population, low birth weight rate, unemployment rate

stunting modeled values are negatively correlated with fcpi_a, hcpi_a,def_a, literacy, current health expenditure, urban population, rural population and positively correlated with mortality rate, low birth weight babies, unemployment rate

#Outlier detction

```
data %>%
  select(Country, Stunting_model, Overweight_model) %>%
  pivot_longer(cols = c(Stunting_model, Overweight_model), names_to = "indicator") %>%
  ggplot(aes(x = indicator, y = value)) +
  geom_boxplot(fill = "lightblue") +
  theme_minimal()
```

```
## Warning: Removed 1 row containing non-finite outside the scale range
## (`stat_boxplot()`).
```



Box plots compare the distributions of overweight and stunting rates across countries.

overweight:

median is around 5-6% and the IQR is narrow multiple outliers clustered around 15-25%,indicating several countries with unusually high overweight rates

stunting:

median is around 25-27% and the IQR is much wider Whiskers extend from about 2% to roughly 62% no visible outliers, suggesting the whiskers capture the full range more normally distributed

patterns:

most countries face low overweight but moderate-to-high stunting few countries have severe overweight problems the dual burden exists but is asymmetric across the global landscape

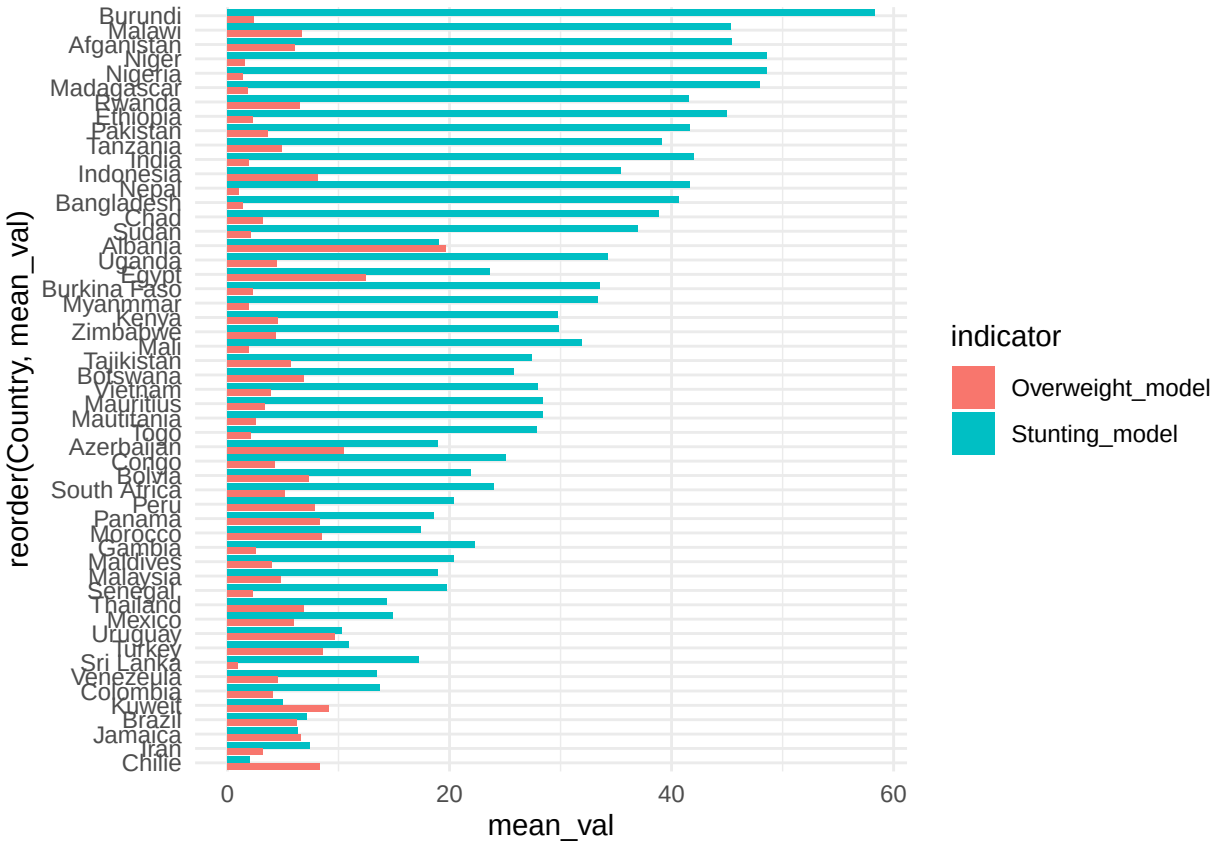
##By country

Bar chart of average by country

```
data %>%
  group_by(Country) %>%
  summarise(across(c(Stunting_model, Overweight_model), mean, na.rm = TRUE)) %>%
  pivot_longer(cols = -Country, names_to = "indicator", values_to = "mean_val") %>%
  ggplot(aes(x = reorder(Country, mean_val), y = mean_val, fill = indicator)) +
  geom_bar(stat = "identity", position = "dodge") +
  coord_flip() +
  theme_minimal()
```

```
## Warning: There was 1 warning in `summarise()`.
```

```
## i In argument: `across(c(Stunting_model, Overweight_model), mean, na.rm =
##   TRUE)`.
## i In group 1: `Country = "Afganistan"`.
## Caused by warning:
## ! The `...` argument of `across()` is deprecated as of dplyr 1.1.0.
## Supply arguments directly to `.fns` through an anonymous function instead.
##
##   # Previously
##   across(a:b, mean, na.rm = TRUE)
##
##   # Now
##   across(a:b, \(x) mean(x, na.rm = TRUE))
```



High prevalence in stunting than the overweight across the selected countries. Countries at the top (Burundi, Afghanistan...) have high combined rates of stunting and overweight.

Dual burden pattern can be seen: some countries show significant levels of both indicators.Ex: Egypt, South Africa. This indicates the prevalence of double burden of malnutrition.

Transition pattern: As move down the chart, there is generally a shift from stunting-dominant to more balanced or overweight-dominant patterns, but this is not perfectly linear

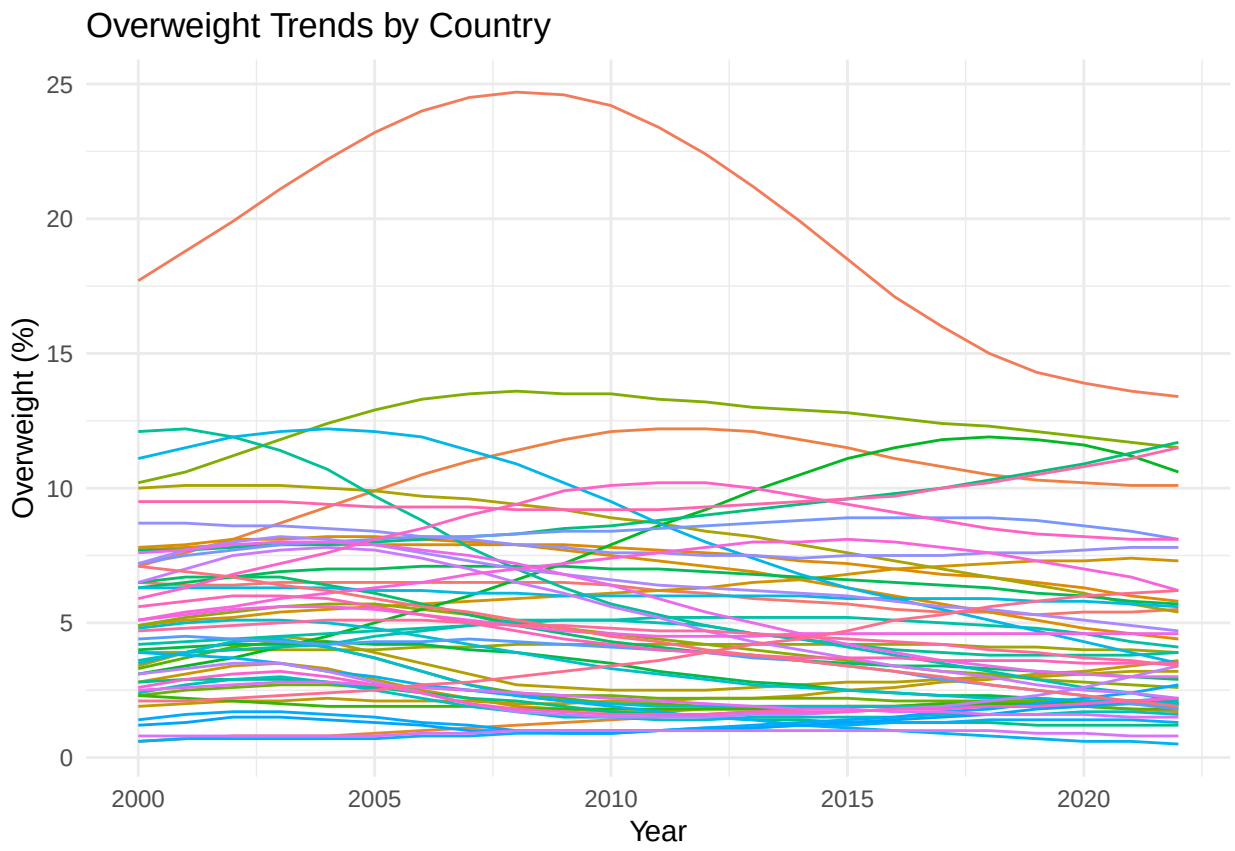
This suggests different countries face different malnutrition challenges.

some countries are primarily dealing with undernutrition (stunting), others with a mixed burden.

#Overweight

```r
overweight_data <- data %>%
  select(Country, Year, Overweight_model) %>%
  filter(!is.na(Overweight_model))
#overweight_data
```

```r
ggplot(data, aes(x = Year, y = Overweight_model, group = Country, color = Country)) +
  geom_line(show.legend = FALSE) +
  theme_minimal() +
  labs(title = "Overweight Trends by Country", y = "Overweight (%)")
```




```r
countries <- unique(overweight_data$Country)


for(country in countries) {
  country_data <- overweight_data %>% filter(Country == country)

  p <- ggplot(country_data, aes(x = Year, y = Overweight_model)) +
    geom_line(color = "steelblue", size = 1) +
    geom_point(color = "steelblue", size = 2) +
    labs(title = paste("Prevalence of Overweight in", country),
         x = "Year",
         y = "Overweight Prevalence (%)") +
    theme_minimal() +
    theme(plot.title = element_text(hjust = 0.5))

  #print(p)
```

```
  ggsave(paste0("overweight_", gsub(" ", "_", country), ".png"), plot = p, width = 8, height = 6)
}
```

```
## Warning: Using `size` aesthetic for lines was deprecated in ggplot2 3.4.0.
## i Please use `linewidth` instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```

countries from the same region and the same sub-region shows different prevalence in overweight. ex: Uruguay, Bolivia, Brazil

most of the countries have declining patterns

```
data$Year <- as.numeric(data$Year)
```

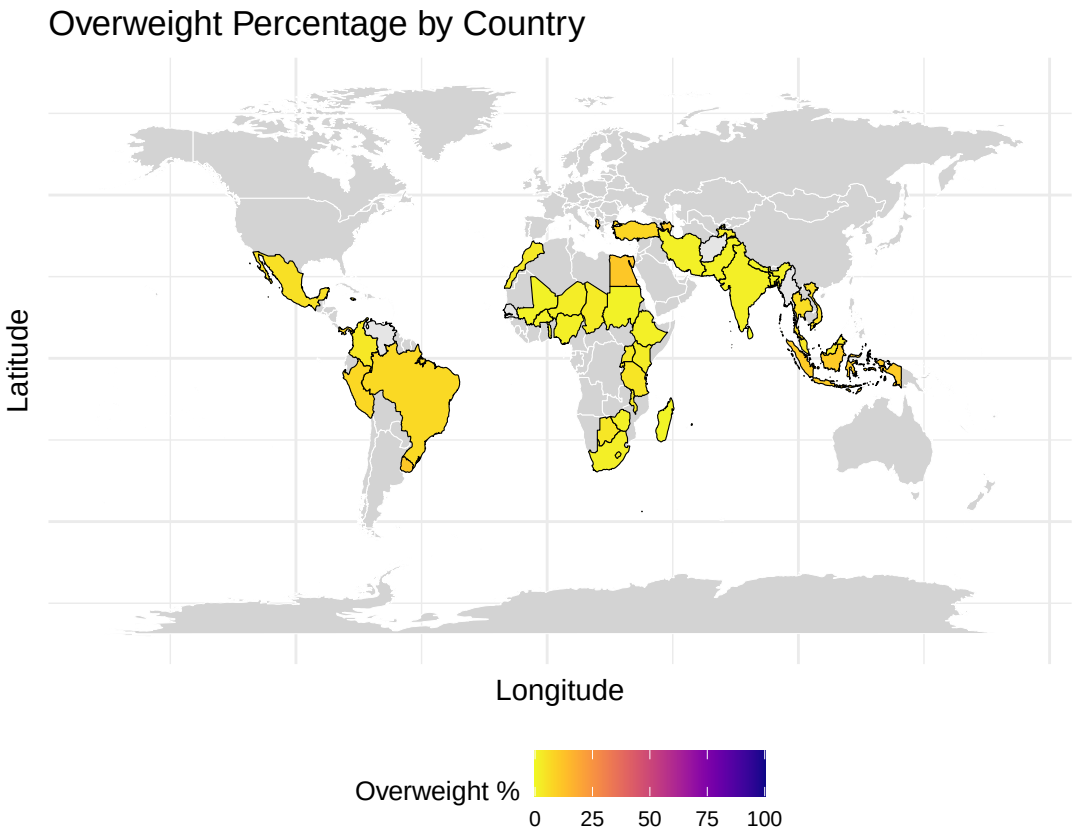
```
data_filtered <- data %>%
  filter(Country %in% selected_countries & !is.na(Overweight_model)) %>%
  group_by(Country) %>%
  filter(Year == max(Year, na.rm = TRUE)) %>%
  select(Country, Year, Overweight_model)
```

```
world_map <- map_data("world")
```

```
highlighted_map <- world_map %>%
  filter(region %in% selected_countries) %>%
  left_join(data_filtered, by = c("region" = "Country"))
```

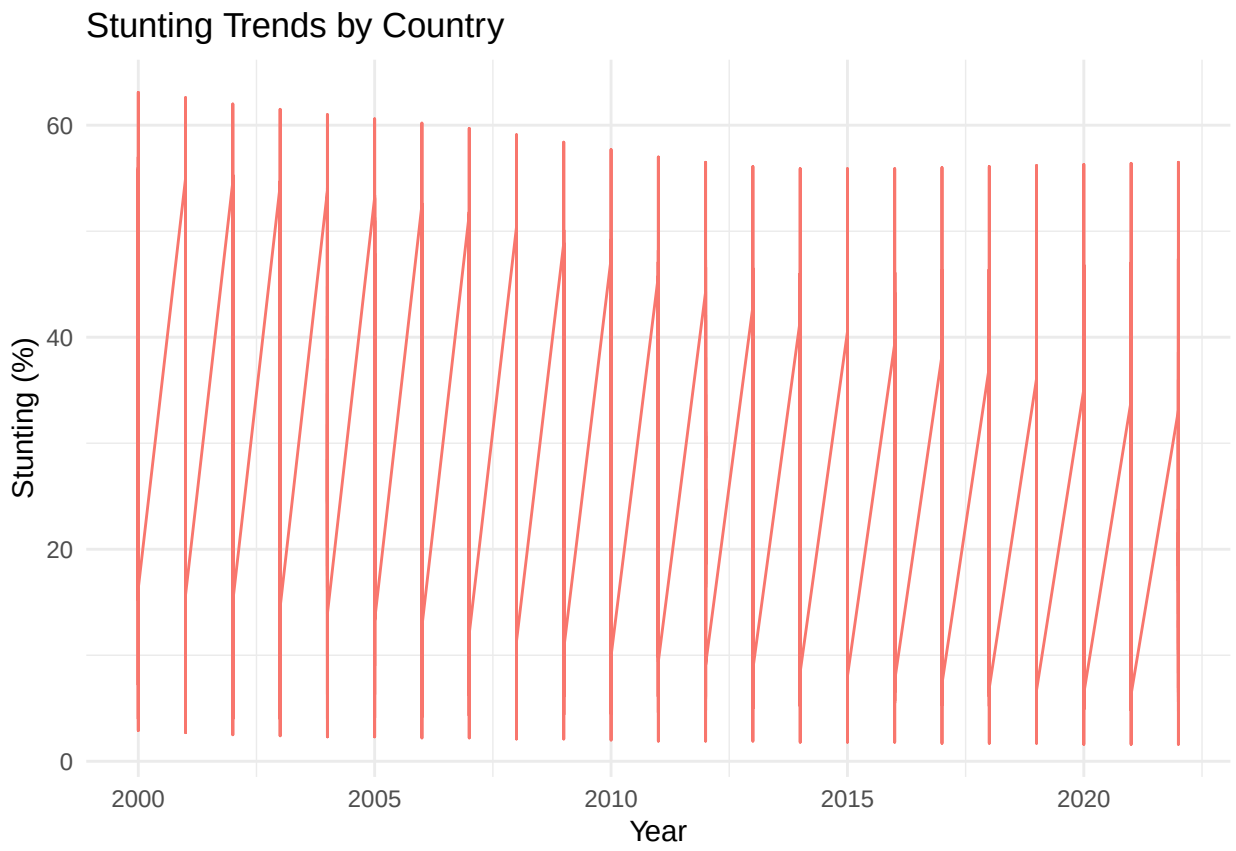
```
ggplot() +
  geom_polygon(
    data = world_map,
    aes(x = long, y = lat, group = group),
    fill = "lightgray",
    color = "white",
    linewidth = 0.1
  ) +
  geom_polygon(
    data = highlighted_map %>% mutate(Overweight = as.numeric(Overweight_model)),
    aes(x = long, y = lat, group = group, fill = Overweight),
    color = "black",
    linewidth = 0.2
  ) +
  scale_fill_viridis(
    name = "Overweight %",
    option = "plasma",
    direction = -1,
    na.value = "grey90",
    limits = c(0, 100)
  ) +
  coord_fixed(ratio = 1.3) +
  theme_minimal() +
  labs(
    title = "Overweight Percentage by Country",
    x = "Longitude",
    y = "Latitude"
```

```
  ) +
  theme(
    legend.position = "bottom",
    legend.title = element_text(size = 10),
    legend.text = element_text(size = 8),
    axis.text = element_blank(),
    axis.ticks = element_blank()
  )
```



#Stunting

```
ggplot(data, aes(x = Year, y = Stunting_model, group = country, color = country)) +
  geom_line(show.legend = FALSE) +
  theme_minimal() +
  labs(title = "Stunting Trends by Country", y = "Stunting (%)")
```




```
stunting_data <- data %>%
  select(Country, Year, Stunting_model) %>%
  filter(!is.na(Stunting_model))

stunting_data$Stunting <- as.numeric(stunting_data$Stunting)
stunting_data$Year <- as.numeric(as.character(stunting_data$Year))


countries <- unique(stunting_data$Country)


y_max <- max(stunting_data$Stunting, na.rm = TRUE)


for (country in countries) {
  country_data <- stunting_data %>% filter(Country == country)

  if (nrow(country_data) < 2) next  # Skip if not enough data

  p <- ggplot(country_data, aes(x = Year, y = Stunting_model)) +
    geom_line(color = "#E69F00", size = 1) +
    geom_point(color = "#E69F00", size = 2) +
    labs(title = paste("Prevalence of Stunting in", country),
         x = "Year",
         y = "Stunting Prevalence (%)") +
    theme_minimal() +
```

```
    theme(plot.title = element_text(hjust = 0.5)) +
    coord_cartesian(ylim = c(0, y_max))

  #print(p)


  safe_country <- gsub("[^A-Za-z0-9_]", "_", country)
  ggsave(filename = paste0("stunting_", safe_country, ".png"),
         plot = p, width = 8, height = 6, dpi = 300)
}
```

almost all countries have similar prevelance of stuning over time

```
data_filtered_st <- data %>%
  filter(Country %in% selected_countries & !is.na(Stunting_model)) %>%
  group_by(Country) %>%
  filter(Year == max(Year, na.rm = TRUE)) %>%
  select(Country, Year, Stunting_model)
```

```
world_map1 <- map_data("world")
```

```
highlighted_map1 <- world_map1 %>%
  filter(region %in% selected_countries) %>%
  left_join(data_filtered_st, by = c("region" = "Country"))
```

```
highlighted_map <- world_map %>%
  left_join(stunting_data, by = c("region" = "Country"))
```

```
## Warning in left_join(., stunting_data, by = c(region = "Country")): Detected an unexpected many-to-ma
## i Row 765 of `x` matches multiple rows in `y`.
## i Row 759 of `y` matches multiple rows in `x`.
## i If a many-to-many relationship is expected, set `relationship =
##   "many-to-many"` to silence this warning.
```

```
highlighted_map$Stunting <- as.numeric(highlighted_map$Stunting)


ggplot() +
  geom_polygon(
    data = world_map,
    aes(x = long, y = lat, group = group),
    fill = "lightgray", color = "white", linewidth = 0.1
  ) +
  geom_polygon(
    data = highlighted_map,
    aes(x = long, y = lat, group = group, fill = Stunting),
    color = "black", linewidth = 0.2
  ) +
  scale_fill_viridis(
    name = "Stunting (%)",
    option = "plasma", direction = -1, na.value = "grey90",
    limits = c(0, max(highlighted_map$Stunting, na.rm = TRUE))
  ) +
  coord_fixed(ratio = 1.3) +
  theme_minimal() +
  labs(title = "Stunting Percentage by Country", x = "Longitude", y = "Latitude") +
```

```
theme(
  legend.position = "bottom",
  legend.title = element_text(size = 10),
  legend.text = element_text(size = 8),
  axis.text = element_blank(),
  axis.ticks = element_blank(),
  panel.grid = element_blank()
)
```