Are Danes having fun in Denmark?

Semester project for Statistics course.

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```
library(plyr)
# install.packages("GGally")
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.1 --
```

```
## v ggplot2 3.3.5     v purrr   0.3.4
## v tibble  3.1.6     v dplyr   1.0.7
## v tidyr   1.1.4     v stringr 1.4.0
## v readr   2.1.0     v forcats 0.5.1
```

```
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::arrange()   masks plyr::arrange()
## x purrr::compact()   masks plyr::compact()
## x dplyr::count()     masks plyr::count()
## x dplyr::failwith()  masks plyr::failwith()
## x dplyr::filter()    masks stats::filter()
## x dplyr::id()        masks plyr::id()
## x dplyr::lag()       masks stats::lag()
## x dplyr::mutate()    masks plyr::mutate()
## x dplyr::rename()    masks plyr::rename()
## x dplyr::summarise() masks plyr::summarise()
## x dplyr::summarize() masks plyr::summarize()
```

```
library(GGally)
```

```
## Registered S3 method overwritten by 'GGally':
##   method from
##   +.gg   ggplot2
```

```
library(ggthemes)
options(repr.plot.width=32, repr.plot.height=20)
```

```
read_csv("./archive/world-happiness-report-2021.csv") -> data_2021_raw
```

```
## Rows: 149 Columns: 20
```

```
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr  (2): Country name, Regional indicator
## dbl (18): Ladder score, Standard error of ladder score, upperwhisker, lowerw...
```

```
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
read_csv("./archive/world-happiness-report.csv") -> data_all_raw
```

```
## Rows: 1949 Columns: 11
```

```
## -- Column specification --------------------------------------------------------
## Delimiter: ","
## chr  (1): Country name
## dbl (10): year, Life Ladder, Log GDP per capita, Social support, Healthy lif...
```

```
##
## i Use `spec()` to retrieve the full column specification for this data.
## i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
head(data_2021_raw)
```

```
## # A tibble: 6 x 20
##   `Country name` `Regional indica~ `Ladder score` `Standard error ~ upperwhisker
##   <chr>          <chr>                      <dbl>             <dbl>        <dbl>
## 1 Finland        Western Europe              7.84             0.032         7.90
## 2 Denmark        Western Europe              7.62             0.035         7.69
## 3 Switzerland    Western Europe              7.57             0.036         7.64
## 4 Iceland        Western Europe              7.55             0.059         7.67
## 5 Netherlands    Western Europe              7.46             0.027         7.52
## 6 Norway         Western Europe              7.39             0.035         7.46
## # ... with 15 more variables: lowerwhisker <dbl>, Logged GDP per capita <dbl>,
## #   Social support <dbl>, Healthy life expectancy <dbl>,
## #   Freedom to make life choices <dbl>, Generosity <dbl>,
## #   Perceptions of corruption <dbl>, Ladder score in Dystopia <dbl>,
## #   Explained by: Log GDP per capita <dbl>, Explained by: Social support <dbl>,
## #   Explained by: Healthy life expectancy <dbl>,
## #   Explained by: Freedom to make life choices <dbl>, ...
```

```
head(data_all_raw)
```

```
## # A tibble: 6 x 11
##   `Country name`  year `Life Ladder` `Log GDP per capita` `Social support`
##   <chr>          <dbl>         <dbl>                <dbl>            <dbl>
## 1 Afghanistan     2008          3.72                 7.37            0.451
## 2 Afghanistan     2009          4.40                 7.54            0.552
## 3 Afghanistan     2010          4.76                 7.65            0.539
## 4 Afghanistan     2011          3.83                 7.62            0.521
## 5 Afghanistan     2012          3.78                 7.70            0.521
## 6 Afghanistan     2013          3.57                 7.72            0.484
## # ... with 6 more variables: Healthy life expectancy at birth <dbl>,
## #   Freedom to make life choices <dbl>, Generosity <dbl>,
## #   Perceptions of corruption <dbl>, Positive affect <dbl>,
## #   Negative affect <dbl>
```

Combine two dataframes

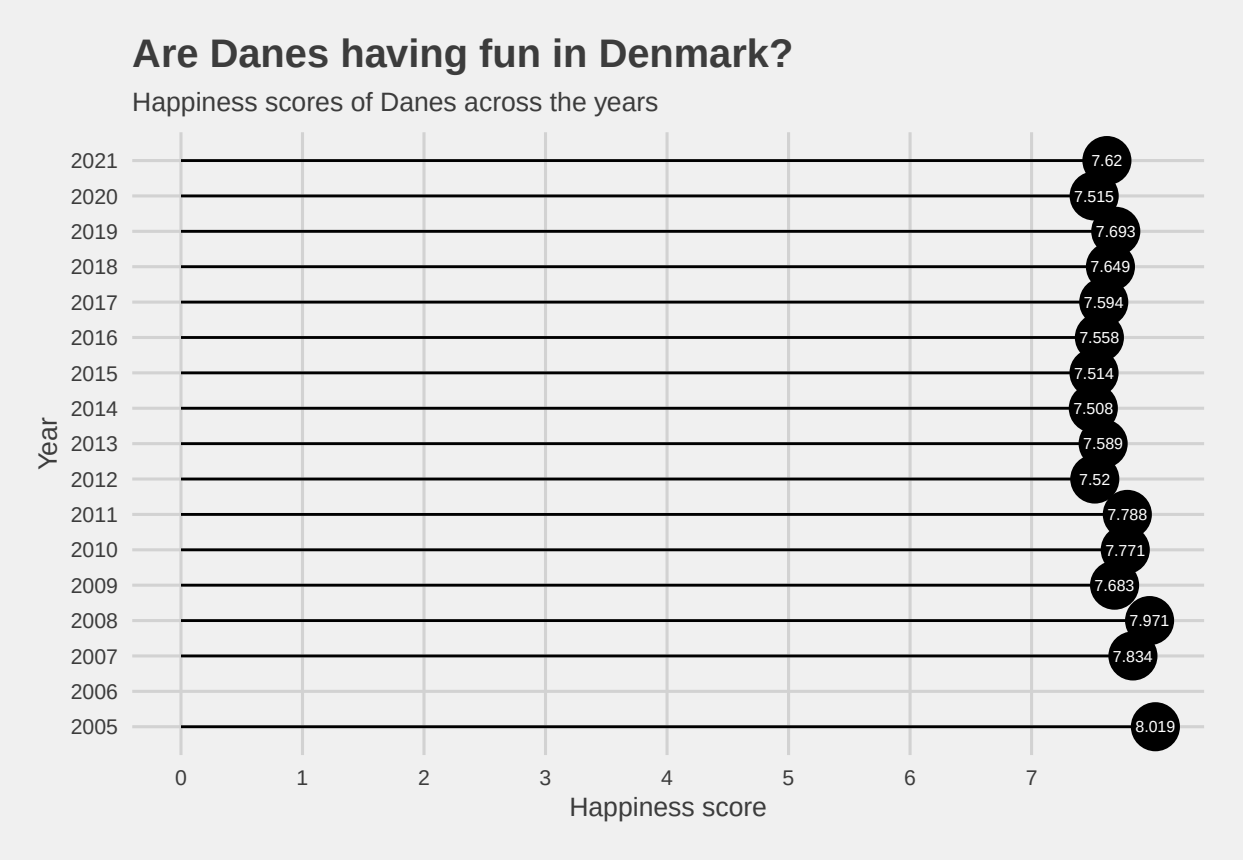
```
# Changing the column names of data_all_raw and naming the dataframe data_all
data_all_raw %>% select(country = 'Country name', score = 'Life Ladder',
                        economy = 'Log GDP per capita',
                        social_support = 'Social support',
                        life_expectancy = 'Healthy life expectancy at birth',
                        freedom = 'Freedom to make life choices',
                        generosity = 'Generosity',
                        corruption = 'Perceptions of corruption', year) -> data_all

# Changing the column names of data_2021_raw and naming the dataframe data_all
data_2021_raw %>% select(country = 'Country name', score = 'Ladder score',
                        economy = 'Logged GDP per capita',
                        social_support = 'Social support',
                        life_expectancy = 'Healthy life expectancy',
                        freedom = 'Freedom to make life choices',
```

```
                        generosity = 'Generosity',
                        corruption = 'Perceptions of corruption',
                        region = 'Regional indicator') -> data_2021

data_2021 %>% select(country, region) -> continent

full_join(data_all, continent, by = "country") -> data_all

bind_rows(data_all, data_2021) -> data

data[,"year"][is.na(data[,"year"])] <- 2021

head(data)
```

```
## # A tibble: 6 x 10
##   country     score economy social_support life_expectancy freedom generosity
##   <chr>       <dbl>   <dbl>          <dbl>           <dbl>   <dbl>      <dbl>
## 1 Afghanistan  3.72    7.37          0.451            50.8   0.718      0.168
## 2 Afghanistan  4.40    7.54          0.552            51.2   0.679      0.19
## 3 Afghanistan  4.76    7.65          0.539            51.6   0.6        0.121
## 4 Afghanistan  3.83    7.62          0.521            51.9   0.496      0.162
## 5 Afghanistan  3.78    7.70          0.521            52.2   0.531      0.236
## 6 Afghanistan  3.57    7.72          0.484            52.6   0.578      0.061
## # ... with 3 more variables: corruption <dbl>, year <dbl>, region <chr>
```

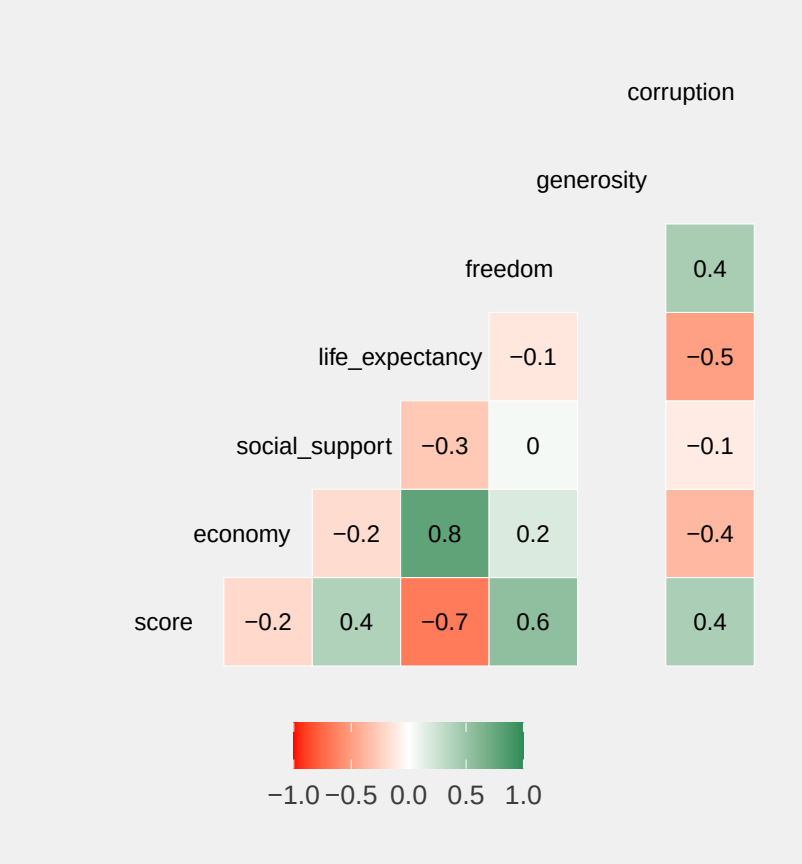
Denmark

```
dk <- data %>% filter(country == "Denmark")

ggplot(dk, aes(x = year, y = score, label = score)) + geom_point(size = 8, color = "black") +
  theme_fivethirtyeight() +
  geom_segment(aes(x = year, xend = year, y = 0, yend = score)) +
  scale_x_continuous(breaks = seq(2005, 2021, 1)) +
  scale_y_continuous(breaks = seq(0, 7, 1)) + geom_text(color = 'white', size = 2) +
  labs(title = "Are Danes having fun in Denmark?",
       subtitle = "Happiness scores of Danes across the years",
       x = "Year", y = "Happiness score") +
  theme(plot.title = element_text(size = 15, face = "bold"),
        plot.subtitle = element_text(size = 10),
        axis.title = element_text(size = 10),
        axis.text = element_text(size = 8)) +
  coord_flip()
```



After seeing the scores, I want to see the linear relationship between score and other variables.

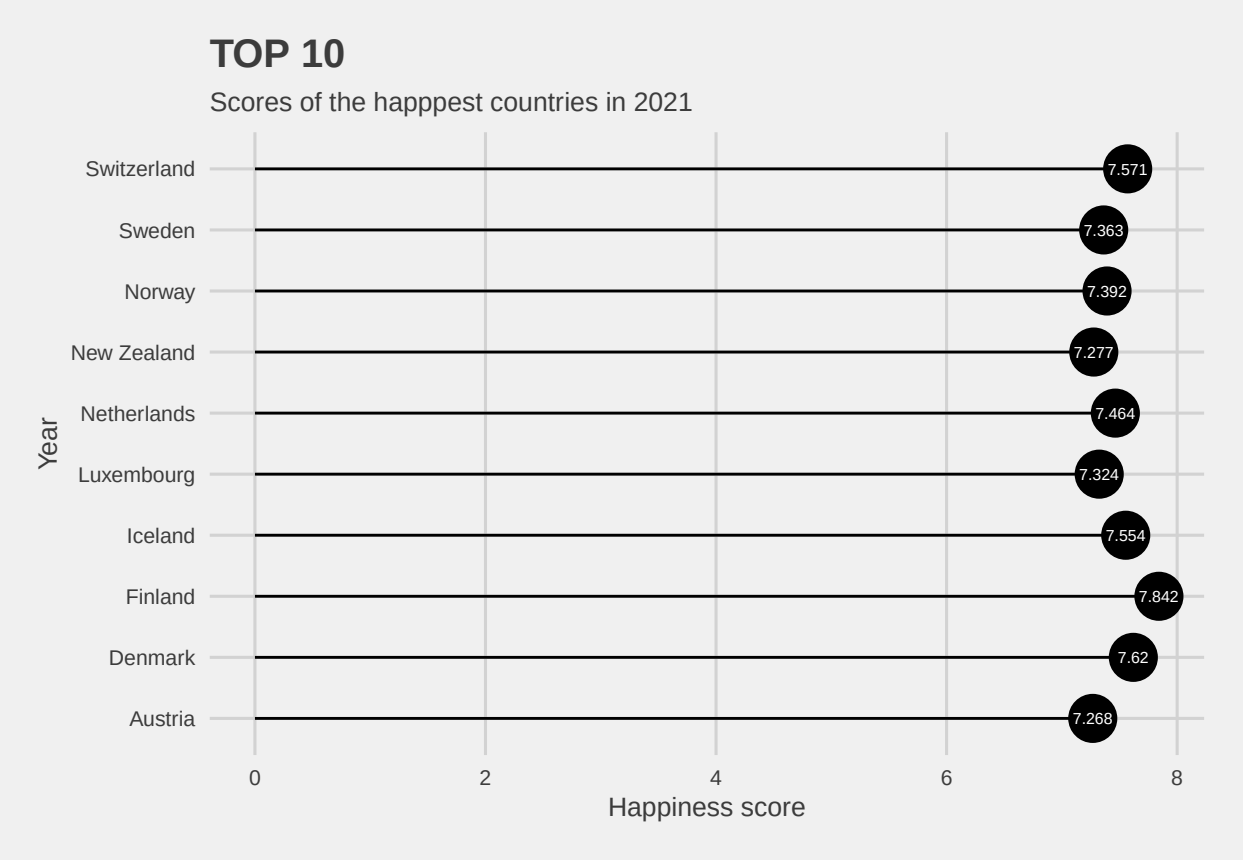
```
dk_corr <- dk %>% select(-c(country, year, region))

ggcorr(dk_corr,
       method = c("everything", "pearson"),
       size = 3, hjust = 0.77,
       low = "#ff0000", mid = "white", high = "#2e8b57",
       label = TRUE, label_size = 3,
       layout.exp = 1) + theme_fivethirtyeight()
```



Note: live expectancy and economy have a strong linear correlation.

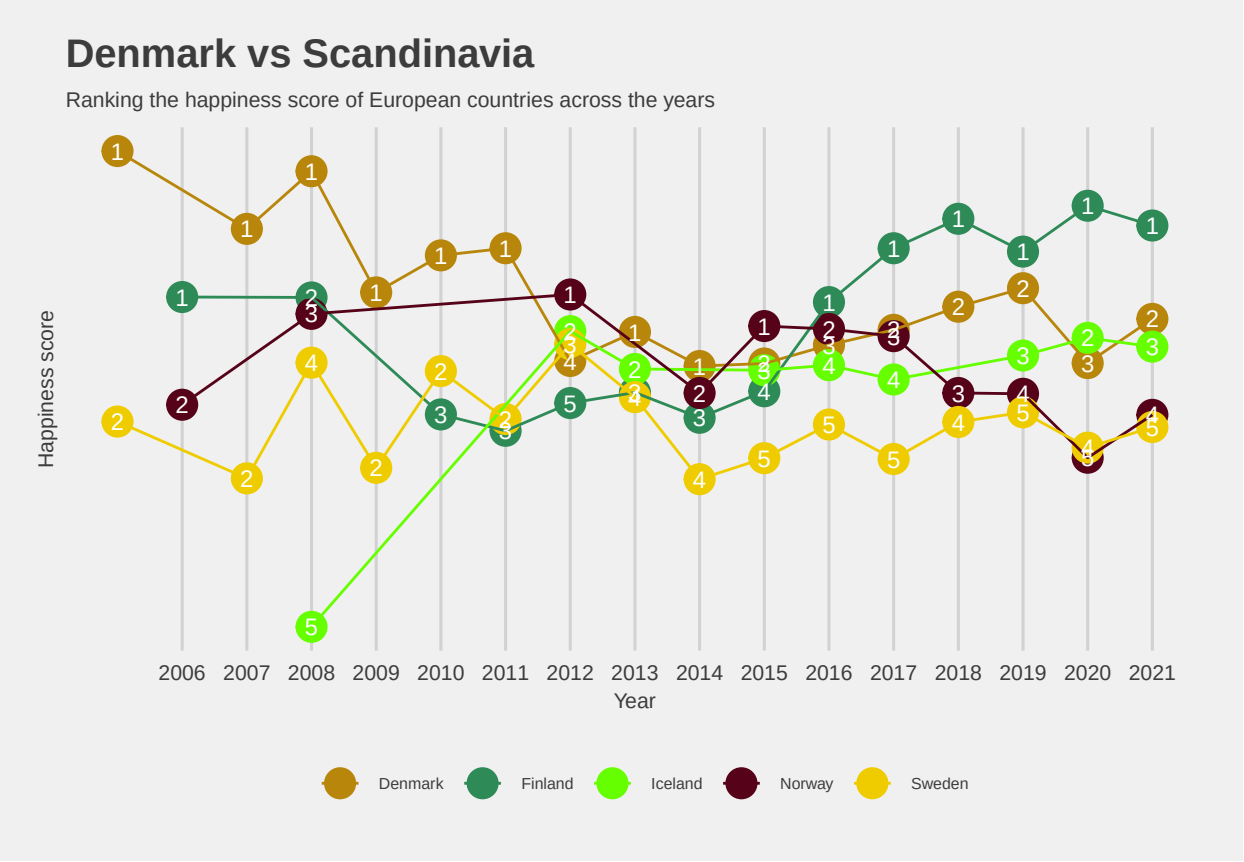
Denmark vs Europe

```
happiest_countries_2021 <- data_2021 %>%
    select(country, score) %>%
    group_by(score) %>%
    arrange(desc(score)) %>%
    head(10)

ggplot(happiest_countries_2021, aes(x = country, y = score, label = score)) +
  geom_point(size = 8, color = "black") +
  theme_fivethirtyeight() +
  geom_segment(aes(x = country, xend = country, y = 0, yend = score)) +
  geom_text(color = 'white', size = 2) +
  labs(title = "TOP 10",
       subtitle = "Scores of the happpest countries in 2021",
       x = "Year", y = "Happiness score") +
  theme(plot.title = element_text(size = 15, face = "bold"),
        plot.subtitle = element_text(size = 10),
        axis.title = element_text(size = 10),
        axis.text = element_text(size = 8)) +
  coord_flip()
```



Denmark vs Scandinavia

```
scandinavia <- data %>% filter(country == 'Denmark' | country == 'Norway' |
                                 country == 'Sweden' | country == 'Finland' |
                                 country == 'Iceland') %>%
  group_by(year) %>%
  mutate(yrrank = row_number(-score))

ggplot(scandinavia, aes(x = year, y = score, label = yrrank)) +
  geom_point(aes(color = country), size = 5) +
  theme_fivethirtyeight() +
  geom_line(aes(color = country)) + scale_x_continuous(breaks = seq(2006, 2021, 1)) +
  scale_y_continuous(breaks = seq(0, 5, 0.5)) + geom_text(color = 'white', size = 3) +
  scale_color_manual(values = c("#b8860b", "#2e8b57", "#66ff00", "#560319", "#efcc00")) +
  labs(title = 'Denmark vs Scandinavia',
       subtitle = 'Ranking the happiness score of European countries across the years',
       x = 'Year', y = 'Happiness score') +
  theme(plot.title = element_text(size = 15, face = 'bold'),
        plot.subtitle = element_text(size = 8),
        axis.title = element_text(size = 8),
        axis.text = element_text(size = 8),
        legend.direction = 'horizontal', legend.position = 'bottom',
        legend.title = element_blank(),
        legend.text = element_text(size = 6))
```



Denmark vs World

```
# Changing the values of region column in Denmark for grasping purposes
data %>%
  mutate(region = case_when(country == 'Denmark' ~ 'Denmark', TRUE ~ region)) -> data

# Checking the unique and missing values
unique(data['region'])
```

```
## # A tibble: 12 x 1
##    region
##    <chr>
##  1 South Asia
##  2 Central and Eastern Europe
##  3 Middle East and North Africa
##  4 <NA>
##  5 Latin America and Caribbean
##  6 Commonwealth of Independent States
##  7 North America and ANZ
##  8 Western Europe
##  9 Sub-Saharan Africa
## 10 Southeast Asia
## 11 East Asia
## 12 Denmark
```

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

```
##         country           score         economy  social_support life_expectancy
##               0               0              36              13              55
##         freedom      generosity      corruption            year          region
##              32              89             110               0              63
```

```
# There are 63 missing values in the column region, so
# investigate null values in this column
data %>% filter(is.na(region)) -> na_region

# Fill up values of the countries with NA region
data %>%
  mutate(
    region = case_when(country =="Angola" | country == "Central African Republic" |
                         country == "Congo (Kinshasa)" | country == "Djibouti"|
                         country == "Somalia" | country == "Somaliland region"|
                         country == "South Sudan" | country == "Sudan"
                       ~ "Sub-Saharan Africa", TRUE ~ region)) %>%
  mutate(
    region = case_when(country == "Belize" | country == "Cuba" | country == "Guyana" |
                         country == "Suriname" | country == "Trinidad and Tobago"
                       ~ "Latin America and Caribbean", TRUE ~ region)) %>%
  mutate(
    region = case_when(country == "Oman" | country == "Qatar" | country == "Syria"
                       ~ "Middle East and North Africa", TRUE ~ region)) %>%
  mutate(
    region = case_when(country == "Bhutan" ~ "South Asia", TRUE ~ region)) -> data

# Checking if any country is missed
data %>% filter(is.na(region)) -> na_region

# Combining some regions
revalue(data$region, c("Central and Eastern Europe" = "Europe and North Asia")) ->
  data$region
revalue(data$region, c("Commonwealth of Independent States" = "Europe and North Asia")) ->
  data$region
revalue(data$region, c("East Asia" = "West, East, Southeast Asia and North Africa")) ->
  data$region
revalue(data$region, c("Southeast Asia" = "West, East, Southeast Asia and North Africa")) ->
  data$region
revalue(data$region, c("Middle East and North Africa" = "West, East, Southeast Asia and North Africa"))
  data$region

# Checking the new set of unique values
unique(data["region"])
```

```
## # A tibble: 8 x 1
##   region
##   <chr>
## 1 South Asia
## 2 Europe and North Asia
## 3 West, East, Southeast Asia and North Africa
## 4 Sub-Saharan Africa
## 5 Latin America and Caribbean
```

```
## 6 North America and ANZ
## 7 Western Europe
## 8 Denmark
```

Creating a new dataframe with average happiness score of each country based on their region and also ranking them by year.

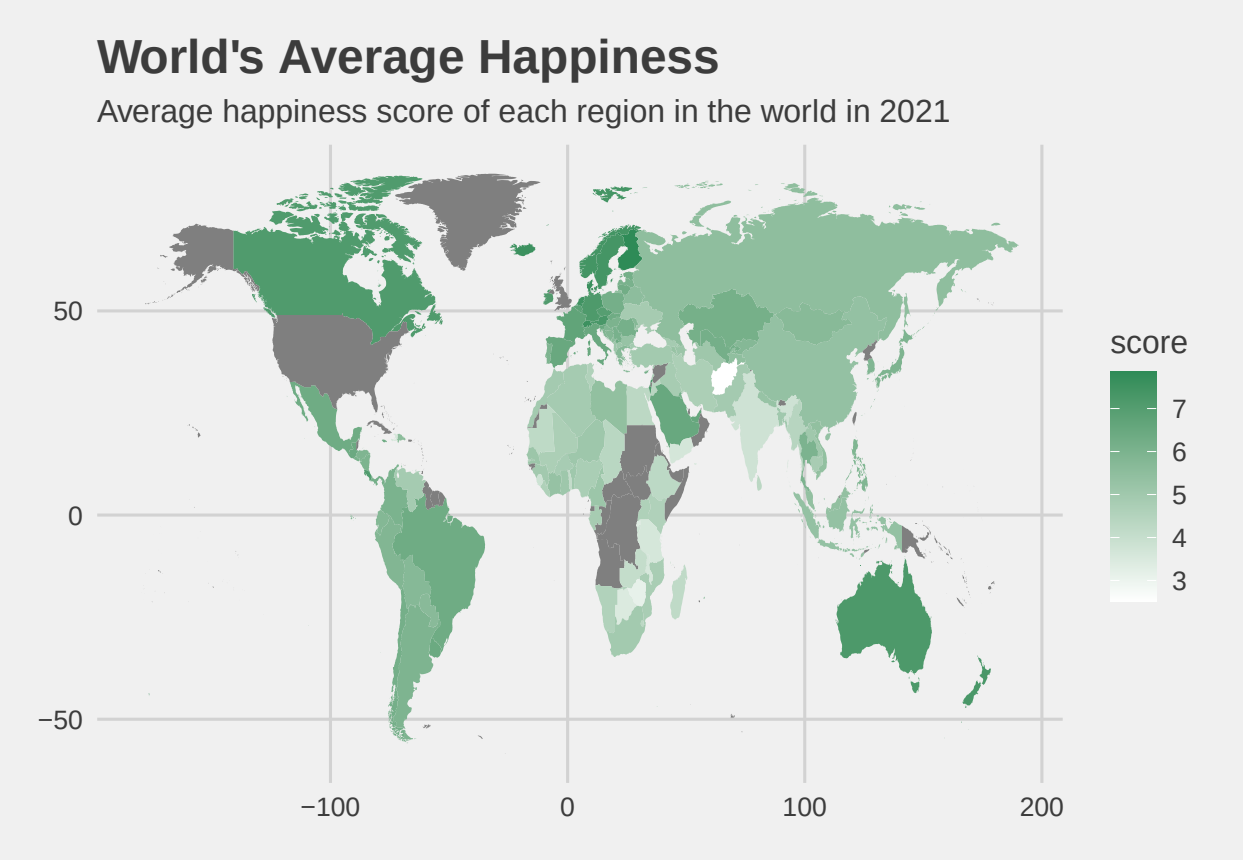
```
data %>%
  select(year, region, score) %>%
  group_by(year,region) %>%
  summarise(avg_score = mean(score)) %>%
  mutate_at(vars(region), factor) %>%
  group_by(year) %>%
  mutate(yrrank = row_number(-avg_score)) -> avg_region
```

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

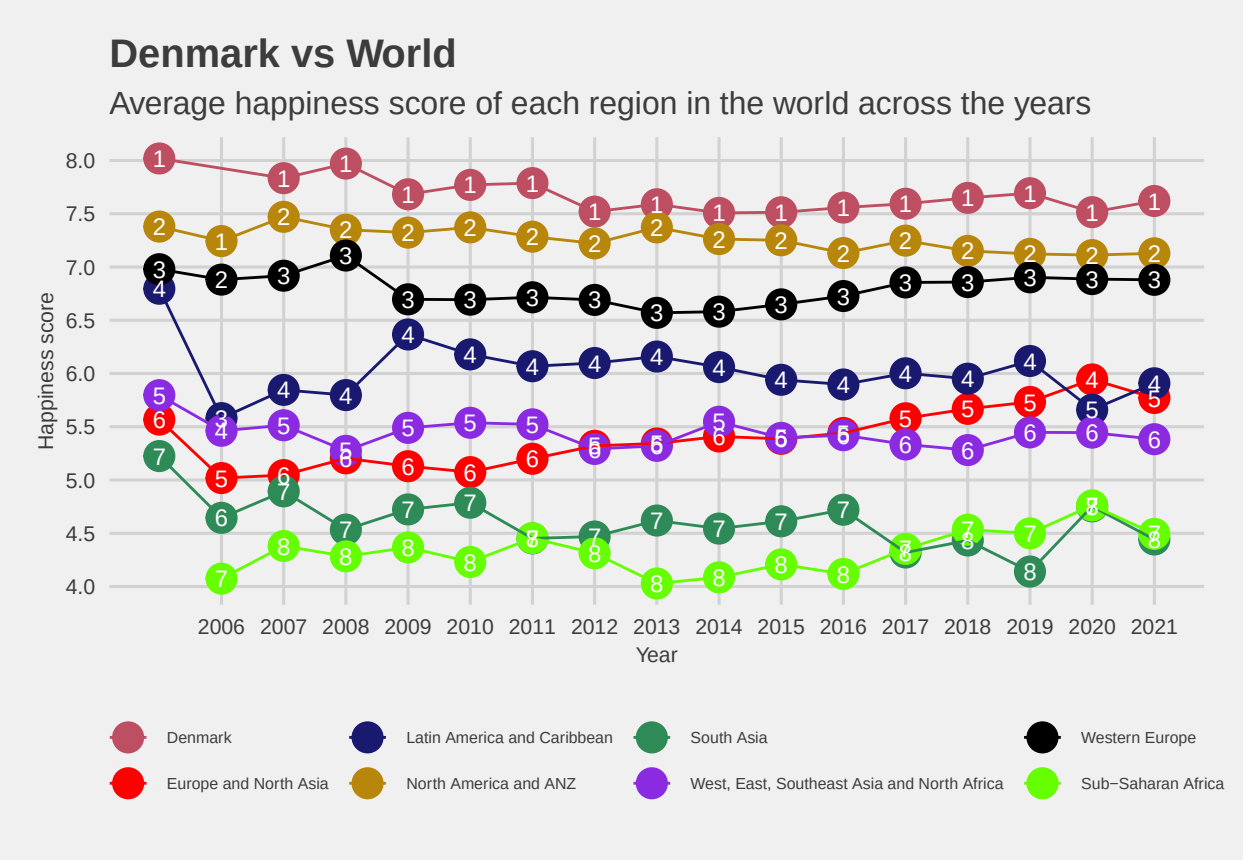
```
head(avg_region)
```

```
## # A tibble: 6 x 4
## # Groups:   year [1]
##    year region                                        avg_score yrrank
##   <dbl> <fct>                                            <dbl>  <int>
## 1  2005 Denmark                                           8.02      1
## 2  2005 Europe and North Asia                             5.57      6
## 3  2005 Latin America and Caribbean                       6.80      4
## 4  2005 North America and ANZ                             7.38      2
## 5  2005 South Asia                                        5.22      7
## 6  2005 West, East, Southeast Asia and North Africa       5.80      5
```

```
worldmap = map_data('world') %>% filter(region != 'Antarctica')

merged_data <- merge(x = worldmap, y = data_2021,
                     by.x = 'region', by.y = 'country', all.x = TRUE) %>%
  arrange(order)
ggplot(merged_data, aes(x = long, y = lat, group = group)) +
  geom_polygon(aes(fill = score)) +

theme_fivethirtyeight() +
  scale_fill_continuous(low = 'white', high = '#2e8b57') +
  labs(title = "World's Average Happiness",
       subtitle = 'Average happiness score of each region in the world in 2021') +
  theme(legend.direction = 'vertical', legend.position = 'right',
        legend.text = element_text(size = 10))
```




```
ggplot(avg_region, aes(x = year, y = avg_score, label = yrrank)) +
  theme_fivethirtyeight() +
  geom_point(aes(color = region), size = 5) +
  geom_line(aes(color = region)) + scale_x_continuous(breaks = seq(2006, 2021, 1)) +
  scale_y_continuous(breaks = seq(0, 8, 0.5)) + geom_text(color = 'white', size = 3) +
  scale_color_manual(values = c("#be4f62","#ff0000","#191970","#b8860b",
                                "#2e8b57", "#8a2be2", "#000000", "#66ff00")) +
  labs(title = 'Denmark vs World',
       subtitle = 'Average happiness score of each region in the world across the years',
       x = 'Year', y = 'Happiness score') +
  theme(plot.title = element_text(size = 15, face = 'bold'),
        axis.title = element_text(size = 8),
        axis.text = element_text(size = 8),
        legend.direction = 'horizontal', legend.position = 'bottom',
        legend.title = element_blank(),
        legend.text = element_text(size = 6))
```



Denmark vs World in 2021

Now, I am using 2021 data and it doesn't have null values.

```
data %>% filter(year == 2021) -> data_2021_final

colSums(is.na(data_2021_final))
```

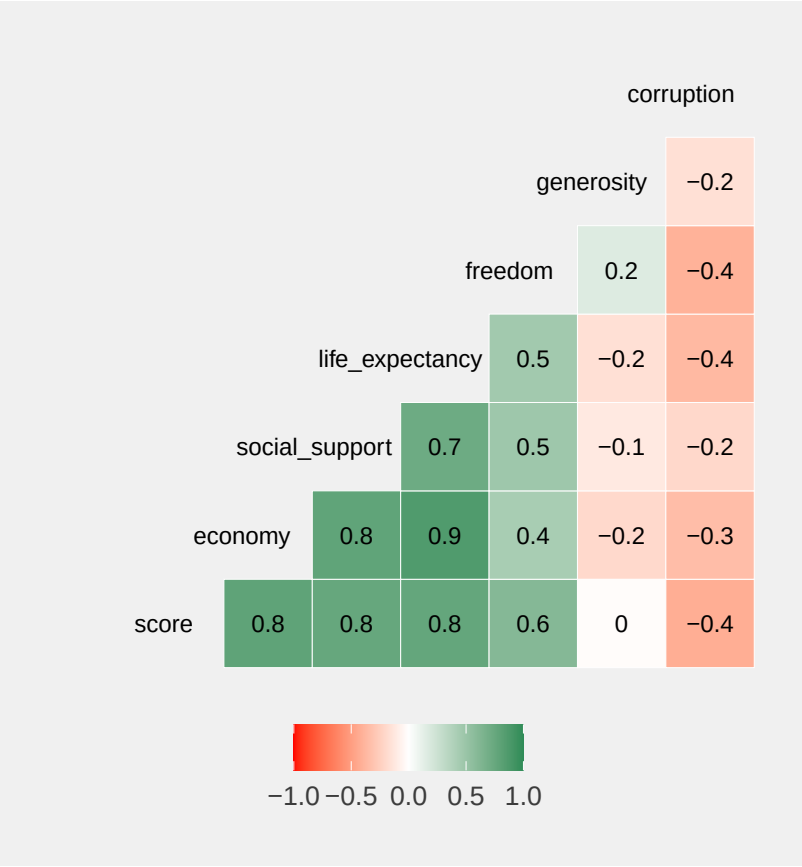
```
##         country           score         economy  social_support life_expectancy
##               0               0               0               0               0
##         freedom      generosity      corruption            year          region
##               0               0               0               0               0
```

```
head(data_2021_final)
```

```
## # A tibble: 6 x 10
##   country     score economy social_support life_expectancy freedom generosity
##   <chr>       <dbl>   <dbl>          <dbl>           <dbl>   <dbl>      <dbl>
## 1 Finland      7.84    10.8          0.954            72     0.949     -0.098
## 2 Denmark      7.62    10.9          0.954            72.7   0.946      0.03
## 3 Switzerland  7.57    11.1          0.942            74.4   0.919      0.025
## 4 Iceland      7.55    10.9          0.983            73     0.955      0.16
## 5 Netherlands  7.46    10.9          0.942            72.4   0.913      0.175
## 6 Norway       7.39    11.1          0.954            73.3   0.96       0.093
## # ... with 3 more variables: corruption <dbl>, year <dbl>, region <chr>
```

Once again, I want to see the linear relationship between the variables, so I am making a correlation matrix.

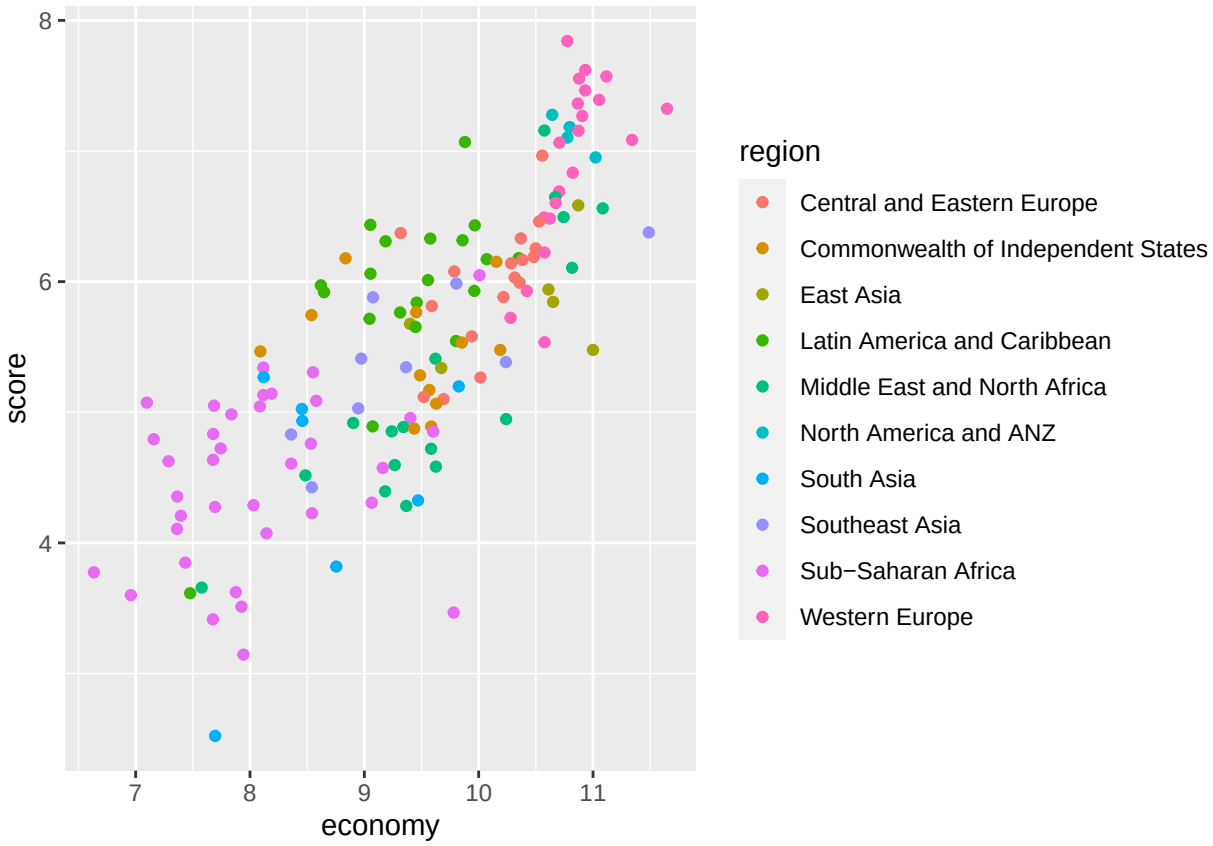
```
data_2021_final %>% select(-c(country, year, region)) -> data_2021_corr

ggcorr(data_2021_corr,
       method = c("everything", "pearson"),
       size = 3, hjust = 0.77,
       low = "#ff0000", mid = "white", high = "#2e8b57",
       label = TRUE, label_size = 3,
       layout.exp = 1) + theme_fivethirtyeight()
```



Note: Economy, social support and life expectancy are highly correlated to score.

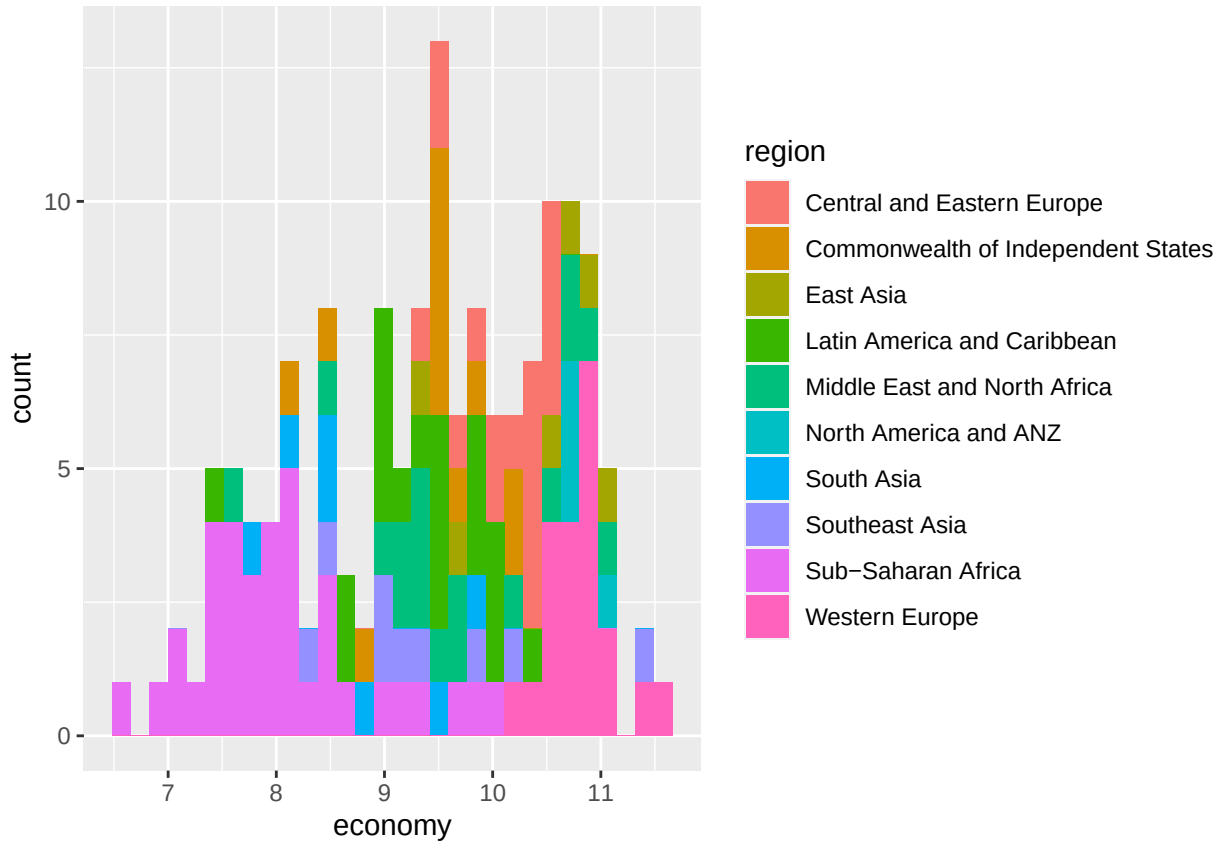
Inference

```
ggplot(data_2021) +
  geom_point(aes(x = economy, y = score, color = region))
```

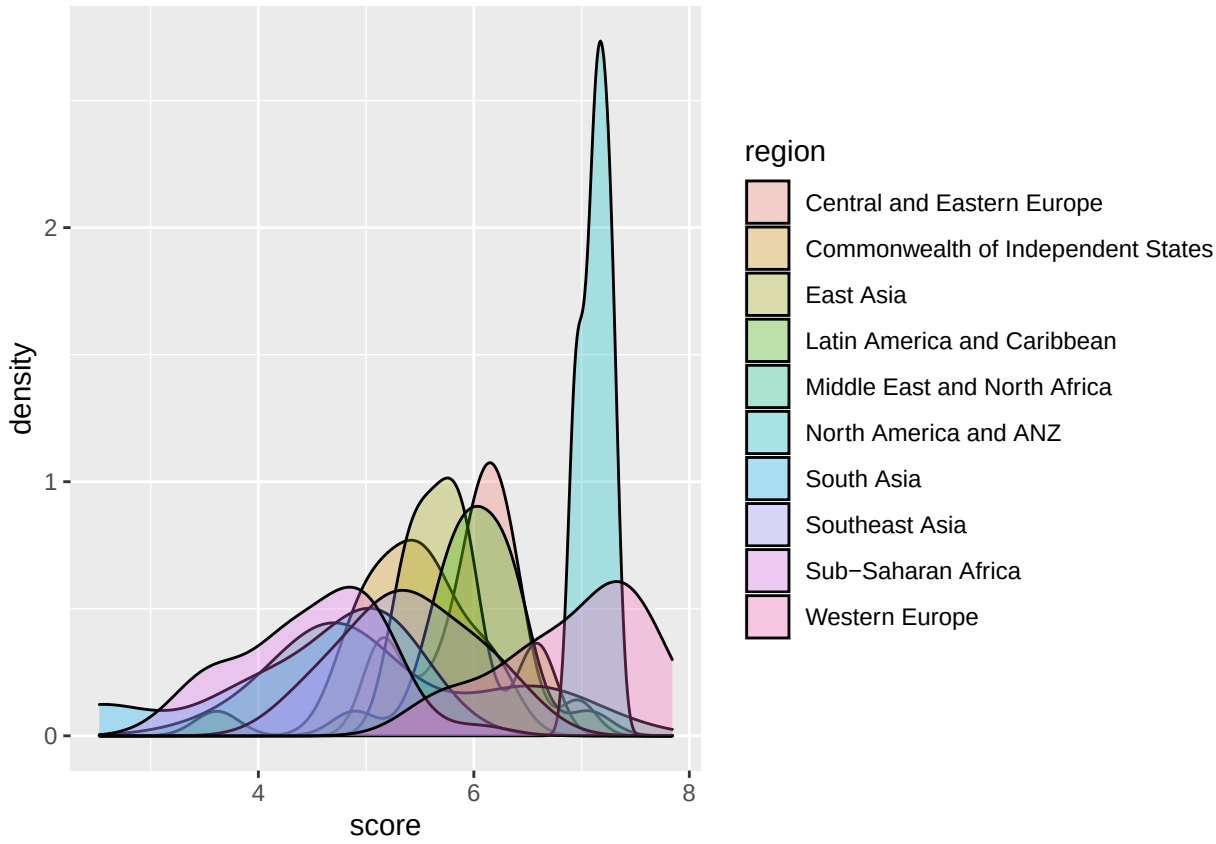



```
ggplot(data_2021) +
  geom_histogram(aes(x = economy, fill = region))
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```




```
ggplot(data_2021) +
  geom_density(aes(x = score, fill = region), alpha = 0.3)
```



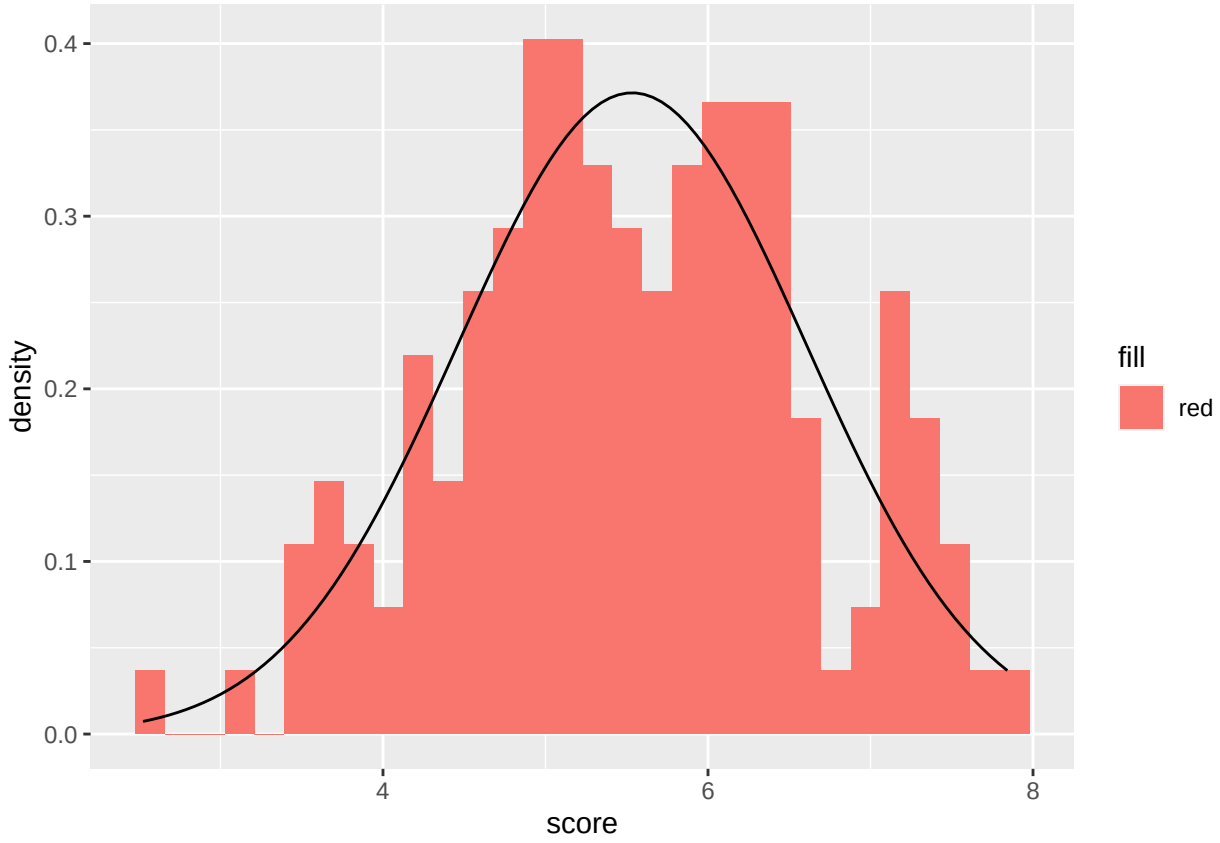

```
xframe <- seq(-10, 10, length = 100)
dnorm(xframe)
```

```
##   [1] 7.694599e-23 5.684422e-22 4.031458e-21 2.744818e-20 1.794074e-19
##   [6] 1.125752e-18 6.781419e-18 3.921696e-17 2.177222e-16 1.160399e-15
##  [11] 5.937273e-15 2.916369e-14 1.375223e-13 6.225578e-13 2.705587e-12
##  [16] 1.128805e-11 4.521180e-11 1.738442e-10 6.417178e-10 2.274068e-09
##  [21] 7.736391e-09 2.526672e-08 7.921998e-08 2.384493e-07 6.890219e-07
##  [26] 1.911373e-06 5.090183e-06 1.301358e-05 3.194006e-05 7.525757e-05
##  [31] 1.702316e-04 3.696626e-04 7.706310e-04 1.542279e-03 2.963159e-03
##  [36] 5.465405e-03 9.677547e-03 1.645068e-02 2.684588e-02 4.205786e-02
##  [41] 6.325461e-02 9.132982e-02 1.265927e-01 1.684535e-01 2.151925e-01
##  [46] 2.639062e-01 3.107045e-01 3.511729e-01 3.810395e-01 3.969123e-01
##  [51] 3.969123e-01 3.810395e-01 3.511729e-01 3.107045e-01 2.639062e-01
##  [56] 2.151925e-01 1.684535e-01 1.265927e-01 9.132982e-02 6.325461e-02
##  [61] 4.205786e-02 2.684588e-02 1.645068e-02 9.677547e-03 5.465405e-03
##  [66] 2.963159e-03 1.542279e-03 7.706310e-04 3.696626e-04 1.702316e-04
##  [71] 7.525757e-05 3.194006e-05 1.301358e-05 5.090183e-06 1.911373e-06
##  [76] 6.890219e-07 2.384493e-07 7.921998e-08 2.526672e-08 7.736391e-09
##  [81] 2.274068e-09 6.417178e-10 1.738442e-10 4.521180e-11 1.128805e-11
##  [86] 2.705587e-12 6.225578e-13 1.375223e-13 2.916369e-14 5.937273e-15
##  [91] 1.160399e-15 2.177222e-16 3.921696e-17 6.781419e-18 1.125752e-18
##  [96] 1.794074e-19 2.744818e-20 4.031458e-21 5.684422e-22 7.694599e-23
```

```
sd_world <- sd(data_2021$score)
mean_world <- mean(data_2021$score)
ggplot(data_2021) +
  geom_histogram(aes(x = score, y = ..density.., fill = 'red')) +
```

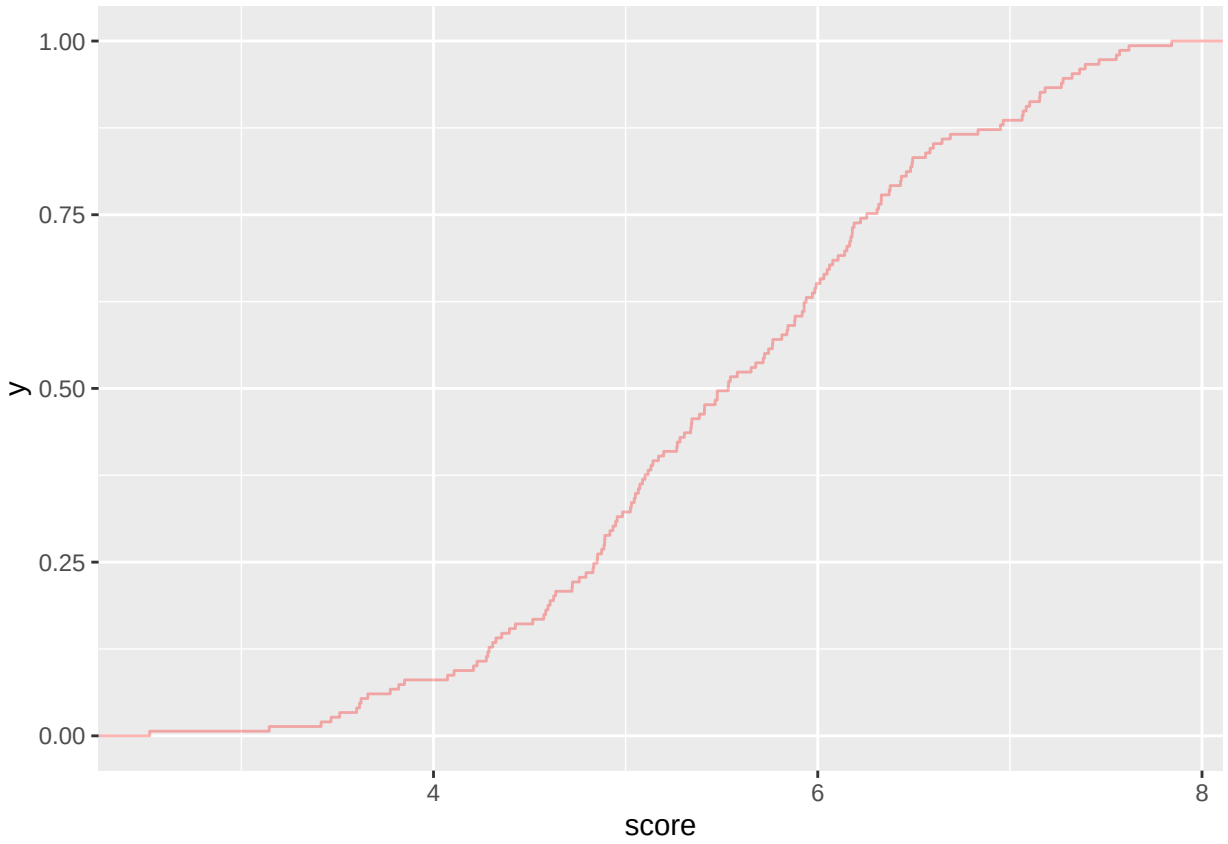
```
  stat_function(fun = dnorm, args = list(mean = mean_world, sd = sd_world))
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

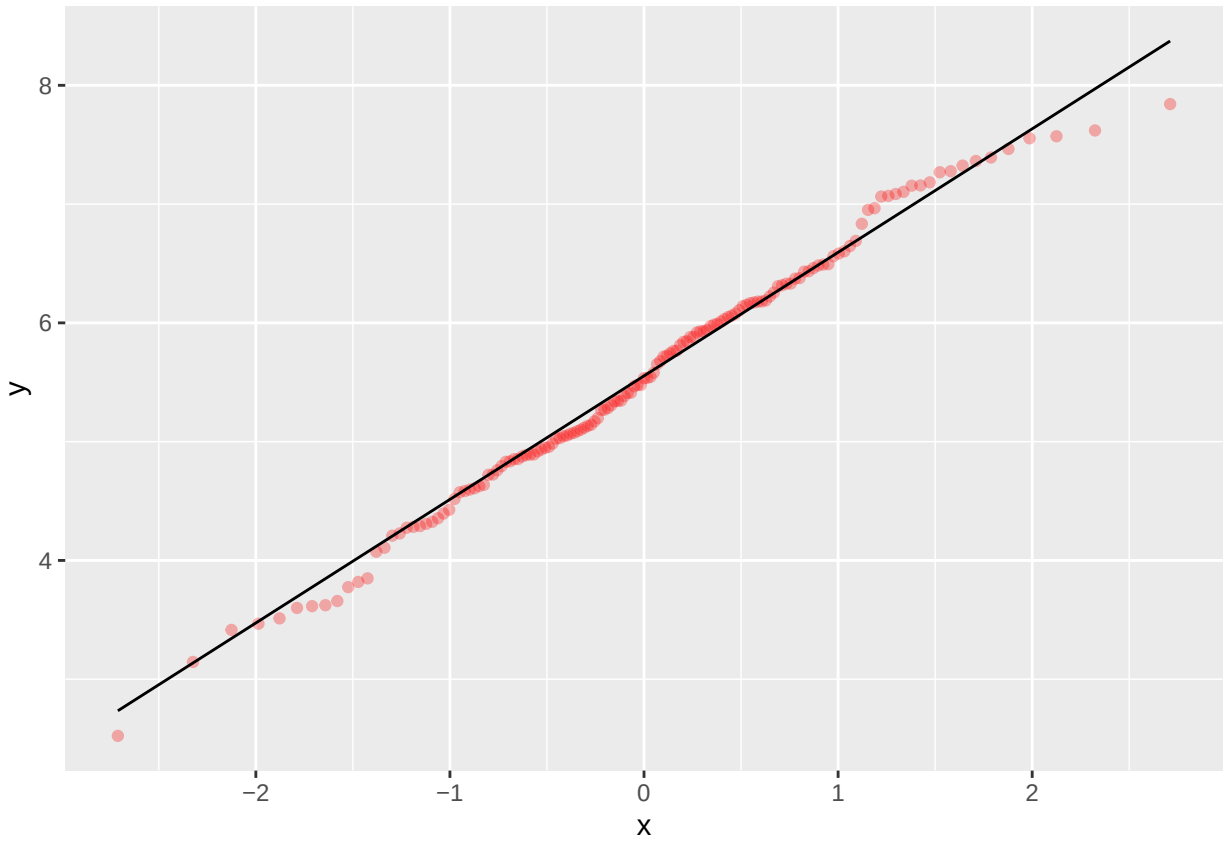



```
ggplot(data_2021) +
  stat_ecdf(aes(x = score), color = 'red', alpha = 0.3) +
  geom_line(stat = 'function', fun = pnorm, args = list(mean = mean, sd = sd))
```

```
## Warning: Computation failed in `stat_function()`:
## Argument nieliczbowy przekazany do funkcji matematycznej
```

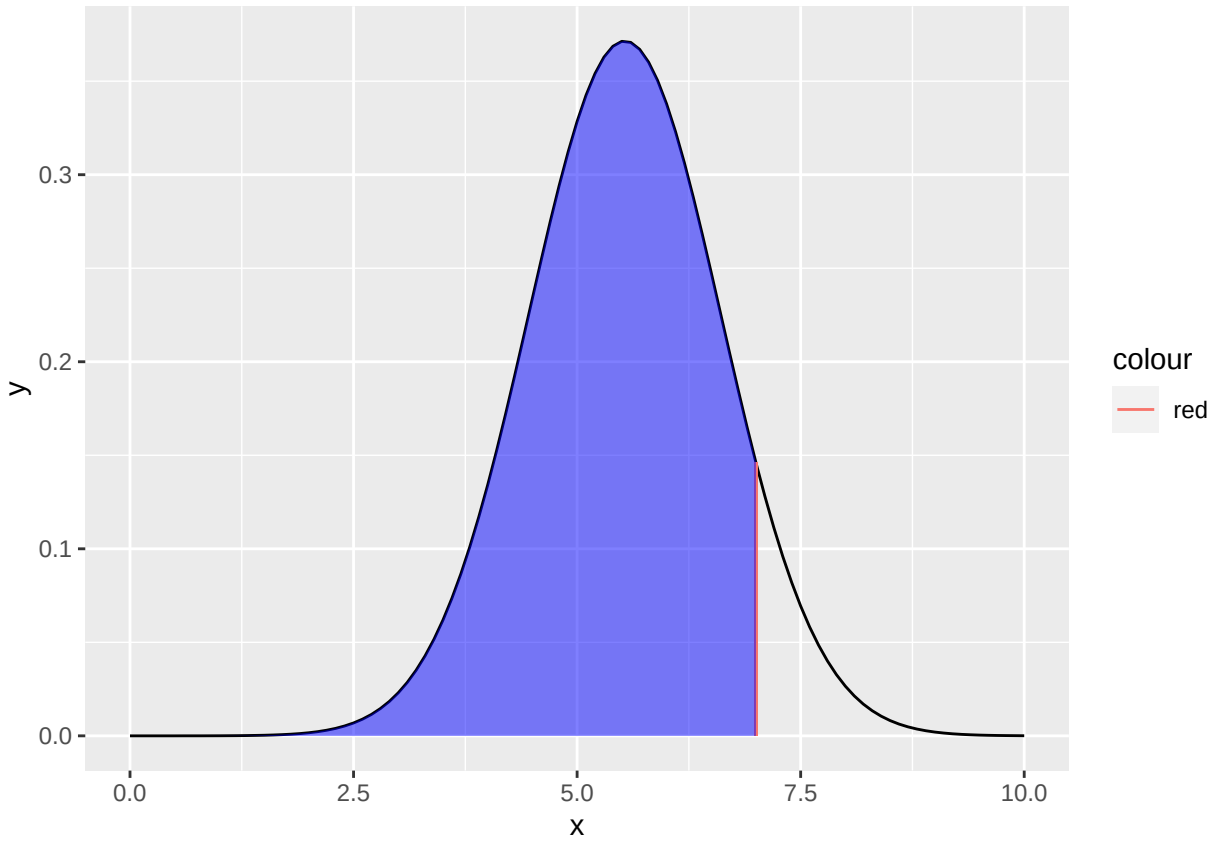



```
ggplot(data_2021) +
  stat_qq(aes(sample = score), color = 'red', alpha = 0.3) +
  stat_qq_line(aes(sample = score))
```



Let's assume that the mean happiness is equal 7.

```
x_dash <- 7
z_score <- (x_dash - mean_world) / sd_world

ggplot(data.frame(x = seq(0, 10, length = 500)), aes(x = x)) +
  stat_function(fun = dnorm, args = list(mean = mean_world, sd = sd_world)) +
  geom_segment(aes(x = x_dash, y = 0, xend = x_dash,
                   yend = dnorm(x_dash, mean = mean_world, sd = sd_world), color = 'red')) +
  geom_area(stat = 'function', fun = dnorm, args = list(mean = mean_world, sd = sd_world),
            fill = 'blue', xlim = c(0, x_dash), alpha = 0.5)
```




```
pnorm(z_score)
```

```
## [1] 0.914057
```

```
pnorm(x_dash, mean_world, sd_world)
```

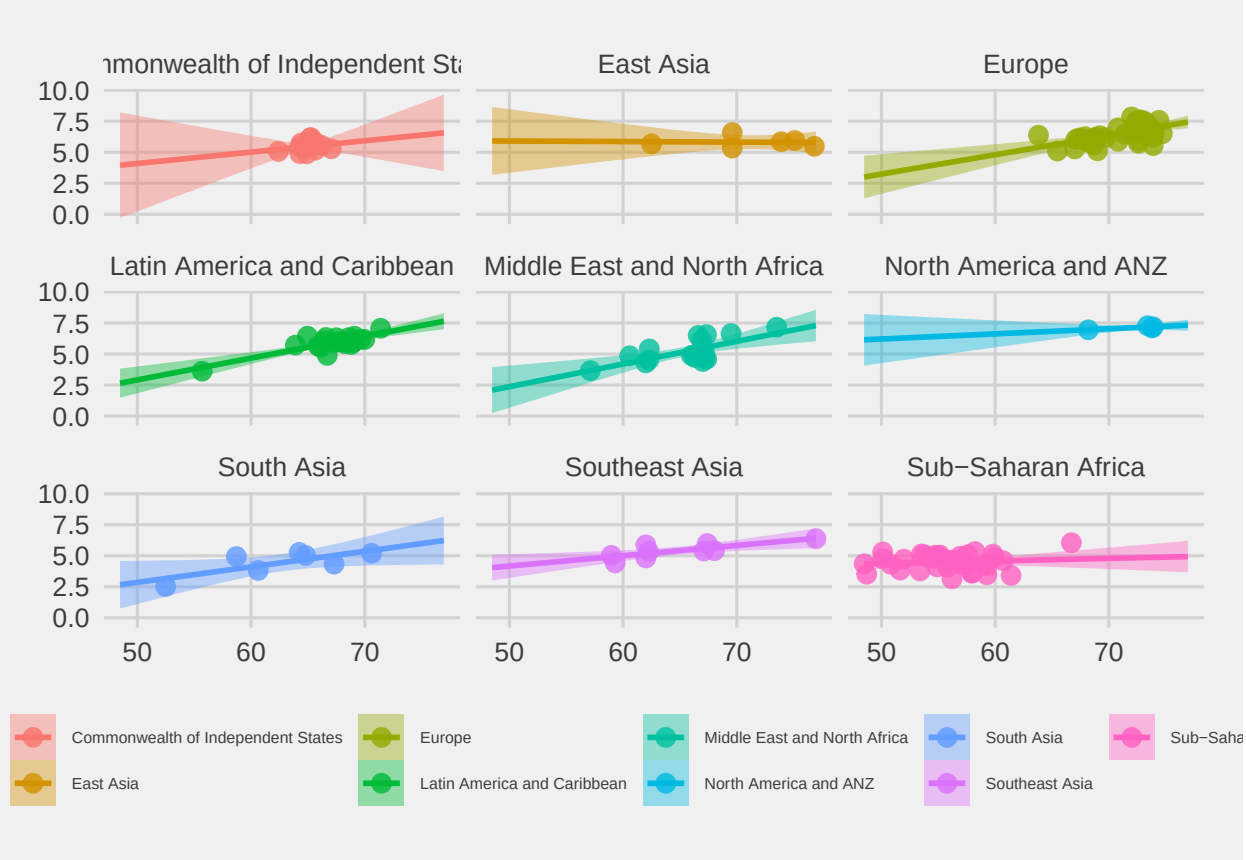
```
## [1] 0.914057
```

Note: Speaking of the population from a sample, we can say that the mean happiness score is less than 7 with 91.4% confidence.

Linear regression

```
# Merging the Europe to make trend more linear
data_2021 %>%
  mutate(region = case_when(region == 'Central and Eastern Europe' |
                              region == 'Western Europe' ~ 'Europe',
                            TRUE ~ region)) -> data_2021_merged

ggplot(data_2021_merged, aes(x = life_expectancy, y = score)) +
  geom_point(aes(color = region), size = 3, alpha = 0.8) +
  geom_smooth(aes(color = region, fill = region), method = 'lm', fullrange = TRUE) +
  facet_wrap(~region) +
  theme_fivethirtyeight() +
  theme(legend.direction = 'horizontal', legend.position = 'bottom',
        legend.title = element_blank(),
        legend.text = element_text(size = 6))
```

```
## `geom_smooth()` using formula 'y ~ x'
```



Predictions

Predict the happiness score of 90 year old people from various regions.

```
data_2021_merged %>% filter(region == 'Europe') %>%
  lm(score ~ life_expectancy, data = .) -> eur_fit

data_2021_merged %>% filter(region == 'Latin America and Caribbean') %>%
  lm(score ~ life_expectancy, data = .) -> la_fit

data_2021_merged %>% filter(region == 'North America and ANZ') %>%
  lm(score ~ life_expectancy, data = .) -> na_fit

data_2021_merged %>% filter(region == 'South Asia') %>%
  lm(score ~ life_expectancy, data = .) -> asia_fit

# Europe
summary(eur_fit)$coefficients[1] + summary(eur_fit)$coefficients[2] * 90
```

```
## [1] 9.463086
```

```
# Latin America
summary(la_fit)$coefficients[1] + summary(la_fit)$coefficients[2] * 90
```

```
## [1] 9.924915
```

```
# North America
summary(na_fit)$coefficients[1] + summary(na_fit)$coefficients[2] * 90
```

```
## [1] 7.856367
```

```
# Asia
summary(asia_fit)$coefficients[1] + summary(asia_fit)$coefficients[2] * 90
```

```
## [1] 7.856741
```