

# Data Visualization (1)

## Basics

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Last update: October 26, 2023

Motivation

Data Preparation

Data Viz Basics

# Motivation

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Life is short. Use graphs!

What does data visualization do? Let's start with some examples.

- ▶ Hans Rosling's Gapminder: <https://www.gapminder.org/tools/>
- ▶ Our World in Data: <https://ourworldindata.org/>
- ▶ V-Dem data visualization tools: <https://v-dem.net/graphing/graphing-tools/>

# Our Task: Extend the “Health and Wealth” Analysis

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<https://www.gapminder.org/fw/world-health-chart/>

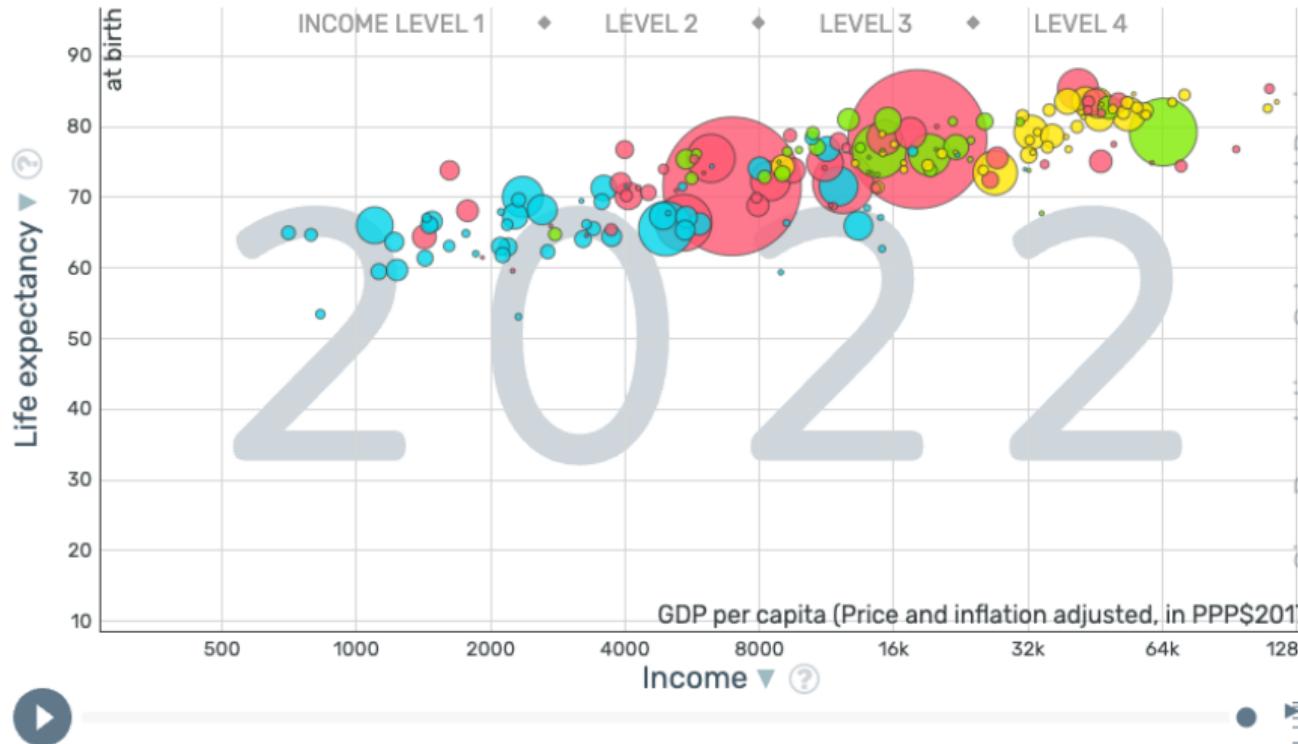
*Hans Rosling shows that income and health go hand in hand. People live longer in richer countries. Or the other way around. Countries are richer where people live longer. There are no high income countries with a short life expectancy, and no low income countries with a long life expectancy. Still, there's a huge difference in life expectancy between countries on the same income level, depending on how the money is distributed and how it is used.*

Our Task: Extend the “Health and Wealth” Analysis

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# Data Preparation

# Load the Data

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```
library(tidyverse)

d_full <- bind_rows(
  read_csv("_DataPublic_/vdem/1789_1827/vdem_1789_1827_external.csv"),
  read_csv("_DataPublic_/vdem/1867_1905/vdem_1867_1905_external.csv"),
  read_csv("_DataPublic_/vdem/1906_1944/vdem_1906_1944_external.csv"),
  read_csv("_DataPublic_/vdem/1945_1983/vdem_1945_1983_external.csv"),
  read_csv("_DataPublic_/vdem/1984_2022/vdem_1984_2022_external.csv")
)
```

# Select Indicators of Interest

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- ▶ Country-year identifiers country\_text\_id year
- ▶ Region e\_regiongeo
- ▶ Wealth: GDP per capita e\_gdppc
- ▶ Health: Life expectancy e\_pelifeex
- ▶ Population: e\_mi popula e\_sb\_pop
- ▶ Extension: Democracy
  - ▶ Binary “democracy” indicator e\_boix\_regime
  - ▶ The Lexical index of Electoral Democracy e\_lexical\_index
  - ▶ Polity V scores (-10 to +10) e\_p\_polity

# Select Indicators of Interest (con'd)

```
d <- d_full |>
  select(
    country_text_id, year,
    e_regiongeo, e_pelifeex, e_gdppc,
    e_mipopula, e_wb_pop,
    e_boix_regime, e_lexical_index, e_p_polity) |>
  rename("region" = "e_regiongeo",
         "life_expectancy" = "e_pelifeex",
         "gdppc" = "e_gdppc",
         "population_ClioInfra" = "e_mipopula",
         "population_WorldBank" = "e_wb_pop",
         "democracy_binary" = "e_boix_regime",
         "democracy_lexical" = "e_lexical_index",
         "democracy_polity5" = "e_p_polity") |>
  filter(year >= 1800)

saveRDS(d, "Lec_07/data/wealth_and_health.rds")
```

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# Take a Quick Look at the Data

```
summary(d)
```

```
## country_text_id      year      region    life_expectancy
## Length:23593      Min.   :1800   Min.   : 1.00   Min.   : 1.50
## Class :character   1st Qu.:1912   1st Qu.: 5.00   1st Qu.:35.50
## Mode  :character   Median :1952   Median : 9.00   Median :50.30
##                  Mean   :1944   Mean   : 9.46   Mean   :51.37
##                  3rd Qu.:1989   3rd Qu.:14.00   3rd Qu.:67.10
##                  Max.   :2022   Max.   :19.00   Max.   :85.30
##                               NA's   :1232
##      gdppc      population_ClioInfra population_WorldBank democracy_binary
##      Min.   : 0.286   Min.   : 17.9   Min.   :4.170e+04   Min.   :0.000
##      1st Qu.: 1.599   1st Qu.: 1021.9   1st Qu.:2.348e+06   1st Qu.:0.000
##      Median : 2.774   Median : 3522.3   Median :7.144e+06   Median :0.000
##      Mean   : 7.194   Mean   : 18688.0   Mean   :3.239e+07   Mean   :0.364
##      3rd Qu.: 7.606   3rd Qu.:  9718.8   3rd Qu.:2.103e+07   3rd Qu.:1.000
##      Max.   :156.628   Max.   :1262645.0   Max.   :1.412e+09   Max.   :1.000
##      NA's   :4571     NA's   :7173     NA's   :13583     NA's   :7623
##      democracy_lexical democracy_polity5
##      Min.   :0.000   Min.   :-88.000
##      1st Qu.:0.000   1st Qu.: -7.000
##      Median :2.000   Median : -3.000
##      Mean   :2.338   Mean   : -3.616
##      3rd Qu.:4.000   3rd Qu.:  7.000
##      Max.   :6.000   Max.   : 10.000
##      NA's   :675     NA's   :8195
```

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# Region

## 9.2.2 Region (geographic) (E) (e\_regiongeo)

*Question:* In which geographic region is this country located?

*Clarification:* Regions are described based on geographic location.

*Responses:*

- 1: Western Europe
- 2: Northern Europe
- 3: Southern Europe
- 4: Eastern Europe
- 5: Northern Africa
- 6: Western Africa
- 7: Middle Africa
- 8: Eastern Africa
- 9: Southern Africa
- 10: Western Asia
- 11: Central Asia
- 12: Eastern Asia
- 13: South-Eastern Asia
- 14: Southern Asia
- 15: Oceania (including Australia and the Pacific)
- 16: North America
- 17: Central America
- 18: South America
- 19: Caribbean (including Belize, Cuba, Haiti, Dominican Republic and Guyana)

*Source(s):* United Nations Statistics Division (2013).

*Notes:* For the countries coded only in the historical project or for which the UN does not have the code, the region is coded by V-Dem Data Manager in accordance with the position of the neighboring countries.

*Data release:* 5-13.

*Citation:* United Nations Statistics Division (2013).

*Years:* 1789-2022

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# Democracy Indicators: Boix et al. 2013

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## 8.2.1 Democracy (BMR) (E) (e\_boix\_regime)

*Question:* Is a country democratic?

*Clarification:* Dichotomous democracy measure based on contestation and participation. Countries coded democratic have (1) political leaders that are chosen through free and fair elections and (2) a minimal level of suffrage.

*Responses:*

0: No

1: Yes

*Source(s):* Boix et al. (2013), Boix et al. (2022)

*Notes:* This variable is taken from version 4 of the Boix-Miller-Rosato dataset. Last update, January 2022.

*Data release:* 5-13.

*Citation:* Boix et al. (2013).

*Years:* 1800-2020

## 8.5 Lexical Index of Electoral Democracy

### 8.5.1 Lexical index (E) (e\_lexical\_index)

*Question:* What is the lexical index of democracy in the country?

*Responses:*

- 0: No elections
- 1: No party or one-party elections
- 2: Multi-party elections for legislature
- 3: Multi-party elections for legislature and executive
- 4: Minimally competitive elections
- 5: Male or female suffrage
- 6: Universal suffrage

*Source(s):* Skaaning *et al.* (2015).

*Data release:* 5-13.

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## 8.8.3 Polity combined score (E) (e\_p\_polity)

*Question:* What is the Polity score?

*Clarification:* The Polity score is computed by subtracting the autocracy score from the democracy score. The resulting unified POLITY scale ranges from +10 (strongly democratic) to -10 (strongly autocratic).

*Responses:*

Numeric.

*Source(s):* Polity 5 (Marshall and Jaggers 2020).

*Notes:* Standardized authority codes (i.e. -66, -77, -88) are set to missing for the online graphs.

*Data release:* 5-13.

*Citation:* Polity 5 (Marshall and Jaggers 2020).

*Years:* 1789-2020

# Democracy Indicators (further readings)

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In addition to the V-Dem dataset, check out more data of democracy indicators

<https://xmarquez.github.io/democracyData/index.html>

# Problem: Multiple Population Data Sources!

We have two population data sources, with different coverage of years.

## 9.6.2 Population total (E) (e\_mipopula)

*Question:* What is the total population (in thousands)?

*Source(s):* Clio Infra ([clio-infra.eu](http://clio-infra.eu)), drawing on Goldewijk, Beusen, Janssen (2010), History Database of Global Environment ([www.pbl.nl/hyde](http://www.pbl.nl/hyde)).

*Notes:* Missing data within a time-series is interpolated using linear interpolation.

*Data release:* 2-13.

*Citation:* Clio Infra ([clio-infra.eu](http://clio-infra.eu)).

*Years:* 1800-2000

## 9.6.9 Population (E) (e\_wb\_pop)

*Question:* What is the total population?

*Clarification:* Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values shown are midyear estimates.

*Scale:* Continuous

*Source(s):* (1) United Nations Population Division. World Population Prospects: 2019 Revision.  
(2) Census reports and other statistical publications from national statistical offices, (3) Eurostat: Demographic Statistics, (4) United Nations Statistical Division. Population and Vital Statistics Report (various years), (5) U.S. Census Bureau: International Database, and (6) Secretariat of the Pacific Community: Statistics and Demography Programme.

*Data release:* 9-13.

*Citation:* World Bank (2022)

*Years:* 1960-2021

# Multiple Population Data Sources

Consistency? Check years that are available in both datasets.

```
d_pop_overlap <- d |> select(country_text_id, year, starts_with("population_")) |>
  drop_na()
print(d_pop_overlap, n = 3)
```

```
## # A tibble: 5,818 x 4
##   country_text_id    year population_ClioInfra population_WorldBank
##   <chr>           <dbl>            <dbl>            <dbl>
## 1 MEX              1960            38578.          37771861
## 2 MEX              1961            39998.          38966049
## 3 MEX              1962            41418.          40195318
## # i 5,815 more rows
```

```
unique(d_pop_overlap$year)
```

```
## [1] 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974
## [16] 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989
## [31] 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000
```

```
cor(d_pop_overlap$population_ClioInfra, d_pop_overlap$population_WorldBank)
```

```
## [1] 0.9997128
```

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# Set a Rule to Merge the Two Population Columns

- ▶ Different units: Divide `population_WorldBank` by 1000 (so that the unit of population is “in thousands”)
- ▶ Different coverage but almost perfect correlation
  - ▶ For years that only one dataset has coverage, take the value from the dataset that has available data points.
  - ▶ For years that both datasets have coverage, take their mean.

That means, effectively, we are taking the `mean` and allow `na.rm = TRUE`. Think about it.

# Merge the Two Population Columns

Below is an implementation of the rule we have just set. The output of this step is a new variable called population which aggregate data from both sources.

```
# STEP 1: "Harmonize" the units
d <- d |> mutate(population_WorldBank = population_WorldBank / 1000)

# STEP 2 Method 1: Slower but use only tidyverse functionality
# [Slow! Not recommended!]
d <- d |> rowwise() |>
  mutate(population = mean(c_across(c("population_ClioInfra", "population_WorldBank")),
                            na.rm = TRUE), .after = population_WorldBank) |>
  ungroup()

# STEP 2 Method 2: Faster but use a non-tidyverse function rowMeans()
# and create a temporary vector tmp_population, which I remove after use with rm()
# [Faster !Recommended!]
tmp_population <- d |> select(population_ClioInfra, population_WorldBank) |> rowMeans(na.rm = TRUE)
d <- d |> mutate(population = !(tmp_population), .after = population_WorldBank)

rm(tmp_population)

# Remove the columns we no longer need
d <- d |> select(-population_ClioInfra, -population_WorldBank)
```

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# Sanity Check

```
summary(d %>% select(-country_text_id, -year, -region))
```

```
## life_expectancy      gdppc          population      democracy_binary
## Min.   : 1.50   Min.   : 0.286   Min.   :    17.9   Min.   :0.000
## 1st Qu.:35.50  1st Qu.: 1.599   1st Qu.: 1246.3  1st Qu.:0.000
## Median :50.30  Median :  2.774   Median : 4234.3  Median :0.000
## Mean   :51.37  Mean   :  7.194   Mean   :23083.3  Mean   :0.364
## 3rd Qu.:67.10  3rd Qu.:  7.606   3rd Qu.:11914.2  3rd Qu.:1.000
## Max.   :85.30  Max.   :156.628   Max.   :1412360.0 Max.   :1.000
## NA's   :1232   NA's   :4571     NA's   :2981     NA's   :7623
## democracy_lexical democracy_polity5
## Min.   :0.000   Min.   :-88.000
## 1st Qu.:0.000   1st Qu.: -7.000
## Median :2.000   Median : -3.000
## Mean   :2.338   Mean   : -3.616
## 3rd Qu.:4.000   3rd Qu.:  7.000
## Max.   :6.000   Max.   : 10.000
## NA's   :675     NA's   :8195
```

*Always watch out for when you see NA, especially when the number is non-trivial!*

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# Check Data Availability

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```
check_data_available <- d |>
  mutate(Available = (!is.na(life_expectancy) & !is.na(gdppc) & !is.na(population)))
# Check number of missing values by country-year
table(check_data_available$Available, useNA = "always")
```

```
##
## FALSE  TRUE  <NA>
## 6003 17590      0
check_data_available |> print(n = 3)
```

```
## # A tibble: 23,593 x 10
##   country_text_id  year region life_expectancy gdppc population democracy_binary
##   <chr>          <dbl>  <dbl>           <dbl>    <dbl>       <dbl>                <dbl>
## 1 MEX            1800     17           26.9    1.35      5100             NA
## 2 MEX            1801     17           26.9    1.34      5174.            NA
## 3 MEX            1802     17           26.9    1.32      5249.            NA
## # i 23,590 more rows
## # i 3 more variables: democracy_lexical <dbl>, democracy_polity5 <dbl>,
## #   Available <lgl>
```

# Check Data Availability (con'd)

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```
check_data_available_wide <- check_data_available |>
  select(country_text_id, year, Available) |>
  pivot_wider(names_from = "country_text_id", values_from = "Available",
              names_prefix = "c_") |>
  arrange(year)

check_data_available_wide |> print(n = 3)
```

```
## # A tibble: 184 x 203
##   year c_MEX c_SWE c_CHE c_JPN c_MMR c_RUS c_EGY c_YEM c_COL c_POL c_BRA c_USA
##   <dbl> <lgl> <lgl> <lgl> <lgl> <lgl> <lgl> <lgl> <lgl> <lgl> <lgl>
## 1 1800 TRUE  TRUE  TRUE  TRUE  FALSE FALSE TRUE  FALSE TRUE  NA   TRUE  FALSE
## 2 1801 TRUE  TRUE  TRUE  TRUE  FALSE FALSE TRUE  FALSE TRUE  NA   TRUE  FALSE
## 3 1802 TRUE  TRUE  TRUE  TRUE  FALSE FALSE TRUE  FALSE TRUE  NA   TRUE  FALSE
## # i 181 more rows
## # i 190 more variables: c_PRT <lgl>, c_BOL <lgl>, cHTI <lgl>, c_PER <lgl>,
## #   c_VDR <lgl>, c_AFG <lgl>, c_ARG <lgl>, c_ETH <lgl>, c_IND <lgl>,
## #   c_KOR <lgl>, c_THA <lgl>, c_VEN <lgl>, c_IDN <lgl>, c_NPL <lgl>,
## #   c_AUS <lgl>, c_CHL <lgl>, c_FRA <lgl>, c_DEU <lgl>, c_GTM <lgl>,
## #   c_IRN <lgl>, c_LBR <lgl>, c_MAR <lgl>, c_NLD <lgl>, c_ESP <lgl>,
## #   c_TUN <lgl>, c_TUR <lgl>, c_GBR <lgl>, c_URY <lgl>, c_CHN <lgl>, ...
```

# Check Data Availability (con'd)

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```
# Check, for each year, the availability of each column
check_data_available_by_column <- d |>
  group_by(year) |>
  summarise(
    life_expectancy = sum(is.na(life_expectancy)),
    gdppc = sum(is.na(gdppc)),
    population = sum(is.na(population))
  )
# summarise_at(vars(life_expectancy, gdppc, population), ~sum(!is.na(.)))
# above is an alternative way to write the summarise() step

check_data_available_by_column |> print(n = 3)
```

```
## # A tibble: 184 x 4
##   year life_expectancy gdppc population
##   <dbl>         <int>   <int>      <int>
## 1 1800            16     31        25
## 2 1801            16     31        25
## 3 1802            17     32        26
## # i 181 more rows
```

# Save Cleaned Data

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**OK. All look good! We are ready to create some beautiful data visualization.**

```
dir.create("Lec_07/data")
```

```
## Warning in dir.create("Lec_07/data"): 'Lec_07/data' already exists
saveRDS(d, "Lec_07/data/wealth_and_health.rds")
```

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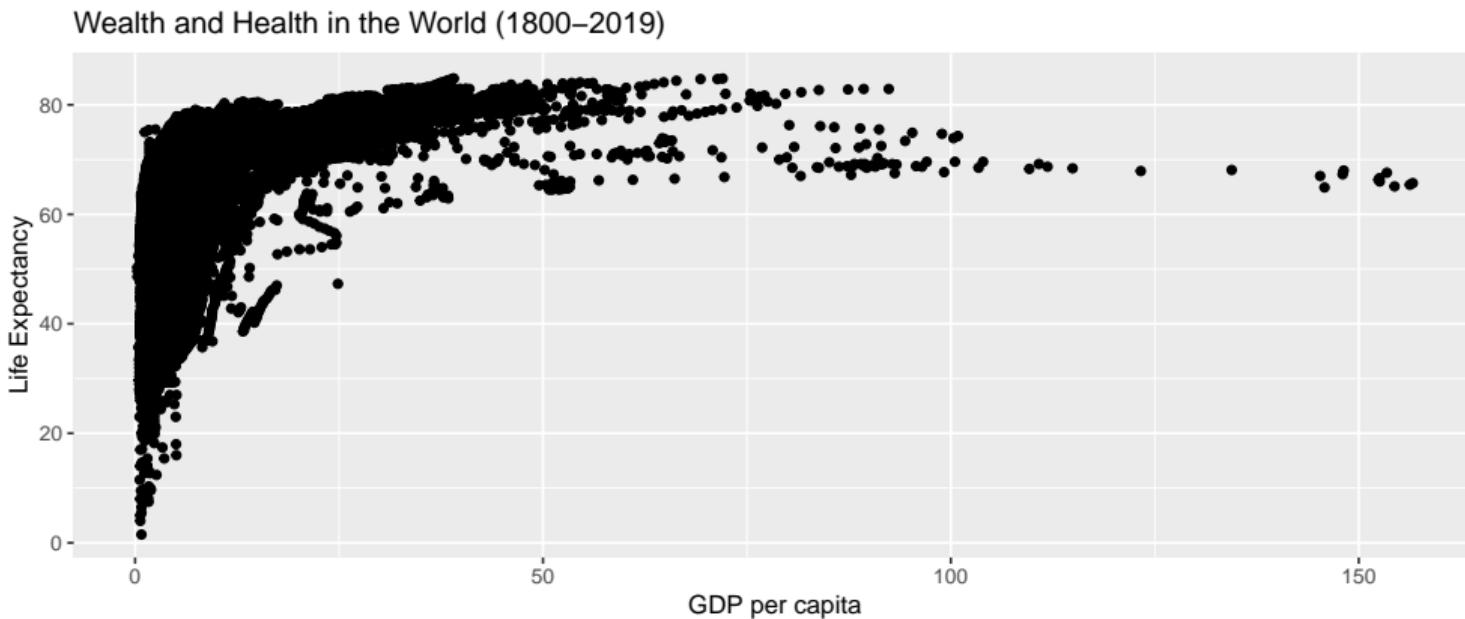
Data Viz Basics

# Data Viz Basics

# Simplest Possible Visualization

Plot a scatter plot with ALL the data points.

```
d |>
  ggplot(aes(x = gdppc, y = life_expectancy)) +
  geom_point() +
  labs(x = "GDP per capita", y = "Life Expectancy",
      title = "Wealth and Health in the World (1800-2019)",
      caption = "By Haohan Chen. Data source: V-Dem v.13")
```



# Store Your First Data Visualization

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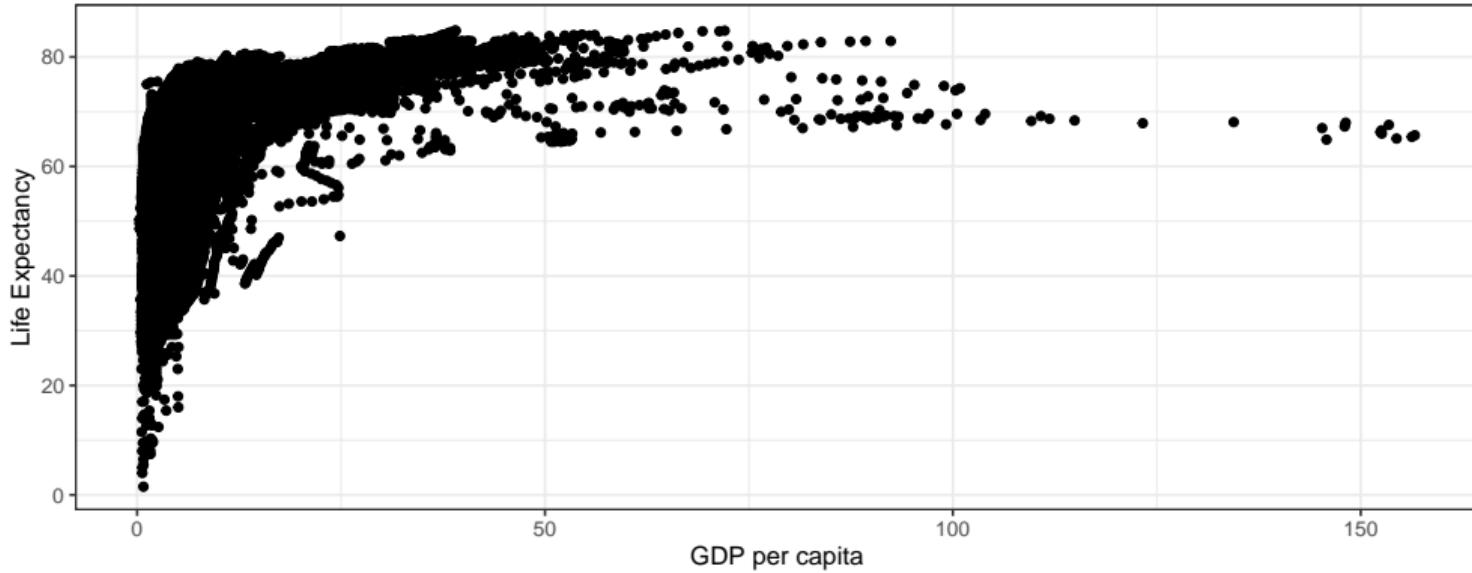
To make your nice data visualization stay. You can either (temporarily) save it in your R Environment, or save it as a file in your folder.

```
# Store in R environment (temporary)
p_all <- d |>
  ggplot(aes(x = gdppc, y = life_expectancy)) +
  geom_point() +
  labs(x = "GDP per capita", y = "Life Expectancy",
       title = "Wealth and Health in the World (1800-2019)",
       caption = "By Haohan Chen. Data source: V-Dem v.13")
# Save plot as a .rds file in your folder
dir.create("Lec_07/1_data_visualization_1/figures")
saveRDS(p_all, "Lec_07/1_data_visualization_1/figures/welath_and_health_all.rds")
# Save plot as a PDF file in your folder
ggsave(filename = "Lec_07/1_data_visualization_1/figures/welath_and_health_all.pdf",
       plot = p_all, width = 9, height = 4)
```

## Set Themes: theme\_bw

```
p_all + theme_bw()
```

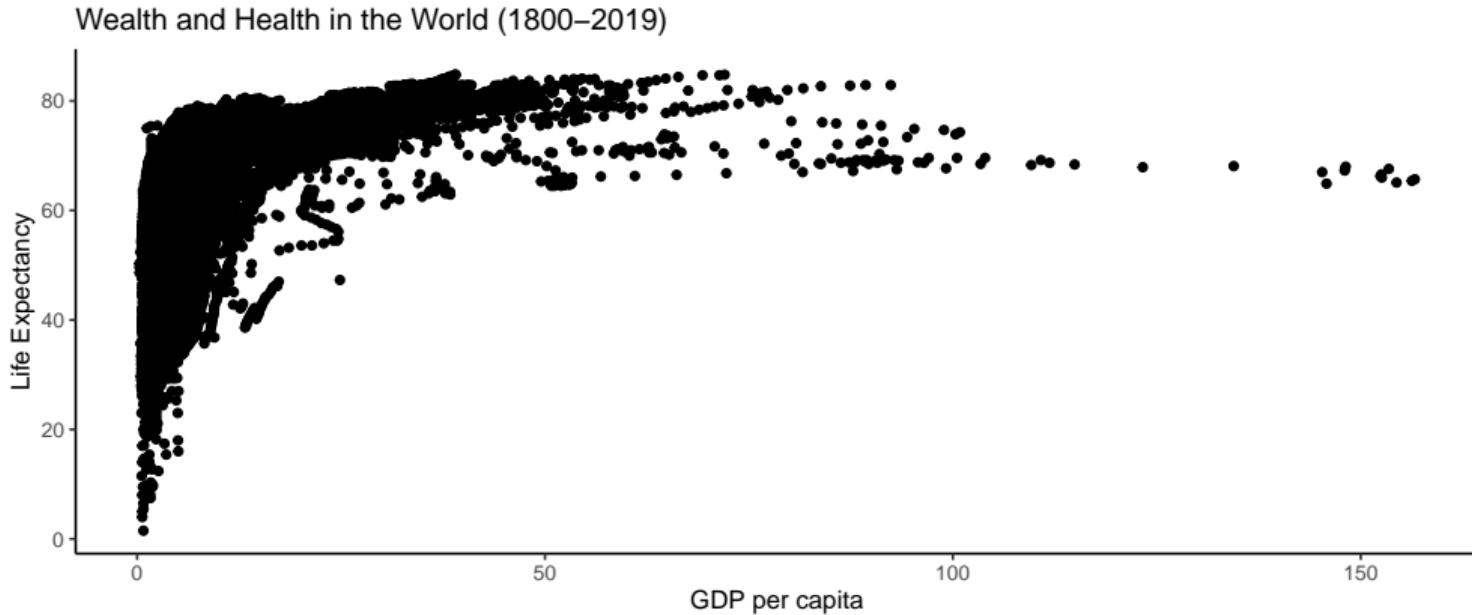
Wealth and Health in the World (1800–2019)



By Haohan Chen. Data source: V-Dem v.13

# Set Themes: theme\_classic

```
p_all + theme_classic()
```



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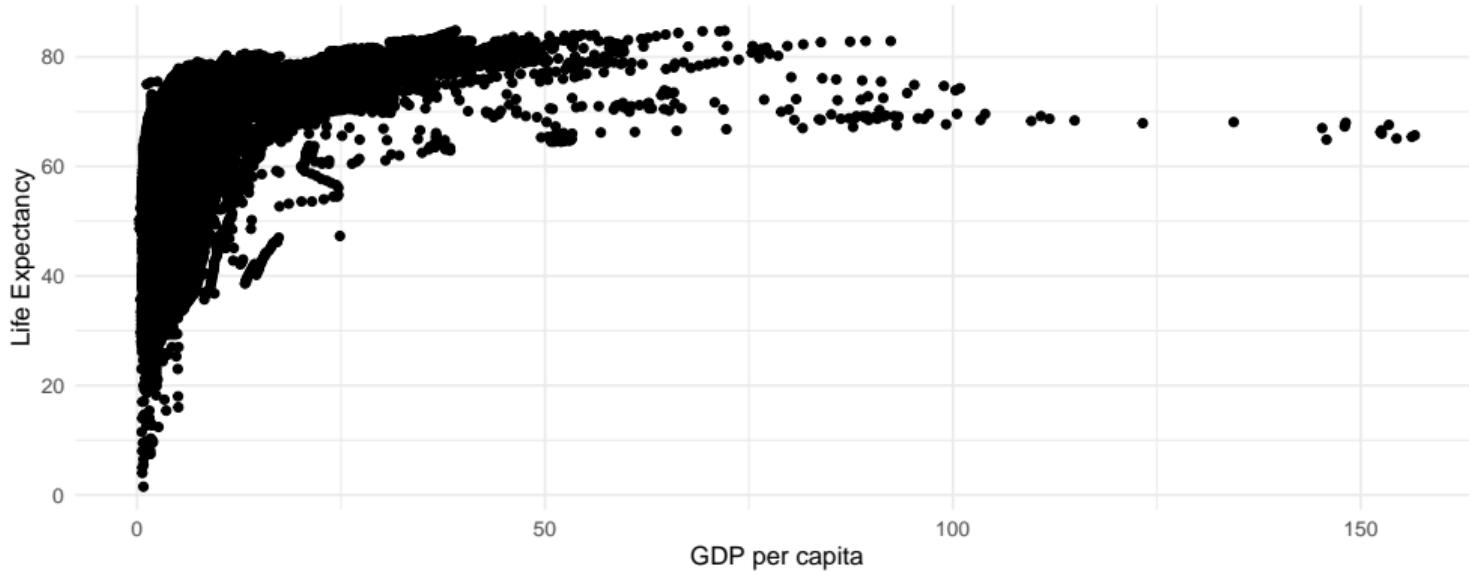
# Set Themes: theme\_minimal

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```
p_all + theme_minimal()
```

Wealth and Health in the World (1800–2019)



By Haohan Chen. Data source: V-Dem v.13

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# Other Fancy Themes: The Economist

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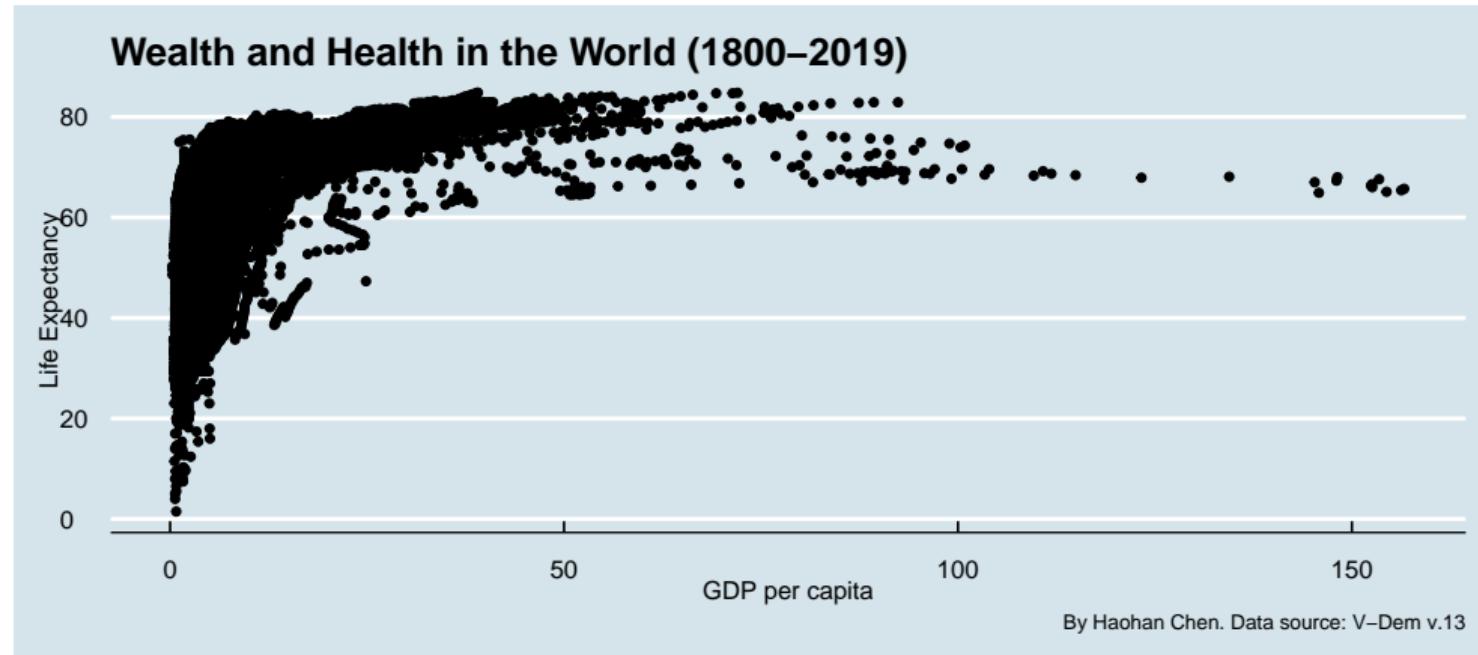
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```
# install.packages("ggthemes") # install the package upon your first use.  
# Take a look at the package's website: https://yutannihilation.github.io/allYourFigureAreBelongToUs/ggthemes/  
library(ggthemes)  
p_all + theme_economist()
```



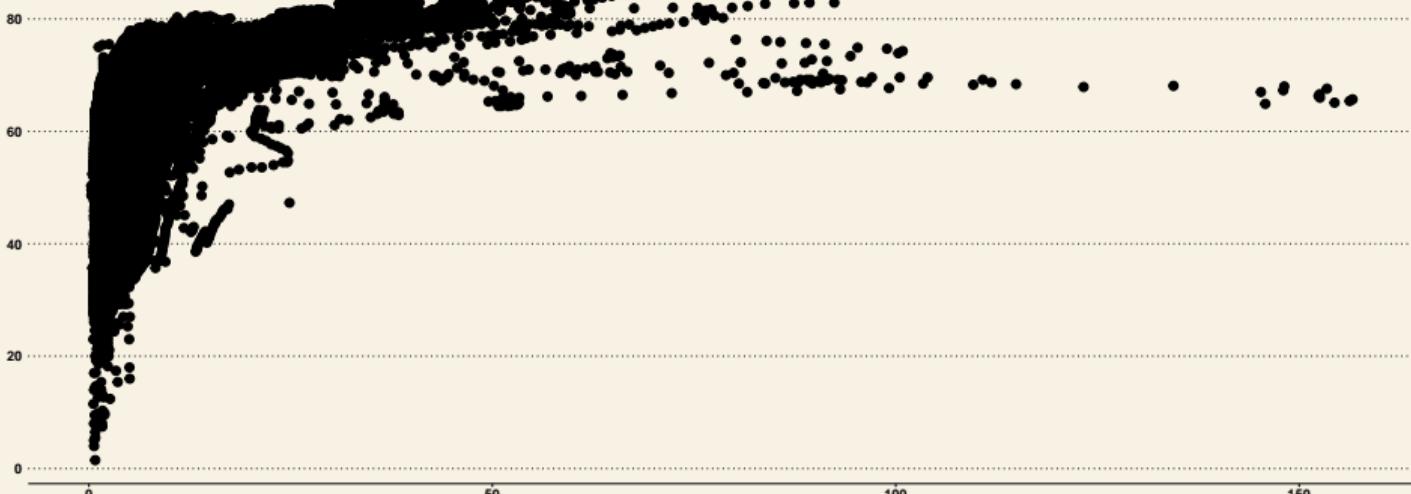
# Other Fancy Themes: The WSJ

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```
p_all + theme_wsj(base_size = 6)
```

Wealth and Health in the World (1800-2019)



By Haohan Chen. Data source: V-Dem v.13

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