

Introduction to ggplot2

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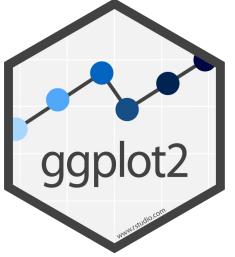
Relax

Experiment

Make Mistakes

Learn

Enjoy



Outline

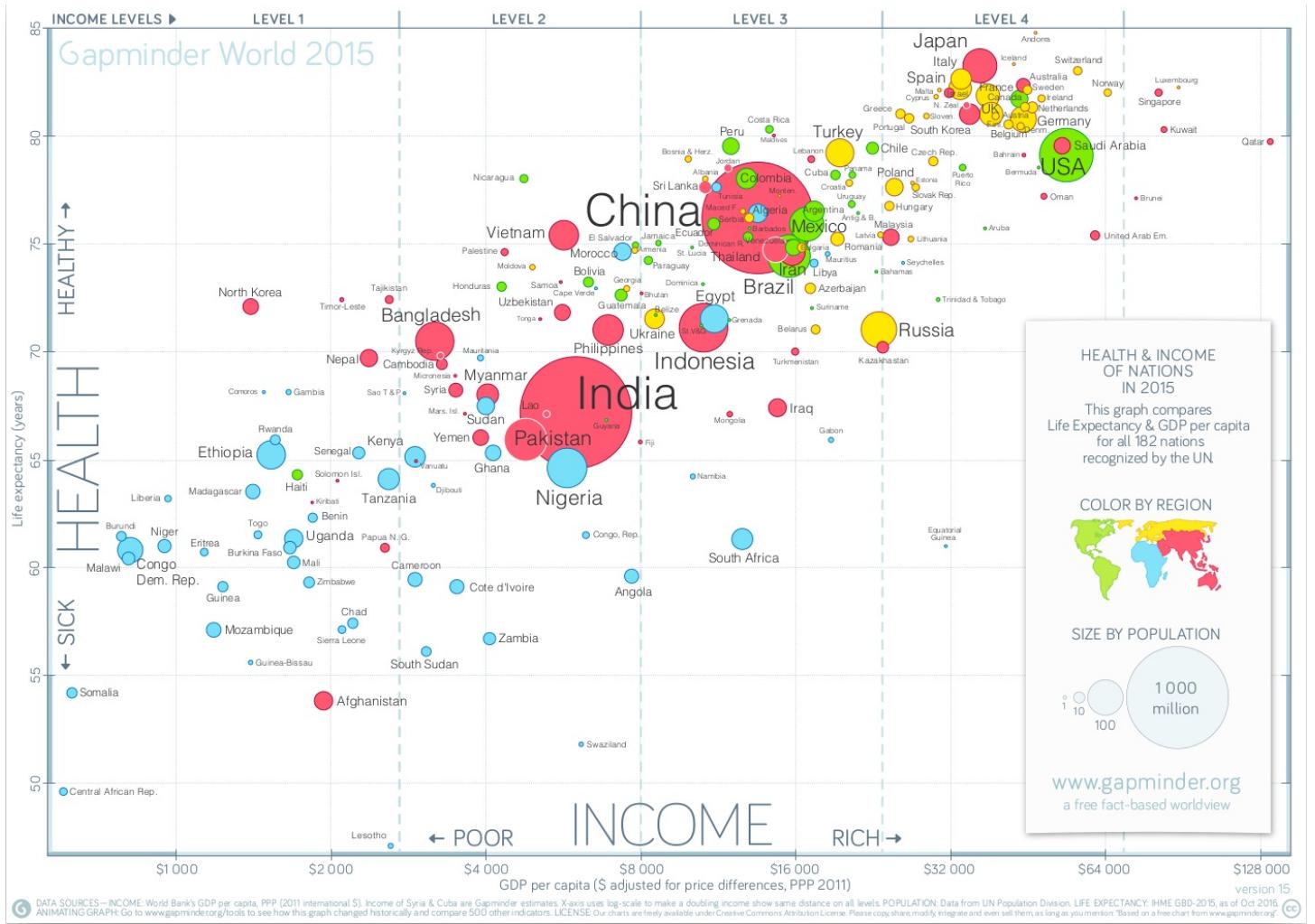
Gapminder Data

Plotting Data

Facetting Plots

Summary







Gapminder Data

- Population (Total)
- GDP per capita (US\$, inflation-adjusted)
- Life expectancy at birth, in years
- Infant Mortality per 1000 births
- Total Fertility (children per woman)



First 10 Observations

continent	country	year	pop	gdpPercap	lifeexp	infmort	fertility
Europe	Albania	1960	1636054	NA	62.87	115.4	6.19
Europe	Albania	1965	1896125	NA	66.59	94.1	5.59
Europe	Albania	1970	2150602	NA	67.83	76.8	5.05
Europe	Albania	1975	2411229	NA	69.77	63.1	4.39
Europe	Albania	1980	2681245	1056.75	71.39	64.0	3.68
Europe	Albania	1985	2966799	1056.50	72.71	45.9	3.23
Europe	Albania	1990	3281453	980.16	73.30	35.1	2.97
Europe	Albania	1995	3106727	909.74	73.70	29.1	2.72
Europe	Albania	2000	3121965	1180.87	74.70	23.2	2.38
Europe	Albania	2005	3082172	1555.24	76.20	18.3	1.92



Last 10 Observations

continent	country	year	pop	gdpPercap	lifeexp	infmort	fertility
Africa	Zimbabwe	1970	5206311	515.23	57.22	72.4	7.42
Africa	Zimbabwe	1975	6170284	550.34	59.41	70.3	7.40
Africa	Zimbabwe	1980	7289083	501.28	62.48	66.4	7.10
Africa	Zimbabwe	1985	8862601	507.41	64.86	53.6	6.22
Africa	Zimbabwe	1990	10484771	536.20	63.00	51.2	5.18
Africa	Zimbabwe	1995	11683136	510.82	56.00	60.1	4.43
Africa	Zimbabwe	2000	12499981	535.20	47.90	63.5	4.07
Africa	Zimbabwe	2005	12984418	351.02	45.10	61.0	3.97
Africa	Zimbabwe	2010	13973897	288.57	49.10	55.8	3.72
Africa	Zimbabwe	2015	15602751	NA	59.30	46.6	3.35

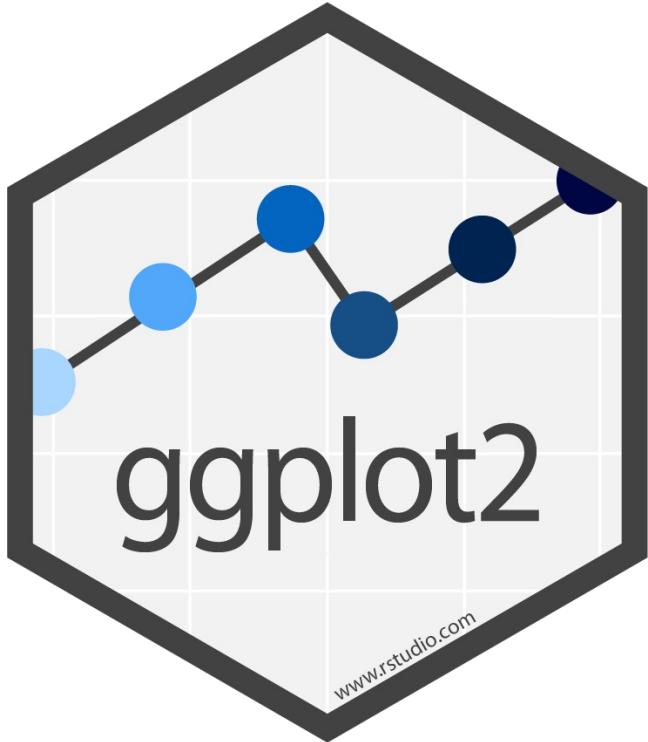


Questions of Interest

What are the time trends for Portugal?

How does Portugal compare to other European countries?

How does Portugal perform on health and wealth?



```
install.packages("ggplot2")  
install.packages("magrittr")  
install.packages("data.table")  
install.packages("here")
```



Imported Gapminder Data

```
library(data.table)
library(here)

gm <- fread(here("data", "gapminder.csv"))

# Create factor (categorical) variables to be used later.

gm[, continent:=as.factor(continent)]
gm[, country:=as.factor(country)]
gm[, fyear:=as.factor(year)]
```

Look at Imported Data



gm

```
##      continent country year      pop gdpPercap lifeexp infmort fertility fyear
## 1:    Europe  Albania 1960 1636054        NA  62.87   115.4     6.19  1960
## 2:    Europe  Albania 1965 1896125        NA  66.59    94.1     5.59  1965
## 3:    Europe  Albania 1970 2150602        NA  67.83    76.8     5.05  1970
## 4:    Europe  Albania 1975 2411229        NA  69.77    63.1     4.39  1975
## 5:    Europe  Albania 1980 2681245 1056.7504  71.39    64.0     3.68  1980
## ---
## 2216: Africa Zimbabwe 1995 11683136 510.8200  56.00    60.1     4.43  1995
## 2217: Africa Zimbabwe 2000 12499981 535.1974  47.90    63.5     4.07  2000
## 2218: Africa Zimbabwe 2005 12984418 351.0233  45.10    61.0     3.97  2005
## 2219: Africa Zimbabwe 2010 13973897 288.5683  49.10    55.8     3.72  2010
## 2220: Africa Zimbabwe 2015 15602751        NA  59.30    46.6     3.35  2015
```

Structure of Gapminder Data



```
str(gm)
```

```
## Classes 'data.table' and 'data.frame': 2220 obs. of 9 variables:  
## $ continent: Factor w/ 5 levels "Africa", "Americas", ...: 4 4 4 4 4 4 4 4 4 4 ...  
## $ country : Factor w/ 185 levels "Albania", "Algeria", ...: 1 1 1 1 1 1 1 1 1 1 ...  
## $ year    : int 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 ...  
## $ pop     : int 1636054 1896125 2150602 2411229 2681245 2966799 3281453 3106727 3121965 3082172 ...  
## $ gdpPercap: num NA NA NA NA 1057 ...  
## $ lifeexp  : num 62.9 66.6 67.8 69.8 71.4 ...  
## $ infmort  : num 115.4 94.1 76.8 63.1 64 ...  
## $ fertility: num 6.19 5.59 5.05 4.39 3.68 3.23 2.97 2.72 2.38 1.92 ...  
## $ fyear   : Factor w/ 12 levels "1960", "1965", ...: 1 2 3 4 5 6 7 8 9 10 ...  
## - attr(*, ".internal.selfref")=<externalptr>
```

What are the time trends for Portugal?



Portuguese Data

Create a dataset for Portugal

```
# Portuguese Data
options(width = 100)
gmPT <- gm[country == "Portugal"]
gmPT
```

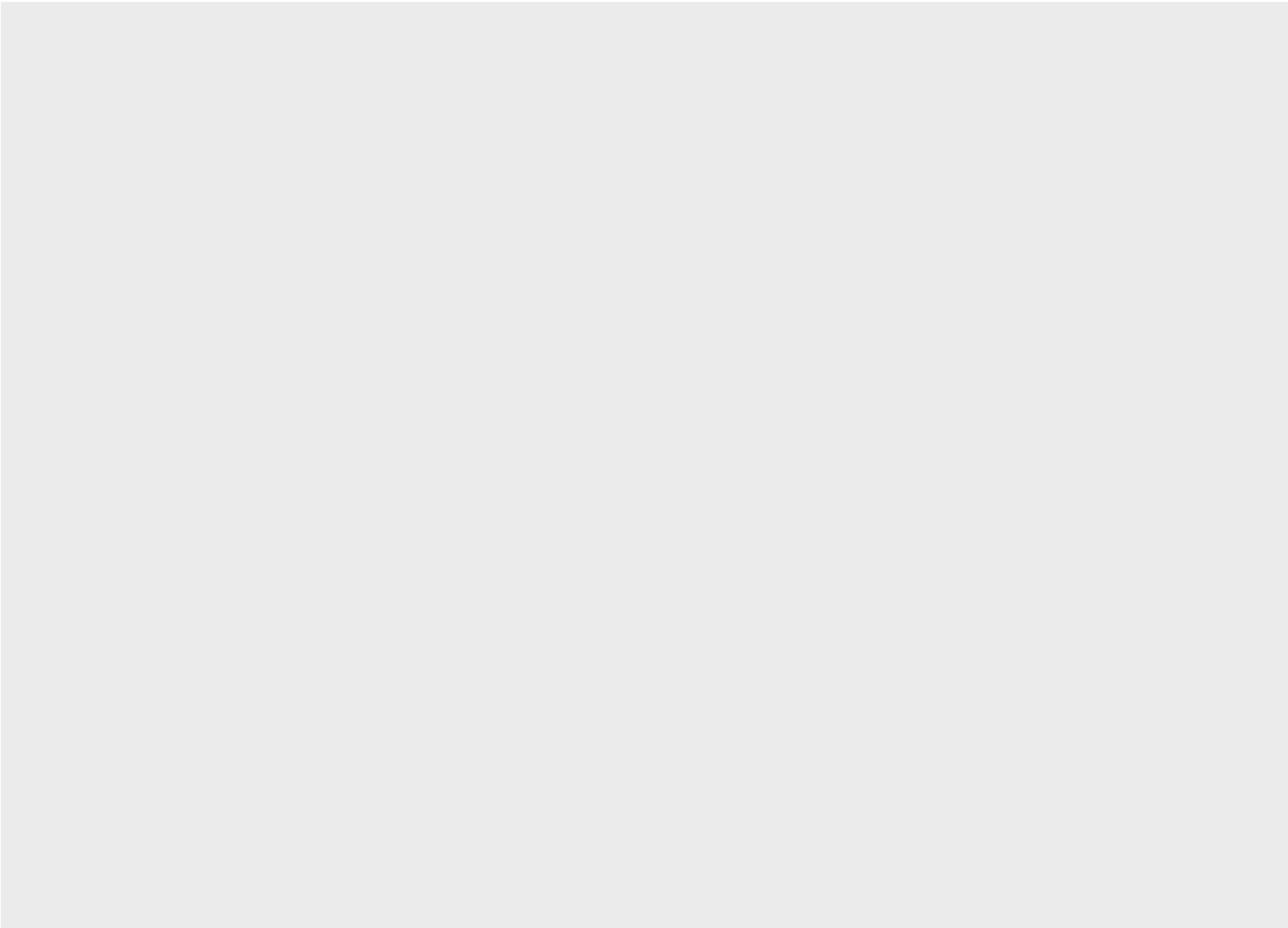
```
##    continent country year      pop gdpPercap lifeexp infmорт fertility fyyear
## 1:     Europe Portugal 1960 8875311 2363.976   64.23     84.6      3.16 1960
## 2:     Europe Portugal 1965 8888635 3212.569   66.17     66.4      3.18 1965
## 3:     Europe Portugal 1970 8670352 4615.613   67.14     55.4      2.99 1970
## 4:     Europe Portugal 1975 9185876 5398.299   68.90     36.0      2.71 1975
## 5:     Europe Portugal 1980 9755635 6518.493   71.71     22.8      2.29 1980
## 6:     Europe Portugal 1985 9929014 6693.814   73.22     16.5      1.78 1985
## 7:     Europe Portugal 1990 9890319 8854.322   74.20     11.5      1.54 1990
## 8:     Europe Portugal 1995 10078431 9455.050   75.50      7.4      1.48 1995
## 9:     Europe Portugal 2000 10278542 11412.078   76.80      5.5      1.47 2000
## 10:    Europe Portugal 2005 10480085 11663.632   78.40      3.7      1.41 2005
## 11:    Europe Portugal 2010 10584837 11805.935   79.90      3.1      1.33 2010
## 12:    Europe Portugal 2015 10349803        NA     80.80      3.0      1.31 2015
```

```
options(width = widthDefault)
```

Life Expectancy



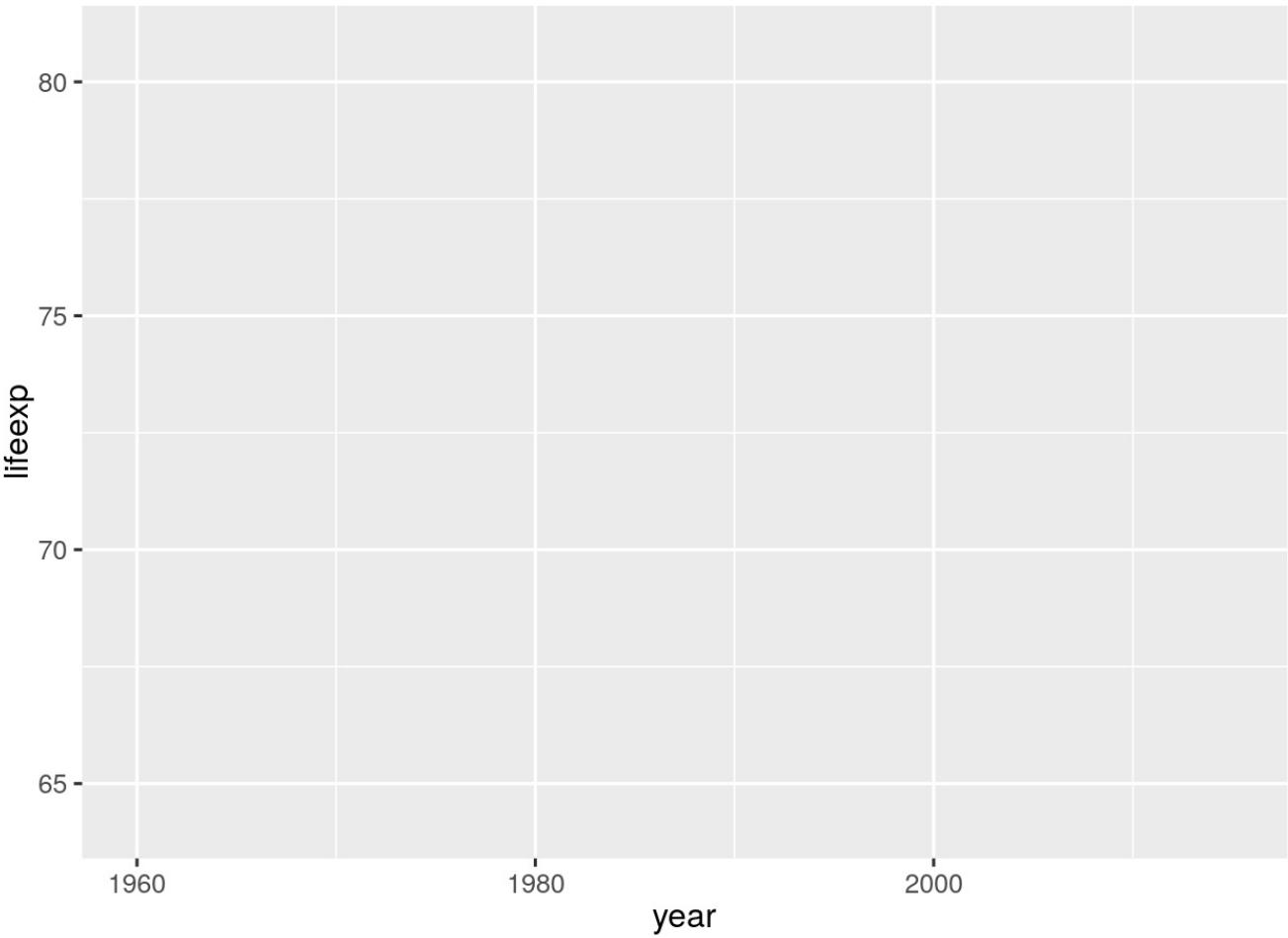
```
ggplot(gmPT)
```



Life Expectancy



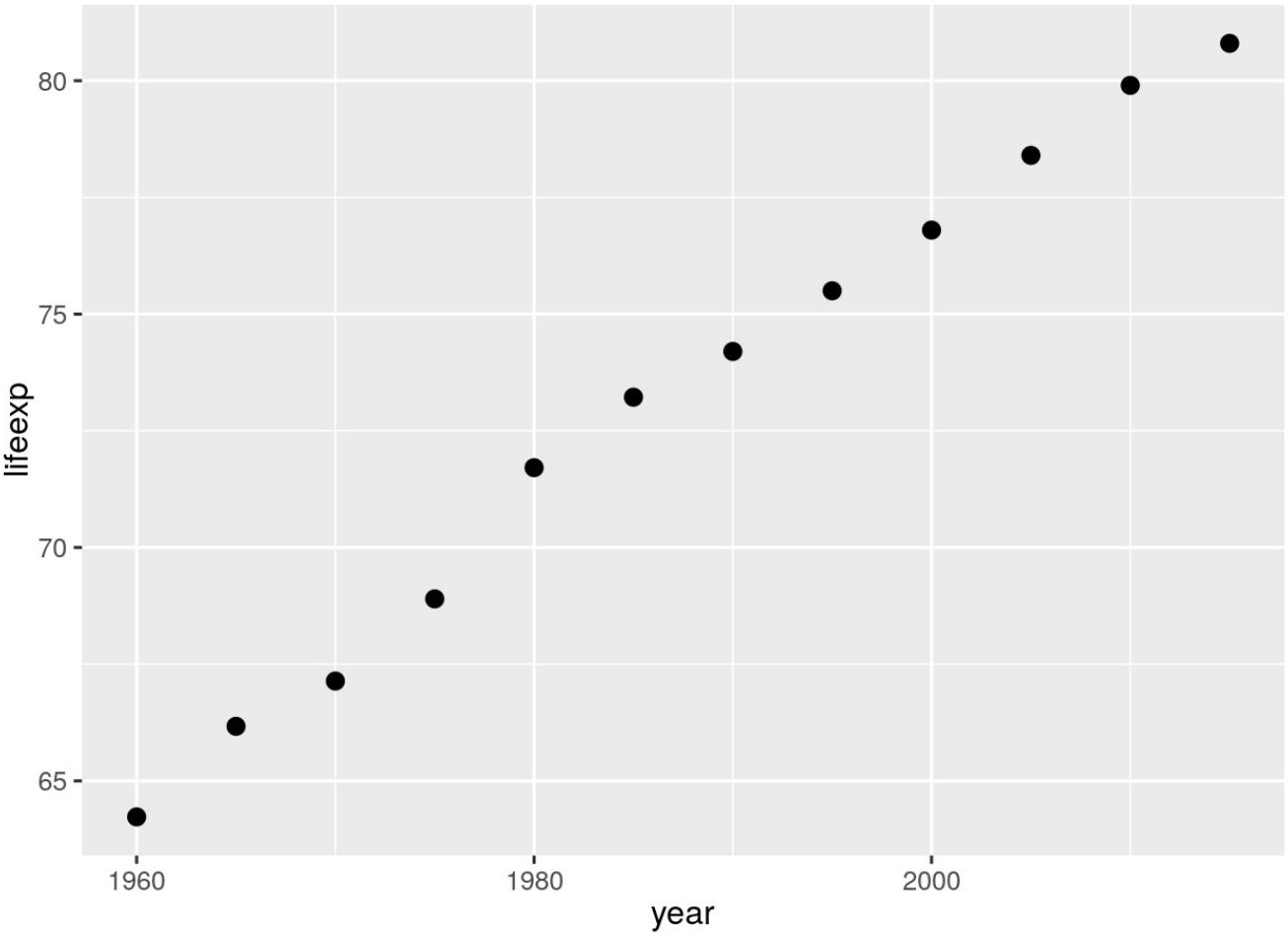
```
ggplot(gmPT, aes(year, lifeexp))
```



Life Expectancy - Points



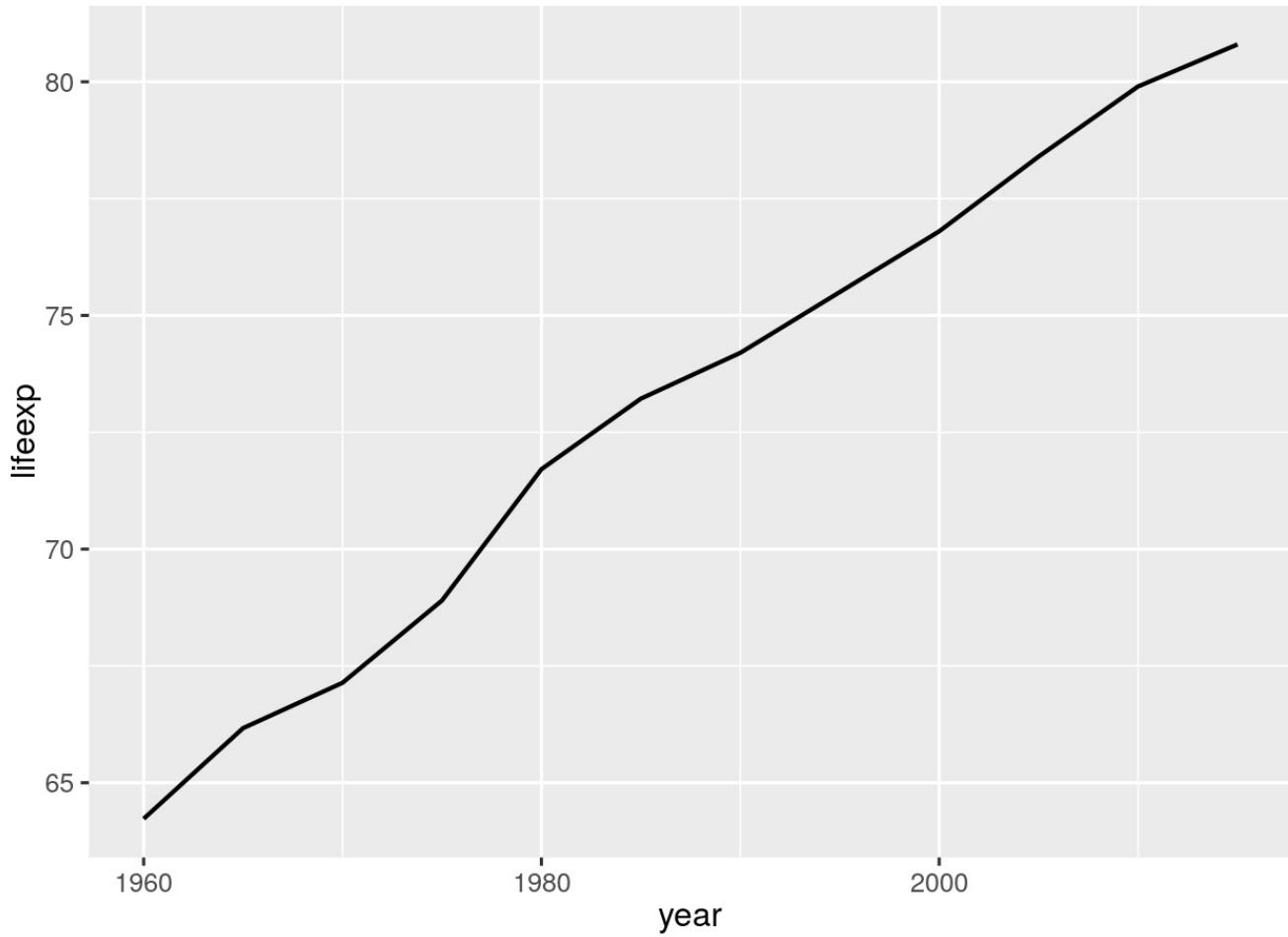
```
ggplot(gmPT, aes(year, lifeexp)) +  
  geom_point()
```



Life Expectancy - Line



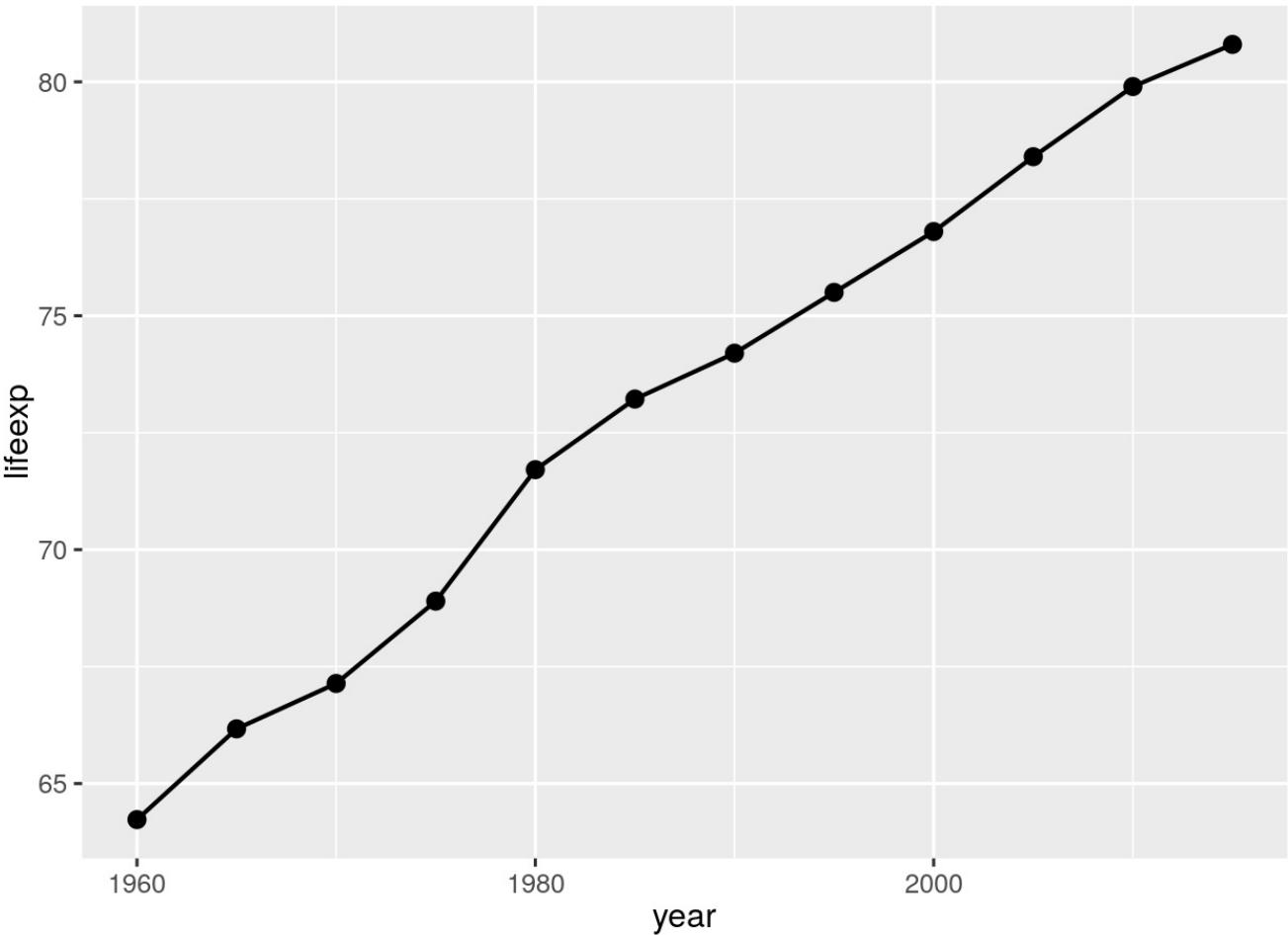
```
ggplot(gmPT, aes(year, lifeexp)) +  
  geom_line()
```



Life Expectancy - Points & Line



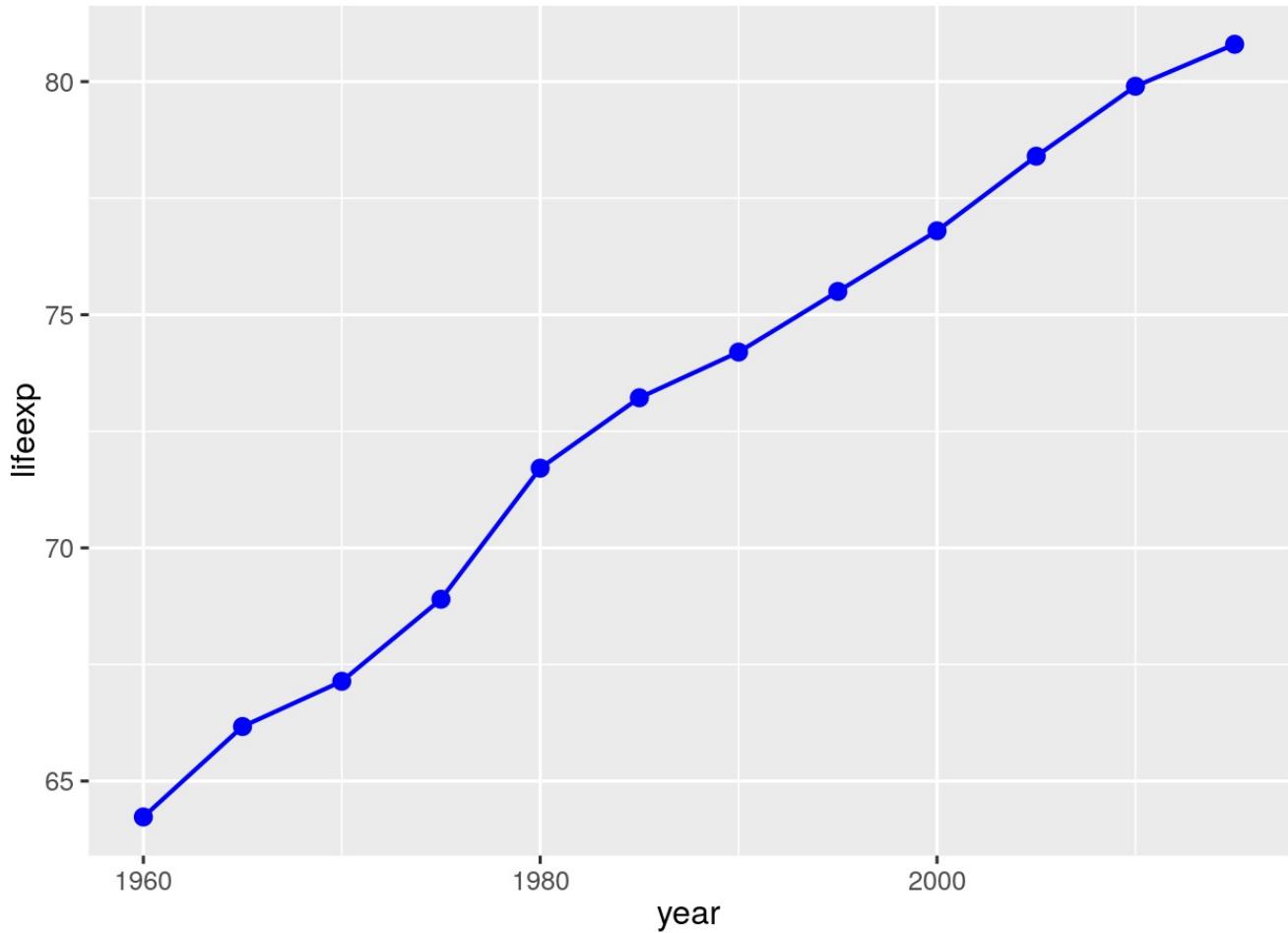
```
ggplot(gmPT, aes(year, lifeexp)) +  
  geom_point() +  
  geom_line()
```



Life Expectancy - Colour



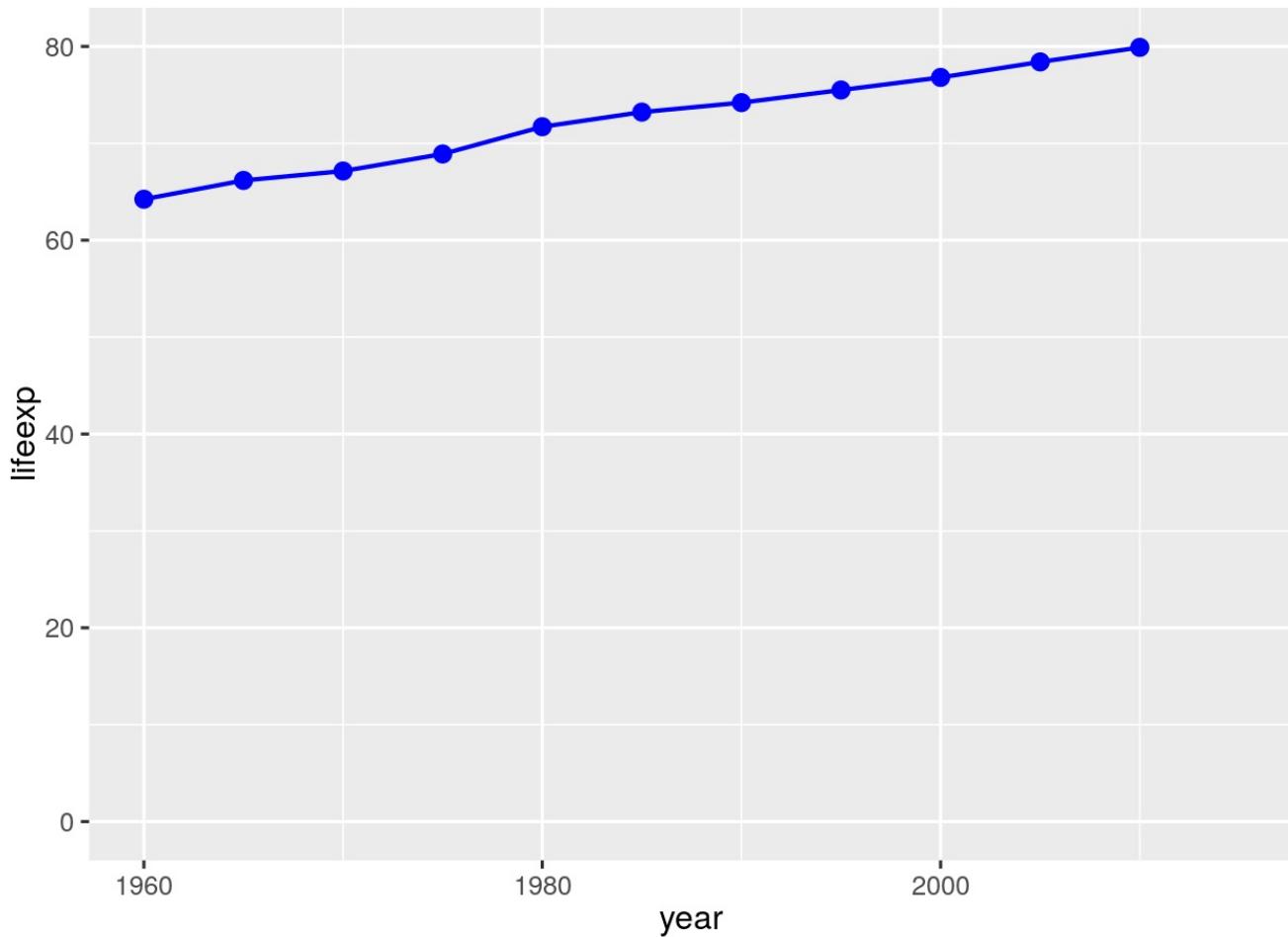
```
ggplot(gmPT, aes(year, lifeexp)) +  
  geom_point(colour="blue") +  
  geom_line(colour="blue")
```



Life Expectancy - Y-axis



```
ggplot(gmPT, aes(year, lifeexp)) +  
  geom_point(colour="blue") +  
  geom_line(colour="blue") +  
  scale_y_continuous(  
    limits=c(0, 80))
```

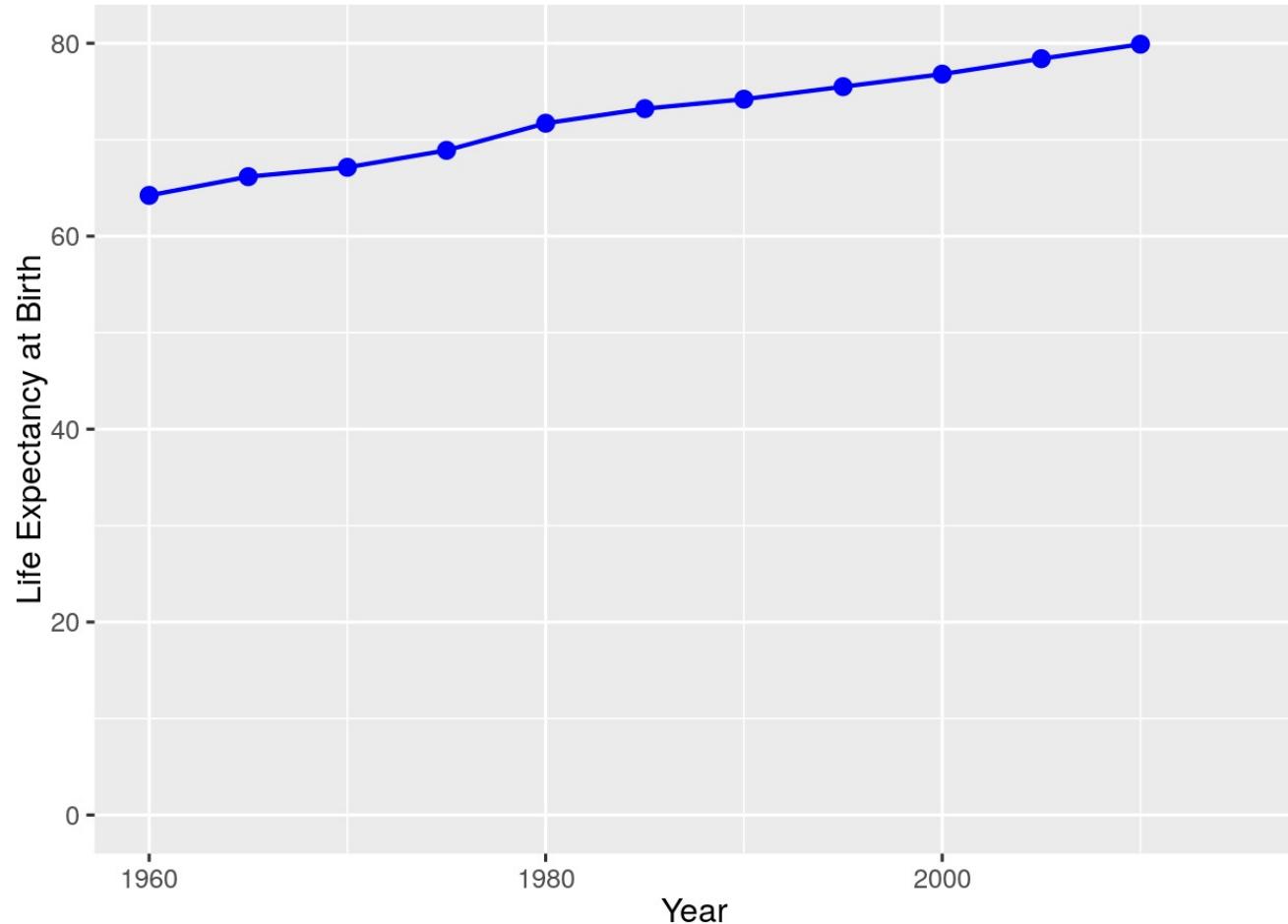


Life Expectancy - Axis labels



```
ggplot(gmPT, aes(year, lifeexp)) +  
  geom_point(colour="blue") +  
  geom_line(colour="blue") +  
  scale_y_continuous(  
    limits=c(0, 80)) +  
  xlab("Year") +  
  ylab("Life Expectancy at Birth")
```

Interpret this plot.



Exercises

Download: <https://ilustat.com/shared/ggplot2-Intro.zip>

Double Click on "ggplot2-Exercises.Rproj"

Open file "ggplot2-Exercises.Rmd"

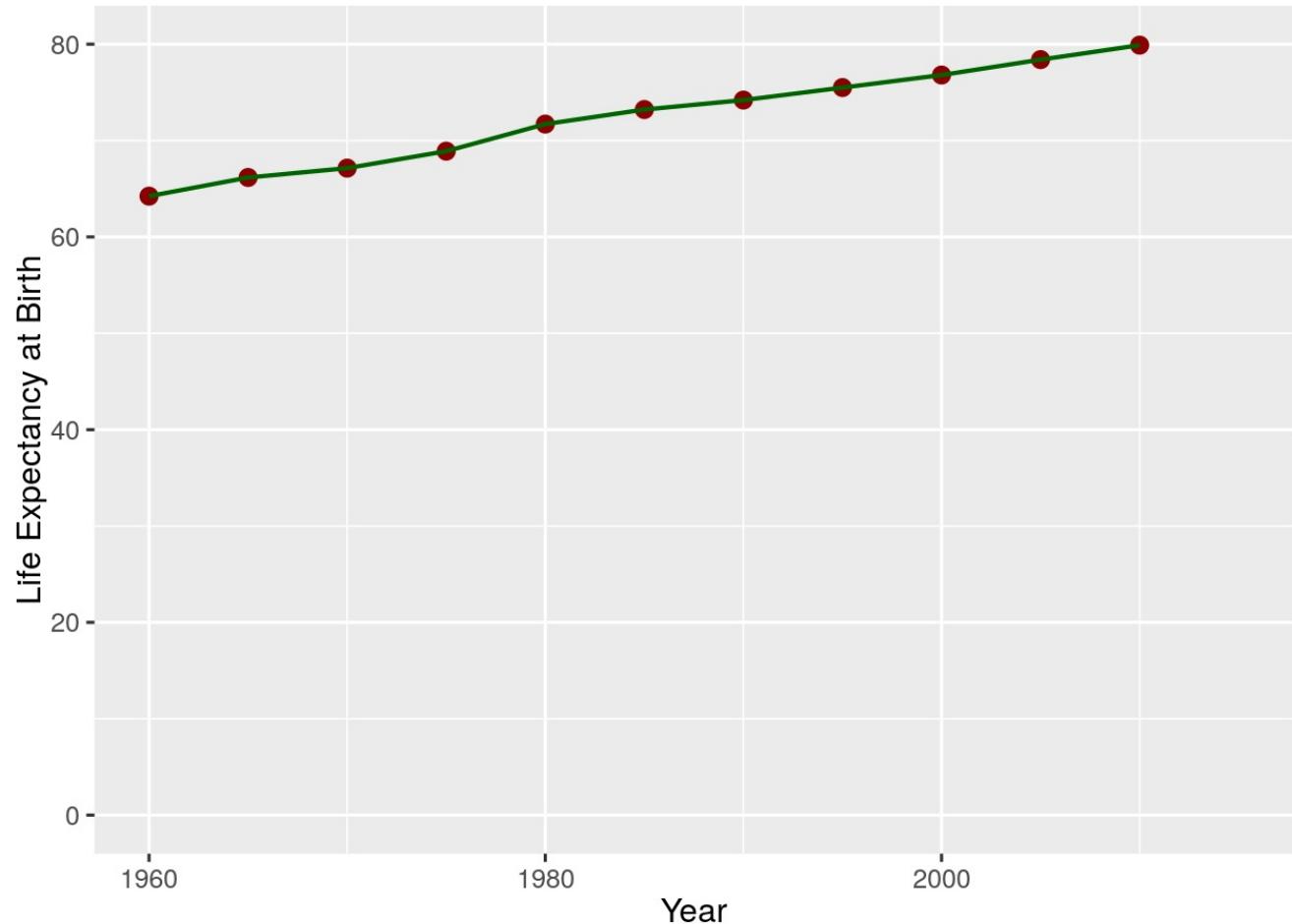
Complete "Exercise 1 - Portugal"



Some comments (i)

Piping data to ggplot2

```
library(magrittr)  
  
gm[country=="Portugal"] %>%  
  ggplot(aes(year, lifeexp)) +  
    geom_point(colour="darkred") +  
    geom_line(colour="darkgreen") +  
    scale_y_continuous(  
      limits=c(0, 80)) +  
    xlab("Year") +  
    ylab("Life Expectancy at Birth")
```

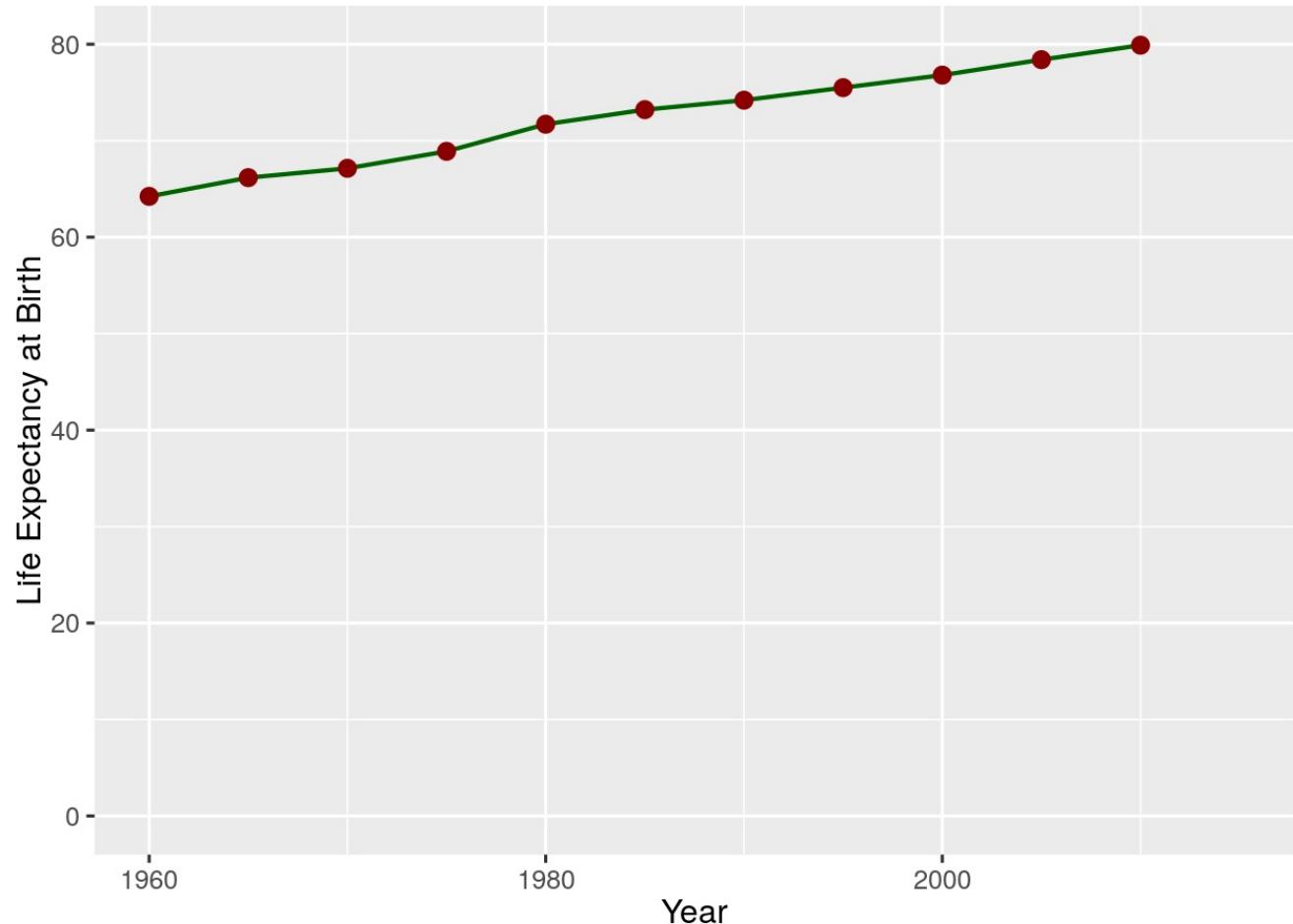


Some comments (ii)



Order matters

```
gm[country=="Portugal"] %>%  
  ggplot(aes(year, lifeexp)) +  
    geom_line(colour="darkgreen") +  
    geom_point(colour="darkred") +  
    scale_y_continuous(  
      limits=c(0, 80)) +  
    xlab("Year") +  
    ylab("Life Expectancy at Birth")
```



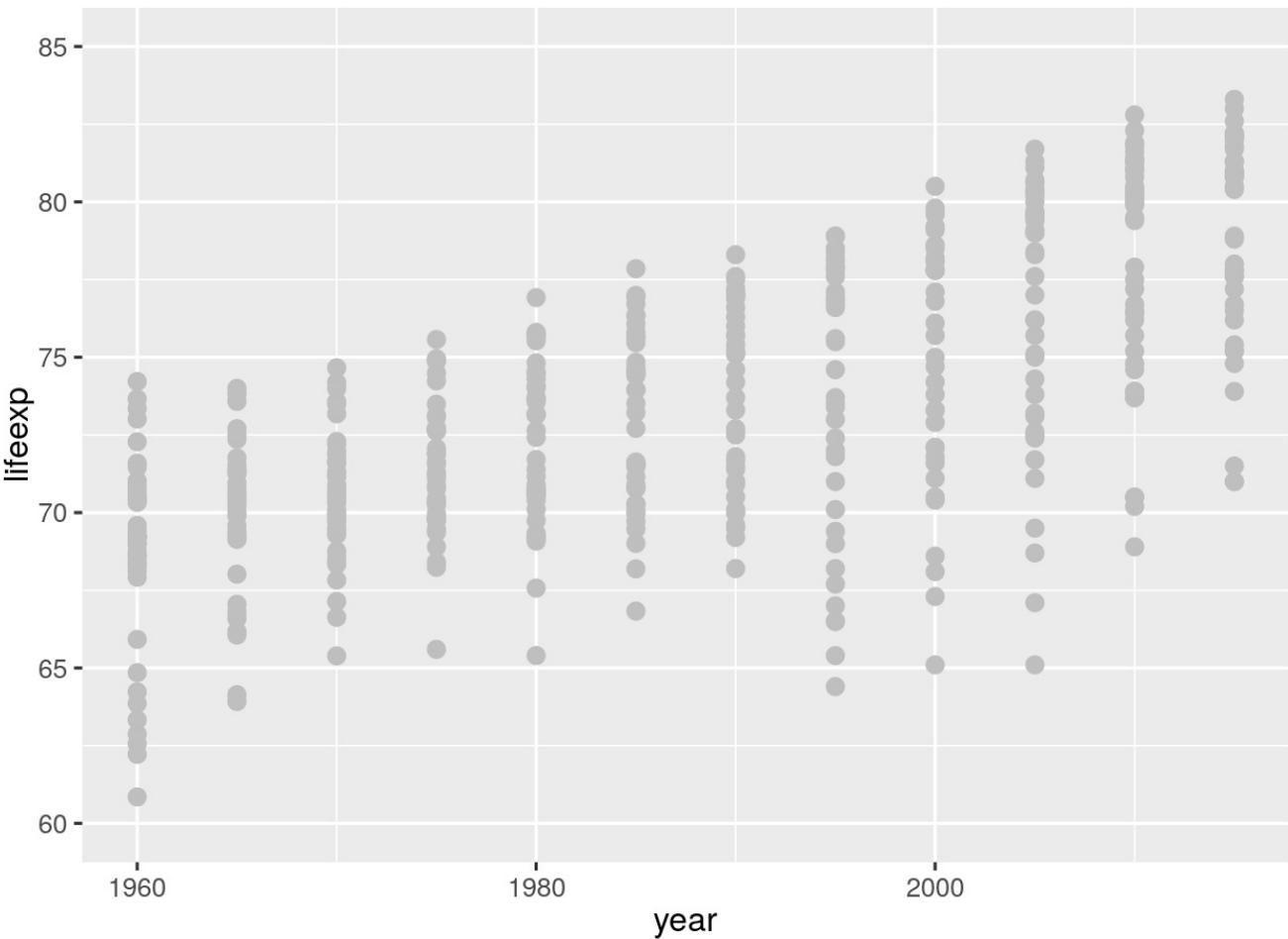
How does Portugal compare to other European countries?

Life Expectancy - Points



European Countries

```
gm[continent=="Europe"] %>%  
  ggplot(aes(year, lifeexp)) +  
  geom_point(colour="grey75") +  
  scale_y_continuous(limits=c(60, 85))
```

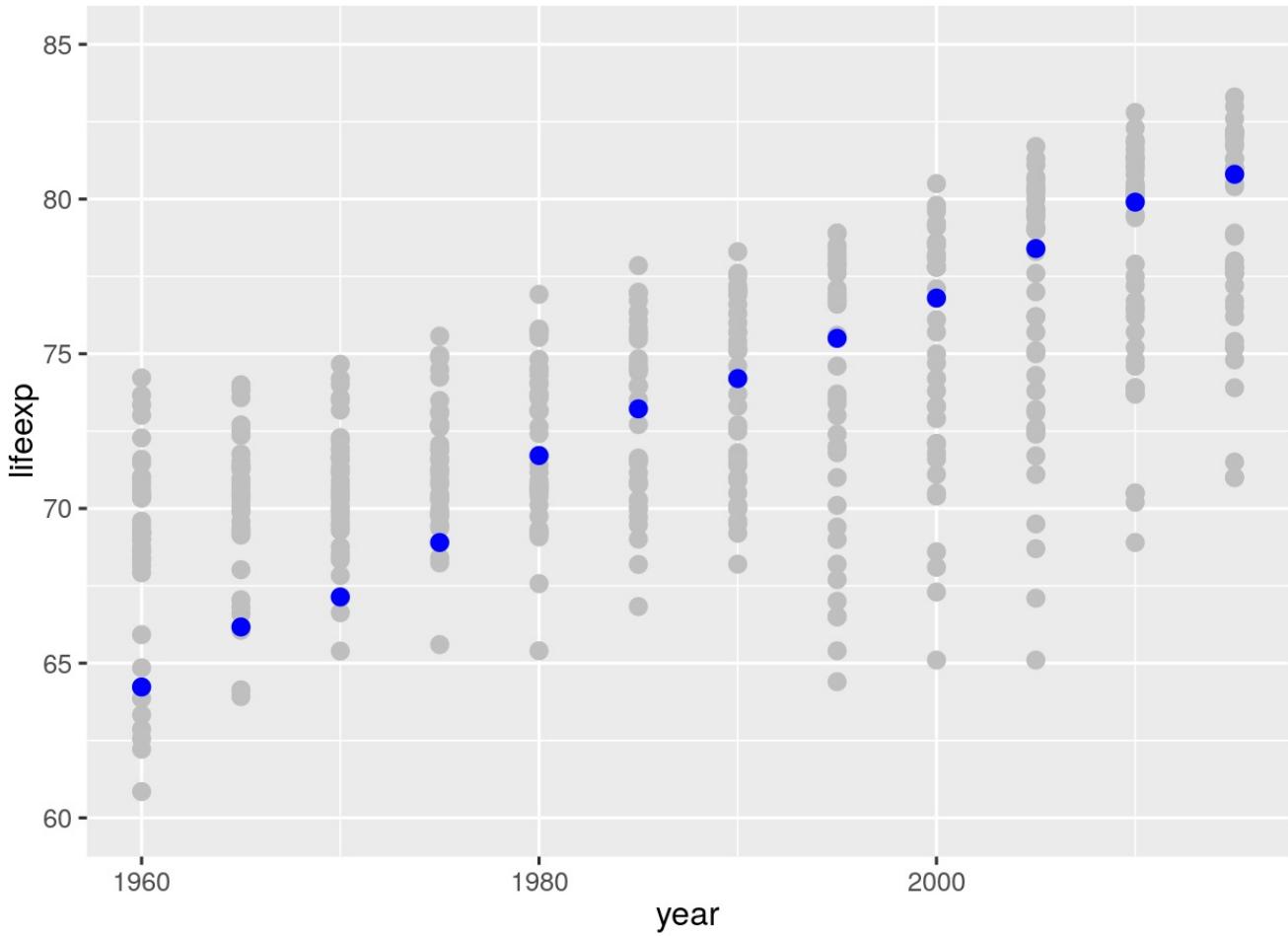


Life Expectancy - Points



Add Portugal (blue)

```
gm[continent=="Europe"] %>%  
  ggplot(aes(year, lifeexp)) +  
  geom_point(colour="grey75") +  
  geom_point(data=gmPT,  
             colour="blue") +  
  scale_y_continuous(limits=c(60,85))
```

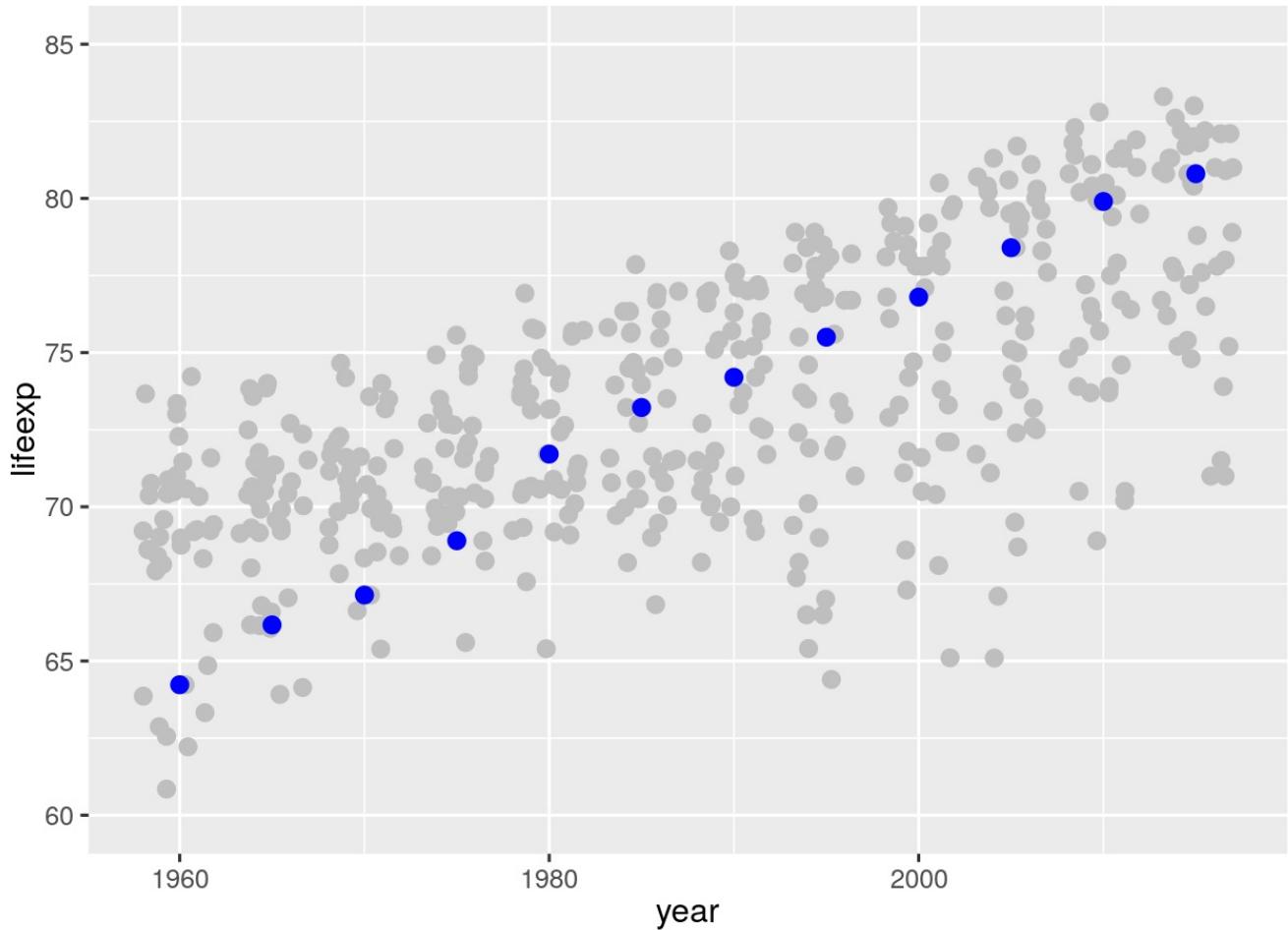


Life Expectancy - Jitter



Jitter overlapping points

```
gm[continent=="Europe"] %>%  
  ggplot(aes(year, lifeexp)) +  
  geom_jitter(colour="grey75") +  
  geom_point(data=gmPT,  
             colour="blue") +  
  scale_y_continuous(limits=c(60,85))
```

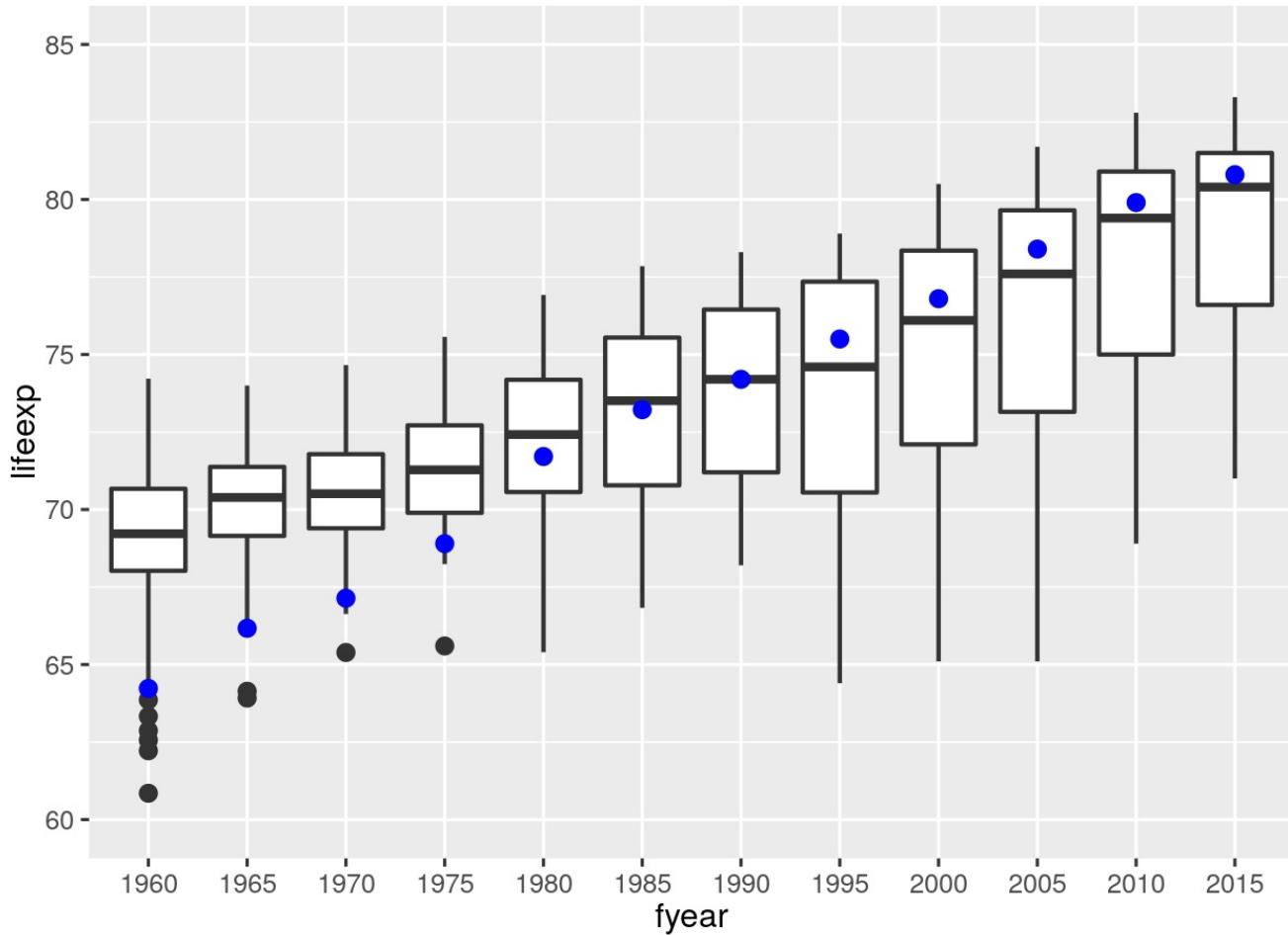


Life Expectancy - Boxplot



```
gm[continent=="Europe"] %>%
  ggplot(aes(fyear, lifeexp)) +
  geom_boxplot() +
  geom_point(data=gmPT,
             colour="blue") +
  scale_y_continuous(limits=c(60,85))
```

fyear **is a factor variable**

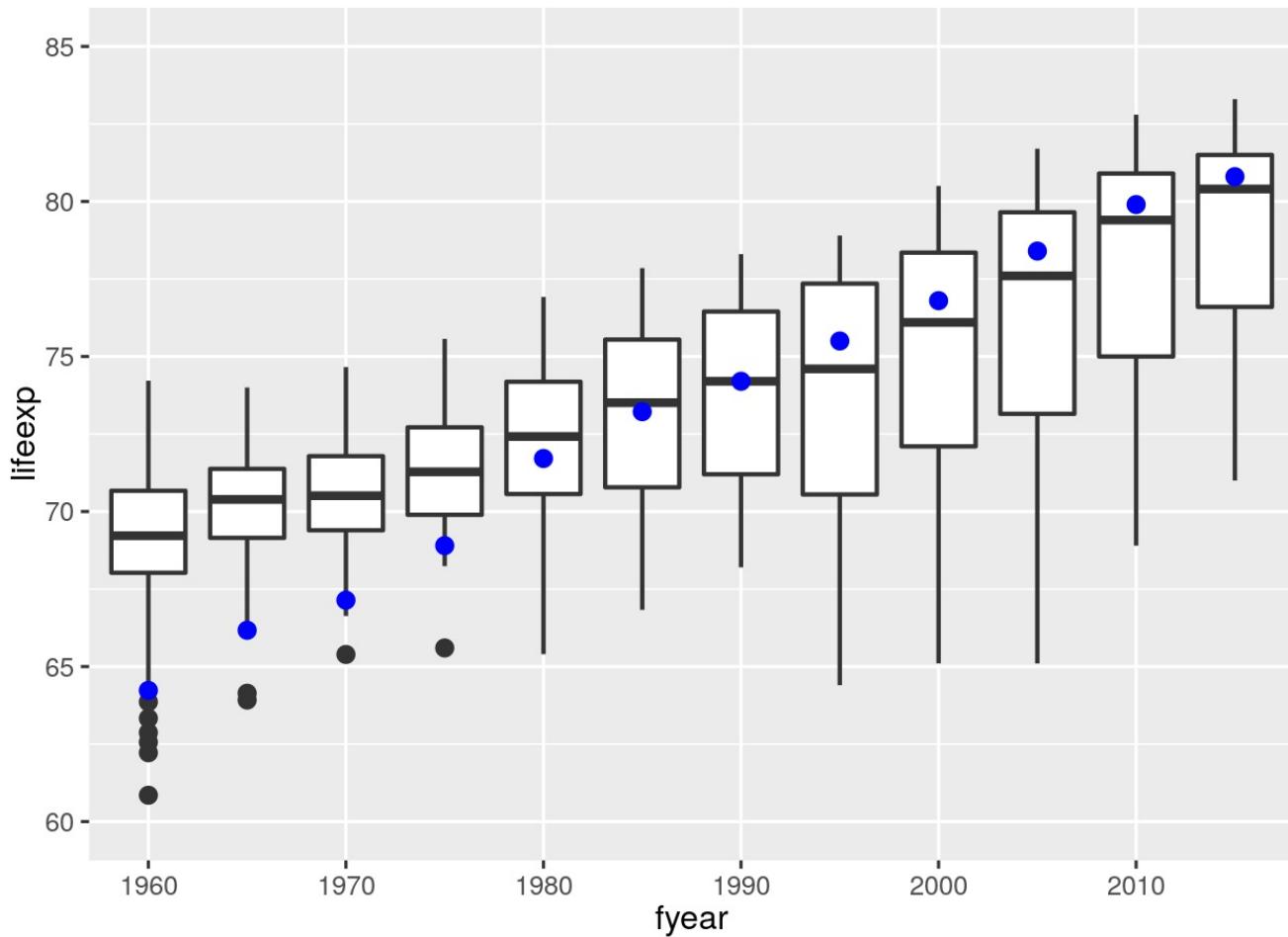


Life Expectancy - Boxplot



Cleaner x-axis

```
gm[continent=="Europe"] %>%
  ggplot(aes(fyear, lifeexp)) +
  geom_boxplot() +
  geom_point(data=gmPT,
             colour="blue") +
  scale_x_discrete(
    breaks=seq(1960, 2010, 10)) +
  scale_y_continuous(limits=c(60,85))
```

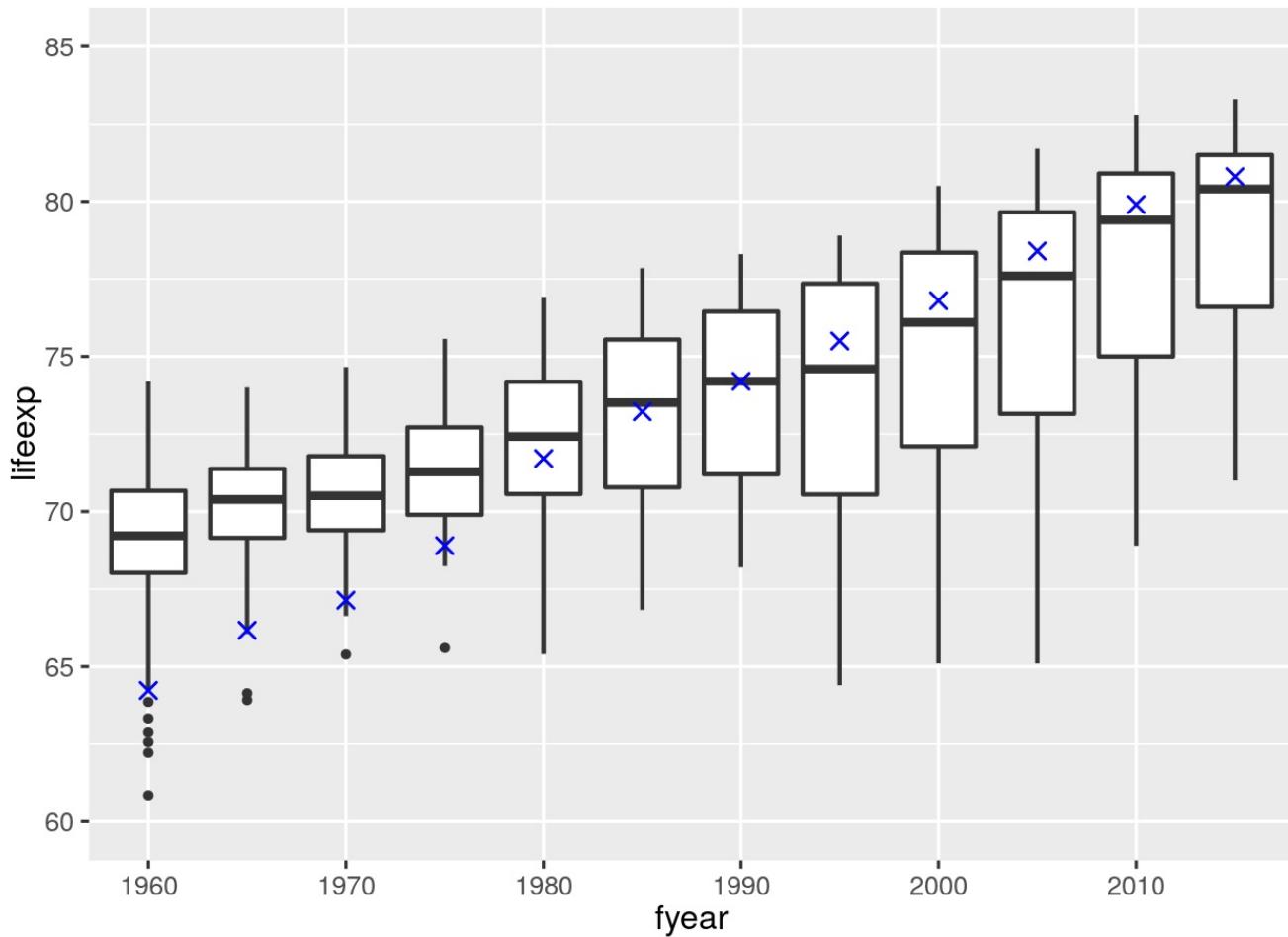


Life Expectancy - Boxplot



Modify points

```
gm[continent=="Europe"] %>%
  ggplot(aes(fyear, lifeexp)) +
  geom_boxplot(outlier.size = .5) +
  geom_point(data=gmPT,
             shape = 4,
             colour="blue") +
  scale_x_discrete(
    breaks=seq(1960, 2010, 10)) +
  scale_y_continuous(limits=c(60,85))
```



Shapes & Values



0	□	1	○	2	△	3	+	4	×
5	◇	6	▽	7	⊗	8	*	9	◊
10	⊕	11	❖	12	田	13	⊗	14	▢
15	■	16	●	17	▲	18	◆	19	●
20	●	21	○	22	□	23	◇	24	△
25	▽								

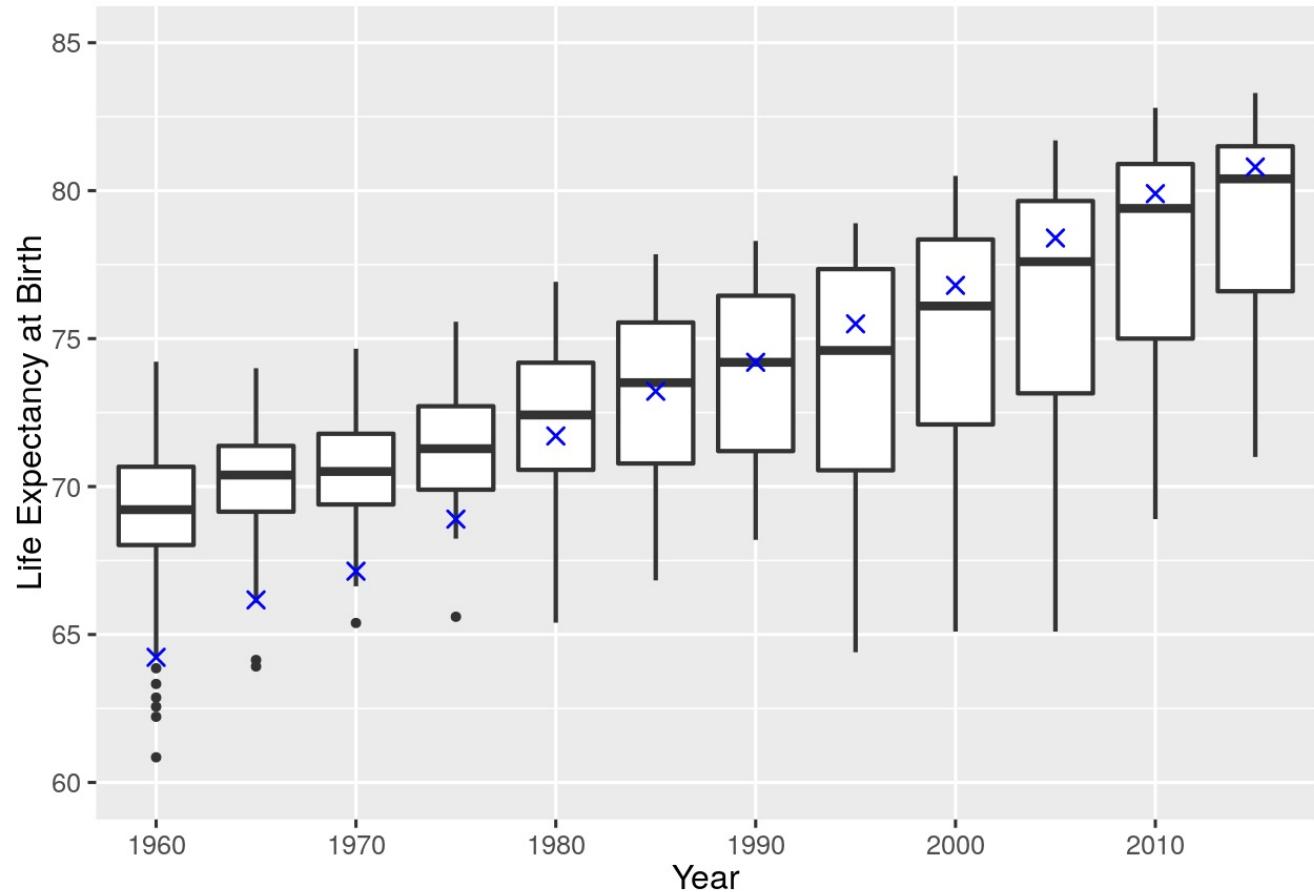
Life Expectancy - Boxplot



Final

```
gm[continent=="Europe"] %>%
  ggplot(aes(fyear, lifeexp)) +
  geom_boxplot(outlier.size = .5) +
  geom_point(data=gmPT,
             shape = 4,
             colour="blue") +
  scale_x_discrete(
    breaks=seq(1960, 2010, 10)) +
  scale_y_continuous(limits=c(60,85)) +
  ggtitle("Portugal (x) in Europe") +
  xlab("Year") +
  ylab("Life Expectancy at Birth")
```

Portugal (x) in Europe

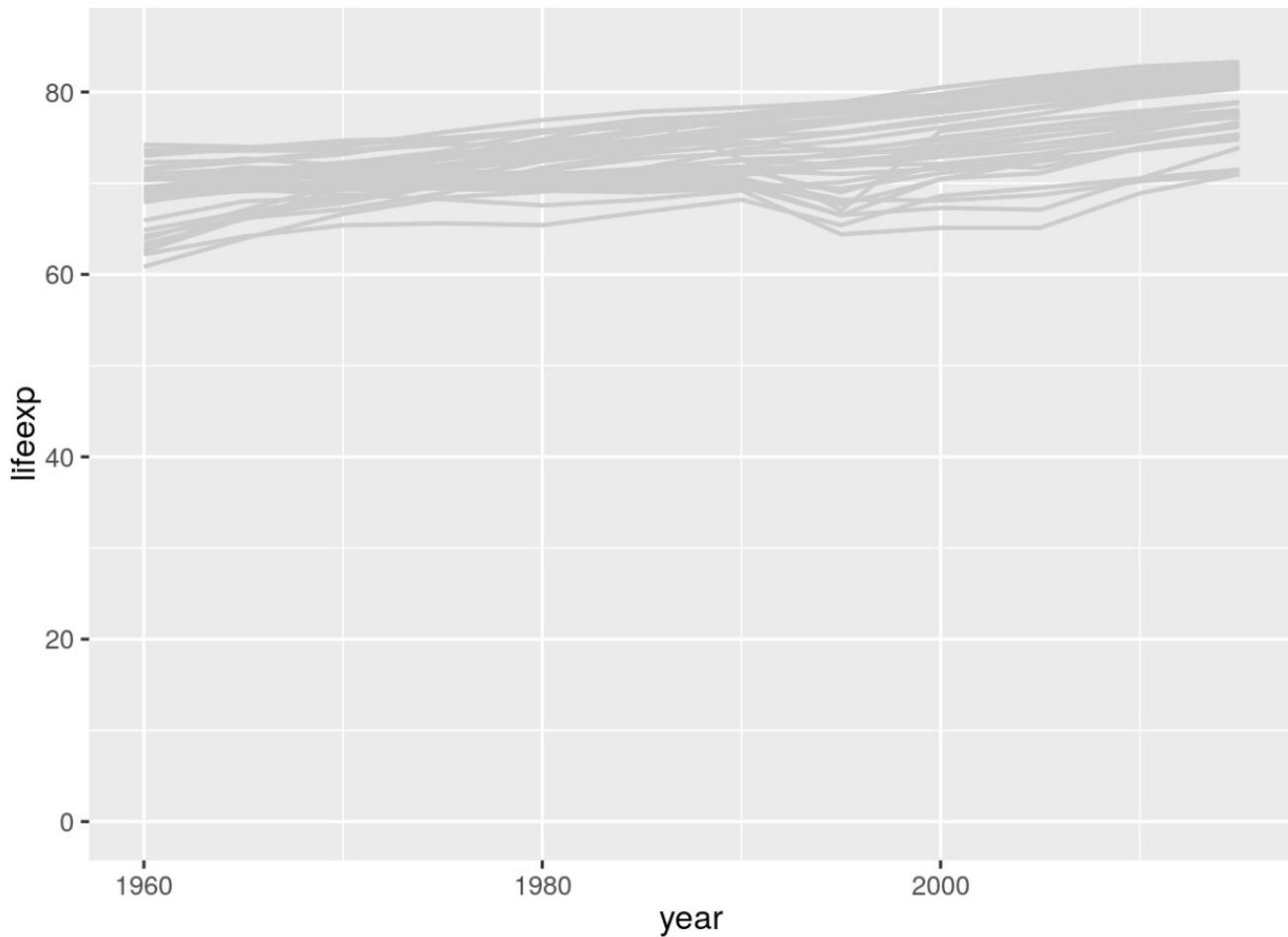


Life Expectancy - Line Plot



Line for each country

```
gm[continent=="Europe"] %>%  
  ggplot(aes(year, lifeexp,  
             group=country)) +  
  geom_line(colour="grey80") +  
  scale_y_continuous(limits=c(0, 85))
```



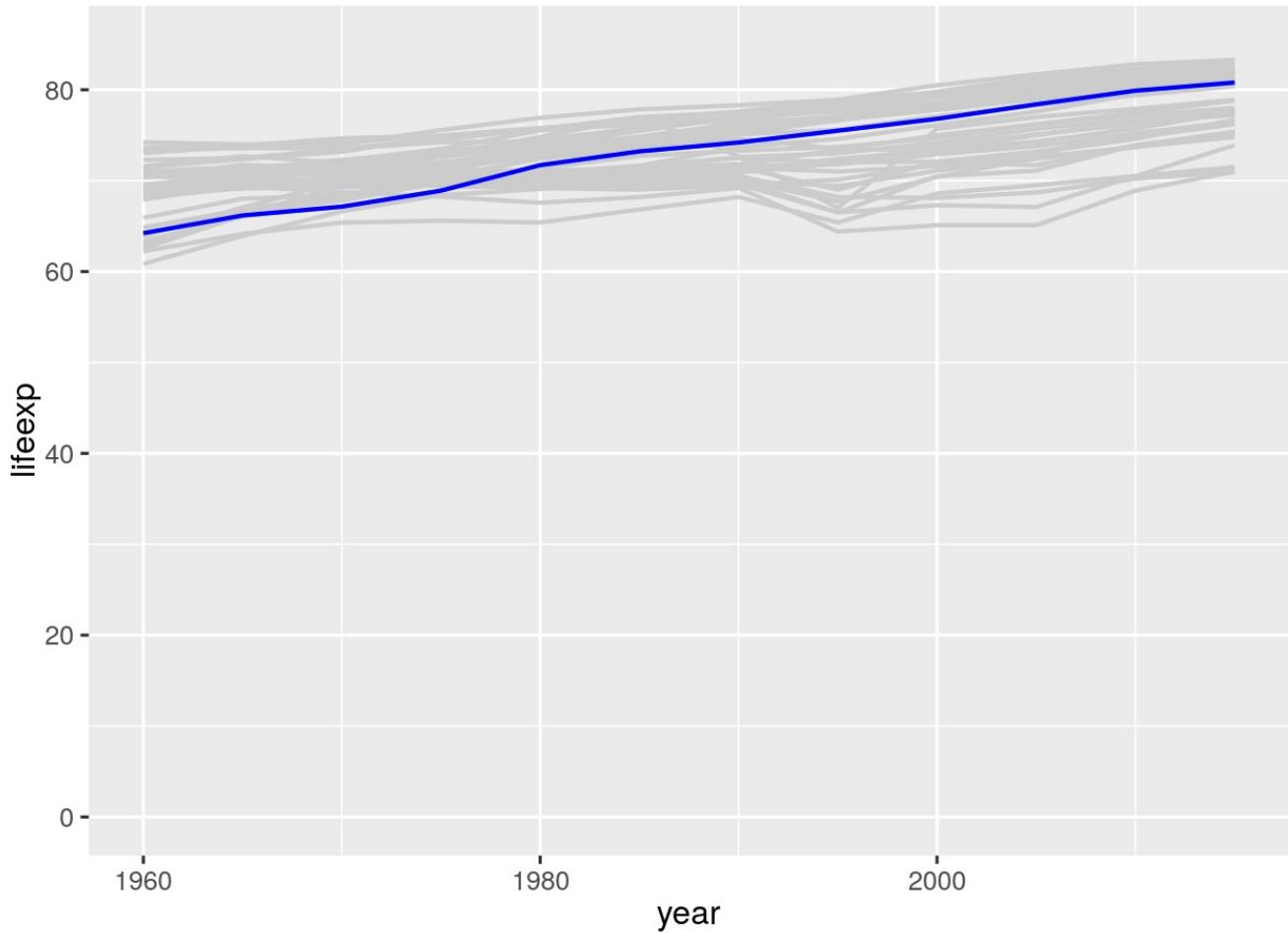
Life Expectancy - Line Plot



```
gm[continent=="Europe"] %>%
  ggplot(aes(year, lifeexp,
             group=country)) +
  geom_line(colour="grey80") +
  geom_line(data=gmPT,
            colour="blue") +
  scale_y_continuous(limits=c(0, 85))
```

Used `geom_line()` twice

See "gghighlight" package



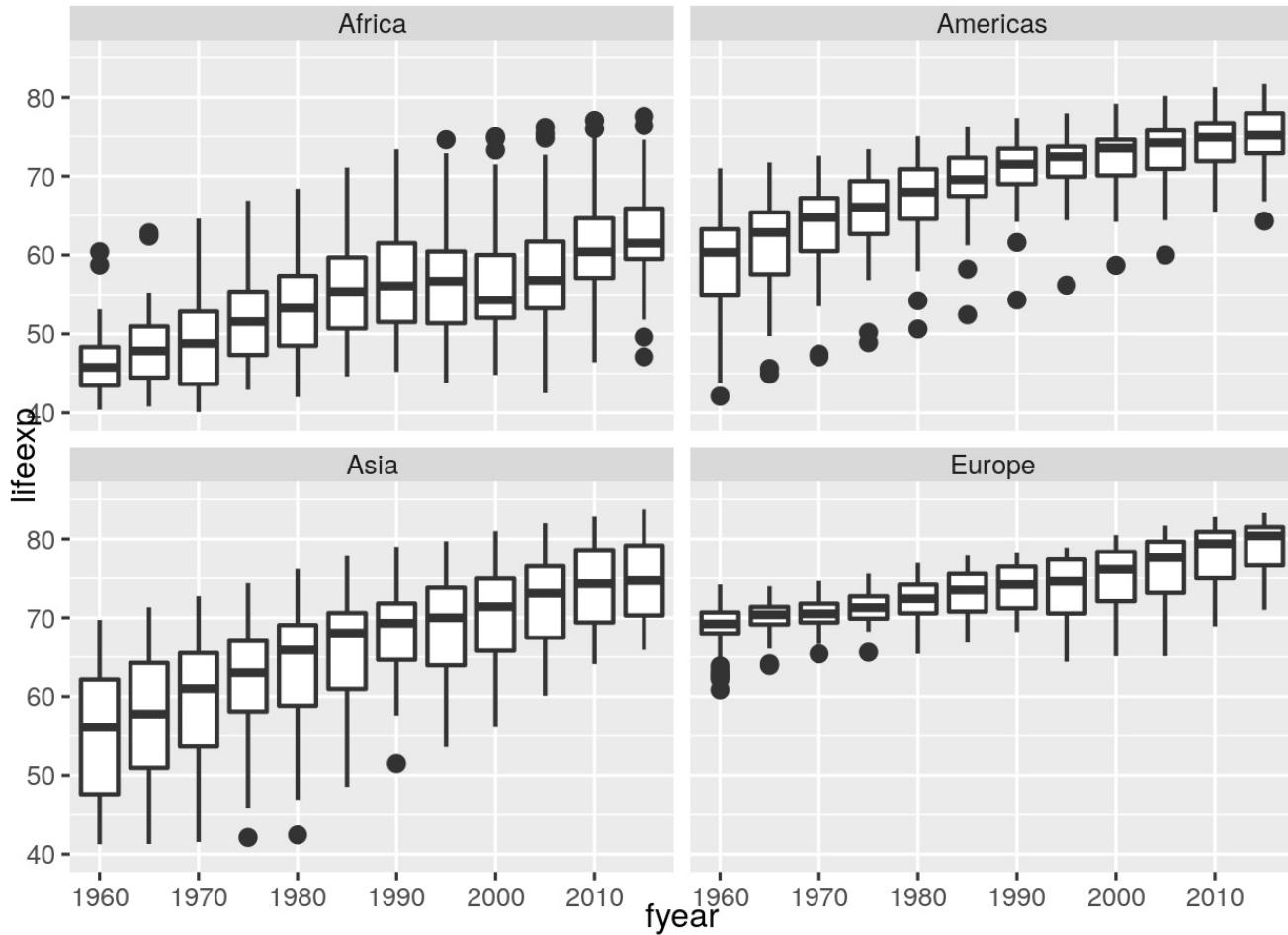
Facetting Plots

Life Expectancy - By Continent



Facetting by continent

```
gm[continent!="Oceania"] %>%
  ggplot(aes(fyear, lifeexp)) +
  geom_boxplot() +
  scale_x_discrete(
    breaks=seq(1960, 2010, 10)) +
  scale_y_continuous(limits=c(40,85)) +
  facet_wrap(~continent)
```

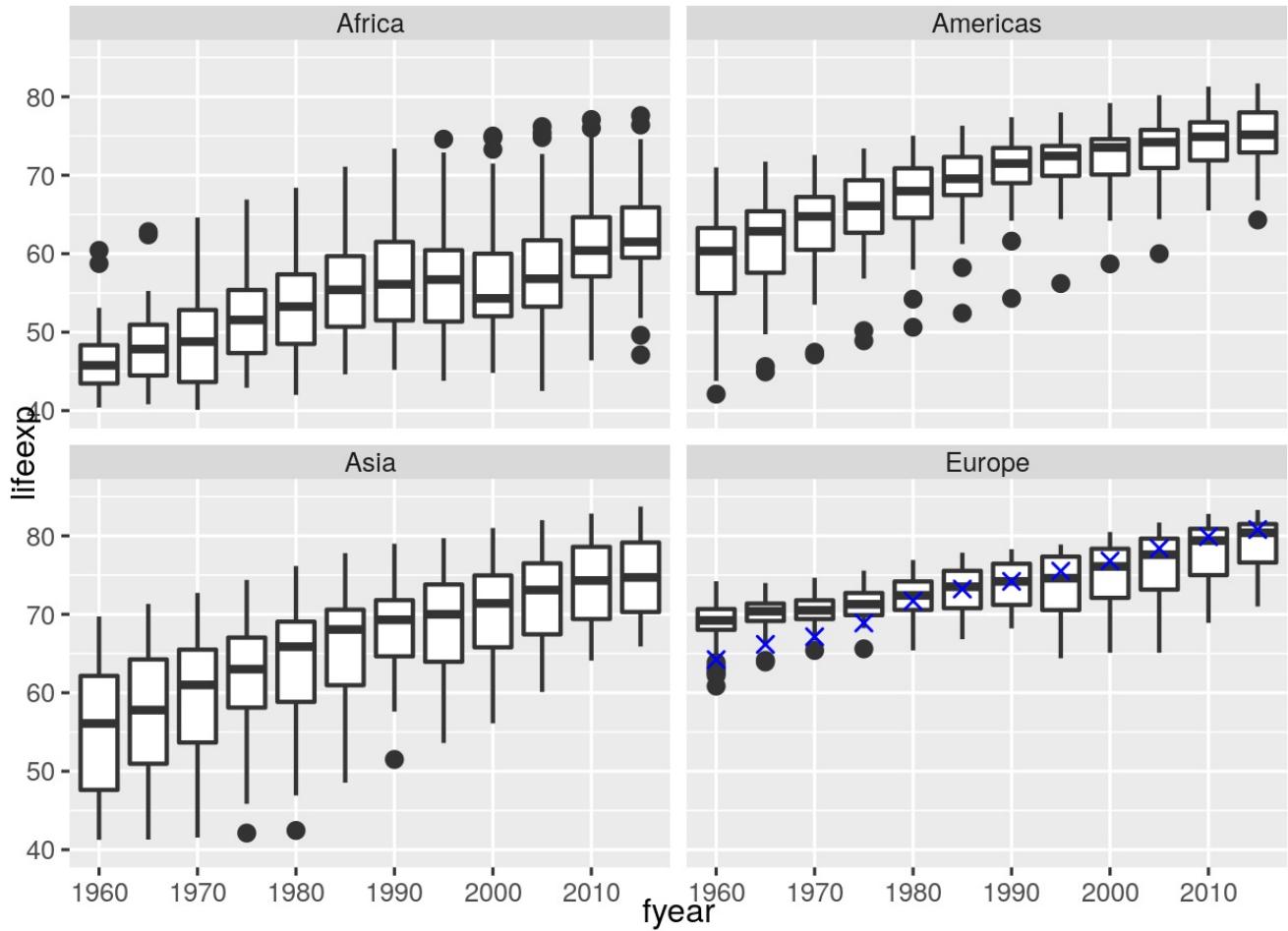


Life Expectancy - By Continent



Adding Portugal

```
gm[continent!="Oceania"] %>%
  ggplot(aes(fyear, lifeexp)) +
  geom_boxplot() +
  geom_point(data=gmPT,
             shape = 4,
             colour="blue") +
  scale_x_discrete(
    breaks=seq(1960, 2010, 10)) +
  scale_y_continuous(limits=c(40,85)) +
  facet_wrap(~continent)
```

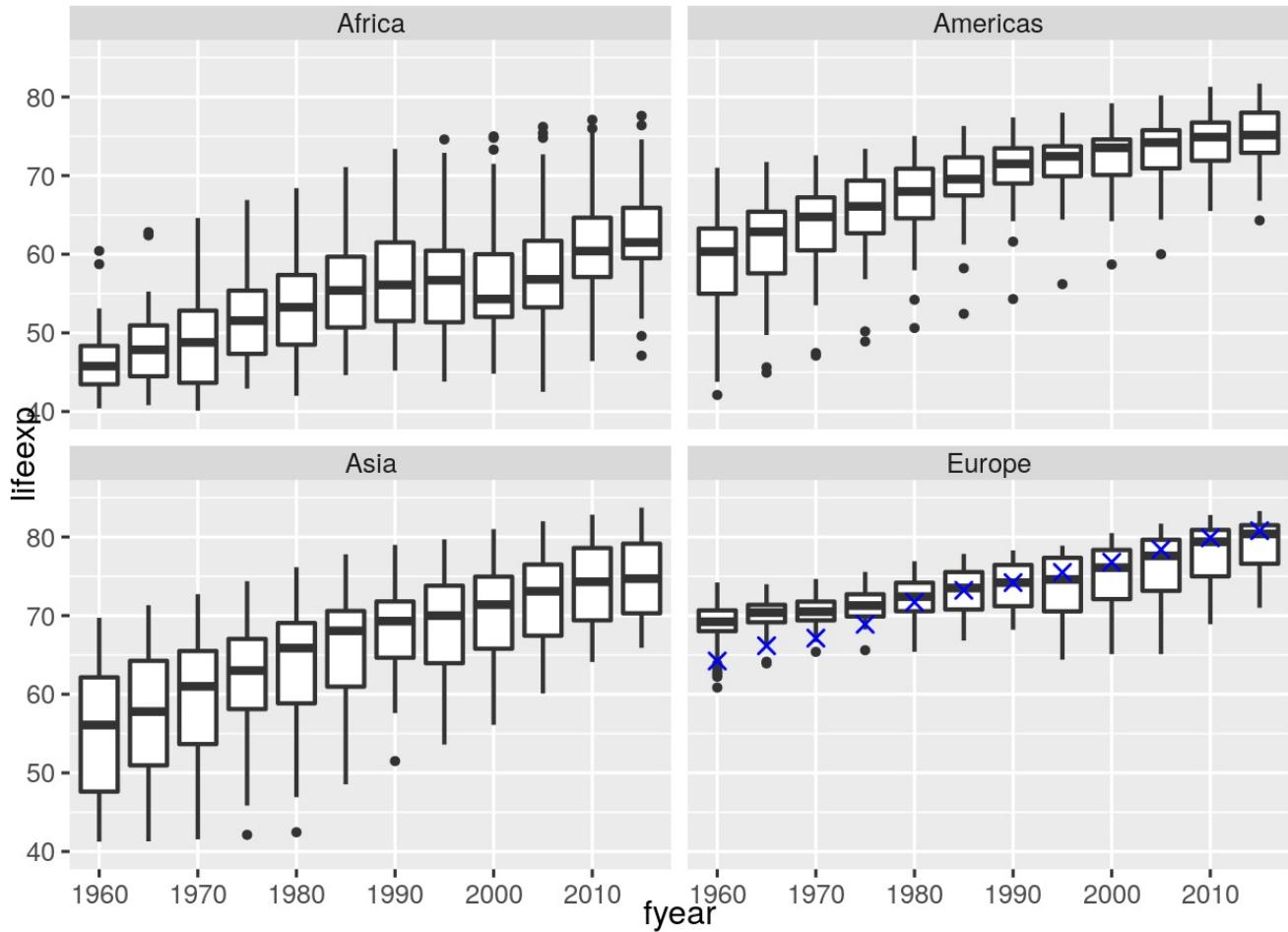


Life Expectancy - By Continent



Reduce outlier size

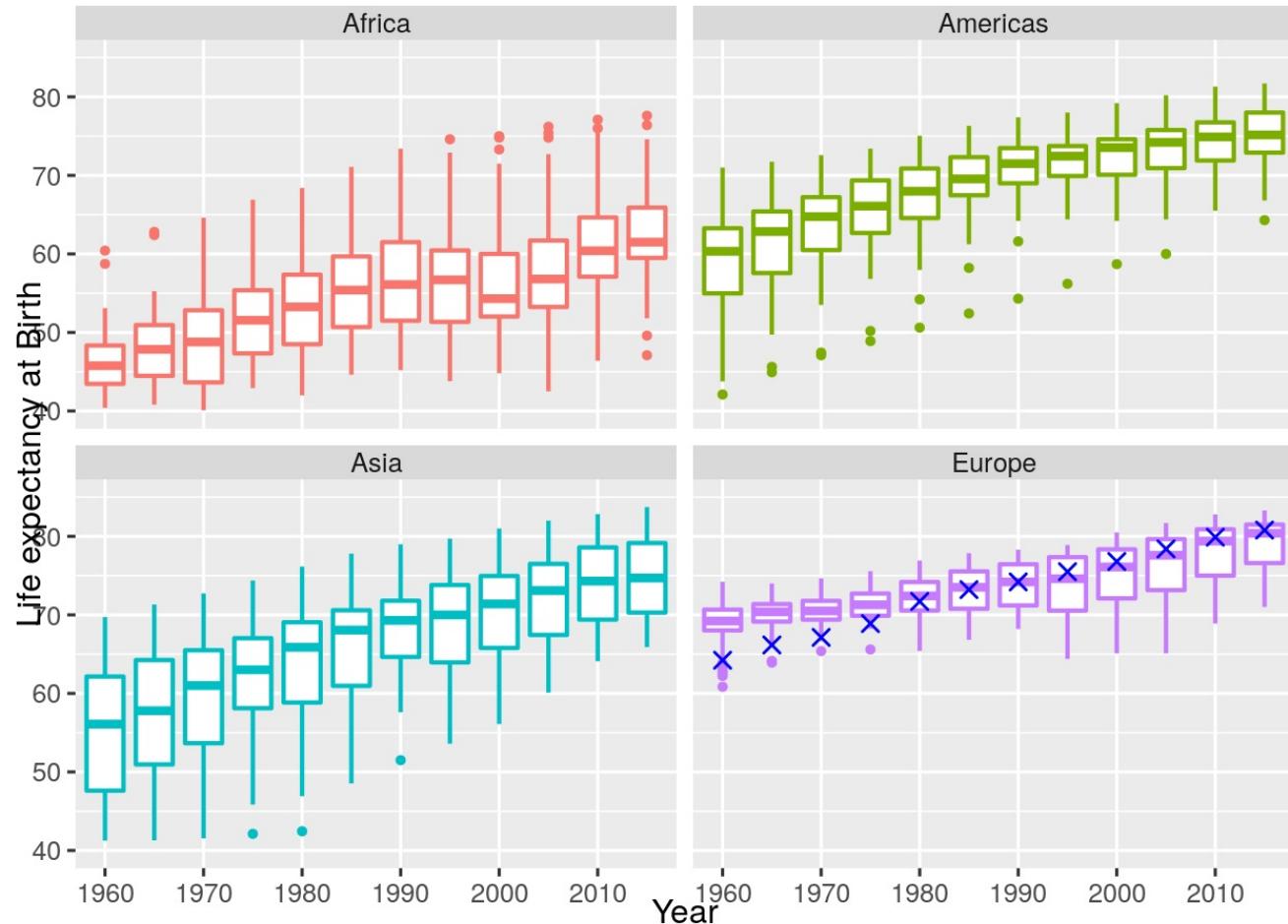
```
gm[continent!="Oceania"] %>%
  ggplot(aes(fyear, lifeexp)) +
  geom_boxplot(outlier.size = .5) +
  geom_point(data=gmPT,
             shape = 4,
             colour="blue") +
  scale_x_discrete(
    breaks=seq(1960, 2010, 10)) +
  scale_y_continuous(limits=c(40,85)) +
  facet_wrap(~continent)
```



Life Expectancy - By Continent



```
gm[continent!="Oceania"] %>%  
  ggplot(aes(fyear, lifeexp,  
             colour = continent)) +  
  geom_boxplot(outlier.size = .5) +  
  geom_point(data=gmPT,  
             shape = 4,  
             colour="blue") +  
  scale_x_discrete(  
    breaks=seq(1960, 2010, 10)) +  
  scale_y_continuous(limits=c(40,85)) +  
  facet_wrap(~continent) +  
  xlab("Year") +  
  ylab("Life expectancy at Birth") +  
  theme(legend.position = "none")
```



Exercises

Double Click on "ggplot2-Exercises.Rproj"

Open file "ggplot2-Exercises.Rmd"

Complete "Exercise 2 - Europe"

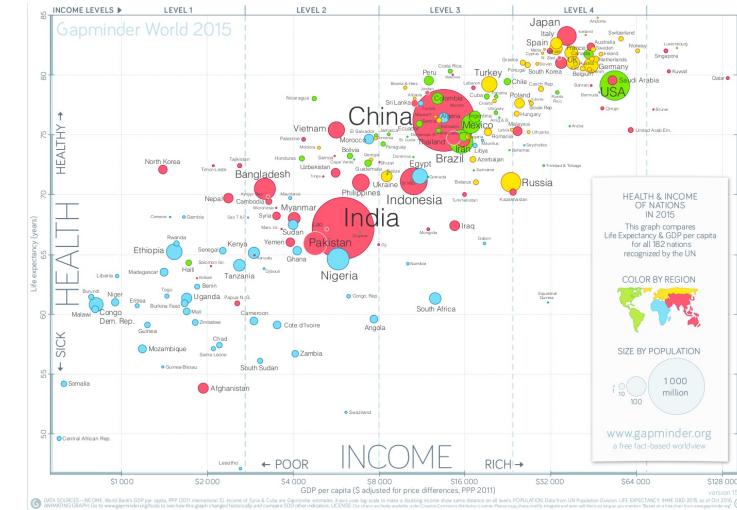
How does Portugal perform on health and wealth?



Health versus Wealth over Time

We will only use data for 1960, 1980, 2000 and 2015.

This is essentially a subset of the famous gapminder plot



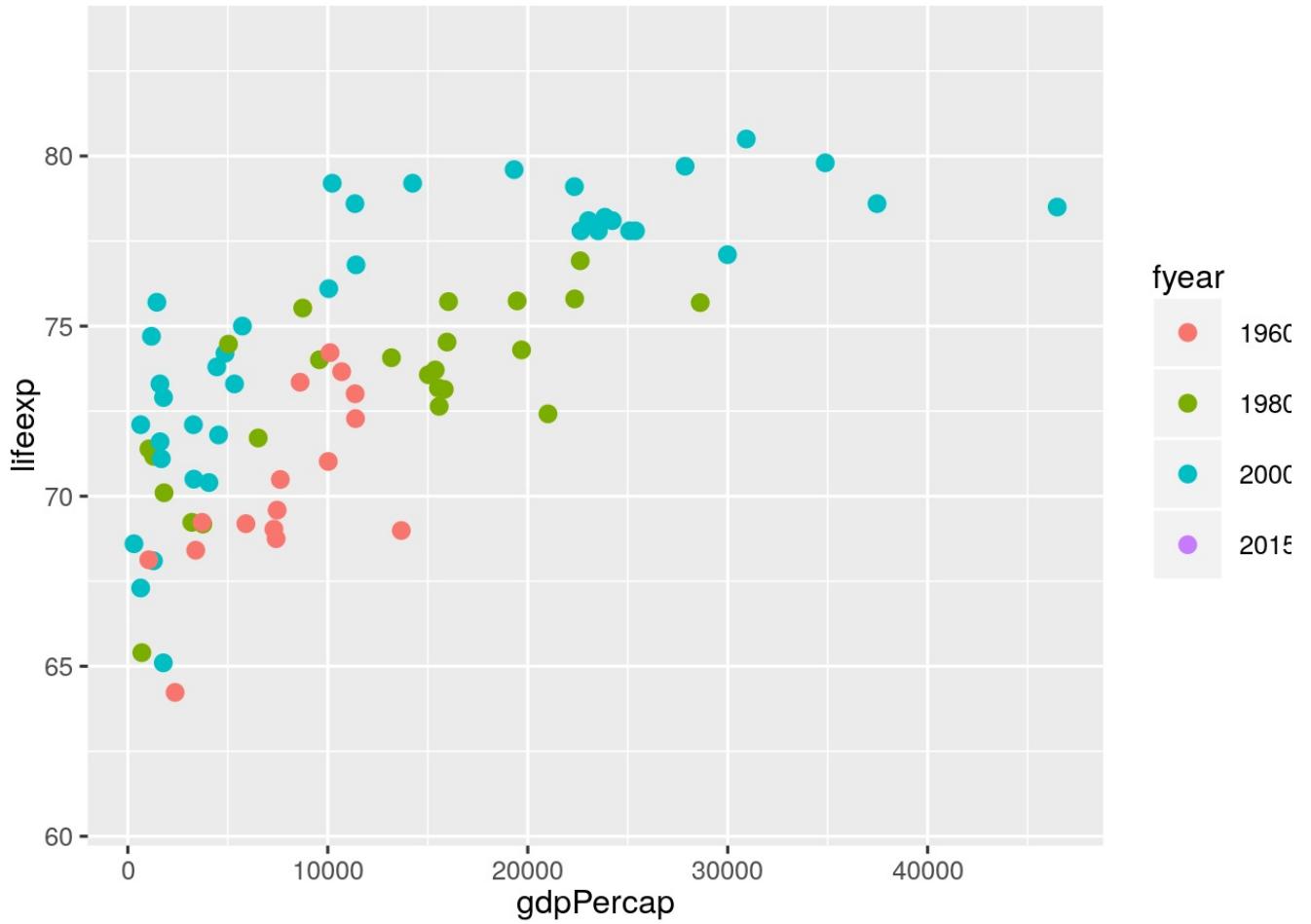
Health vs Wealth



Colour code by year

```
yrs <- c(1960, 1980, 2000, 2015)
gm[continent=="Europe" &
  year %in% yrs] %>%
  ggplot(aes(gdpPerCap, lifeExp,
             colour=fyear)) +
  geom_point()
```

Not easy to interpret

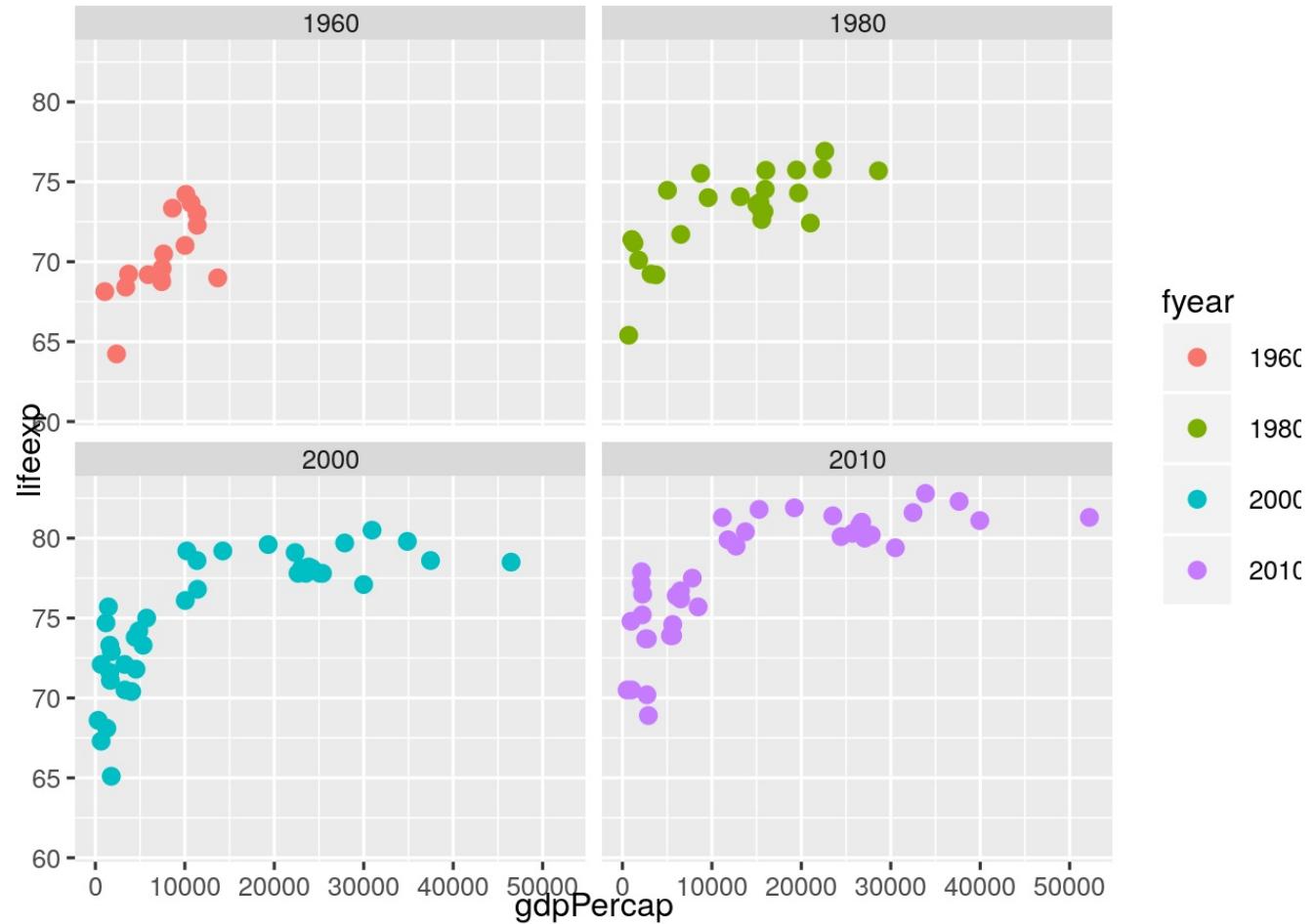


Health vs Wealth - Facet



Plot years separately

```
yrs <- c(1960, 1980, 2000, 2010)
gm[continent=="Europe" &
  year %in% yrs] %>%
  ggplot(aes(gdpPerCap, lifeexp,
             colour=fyear)) +
  geom_point() +
  facet_wrap(~fyear)
```

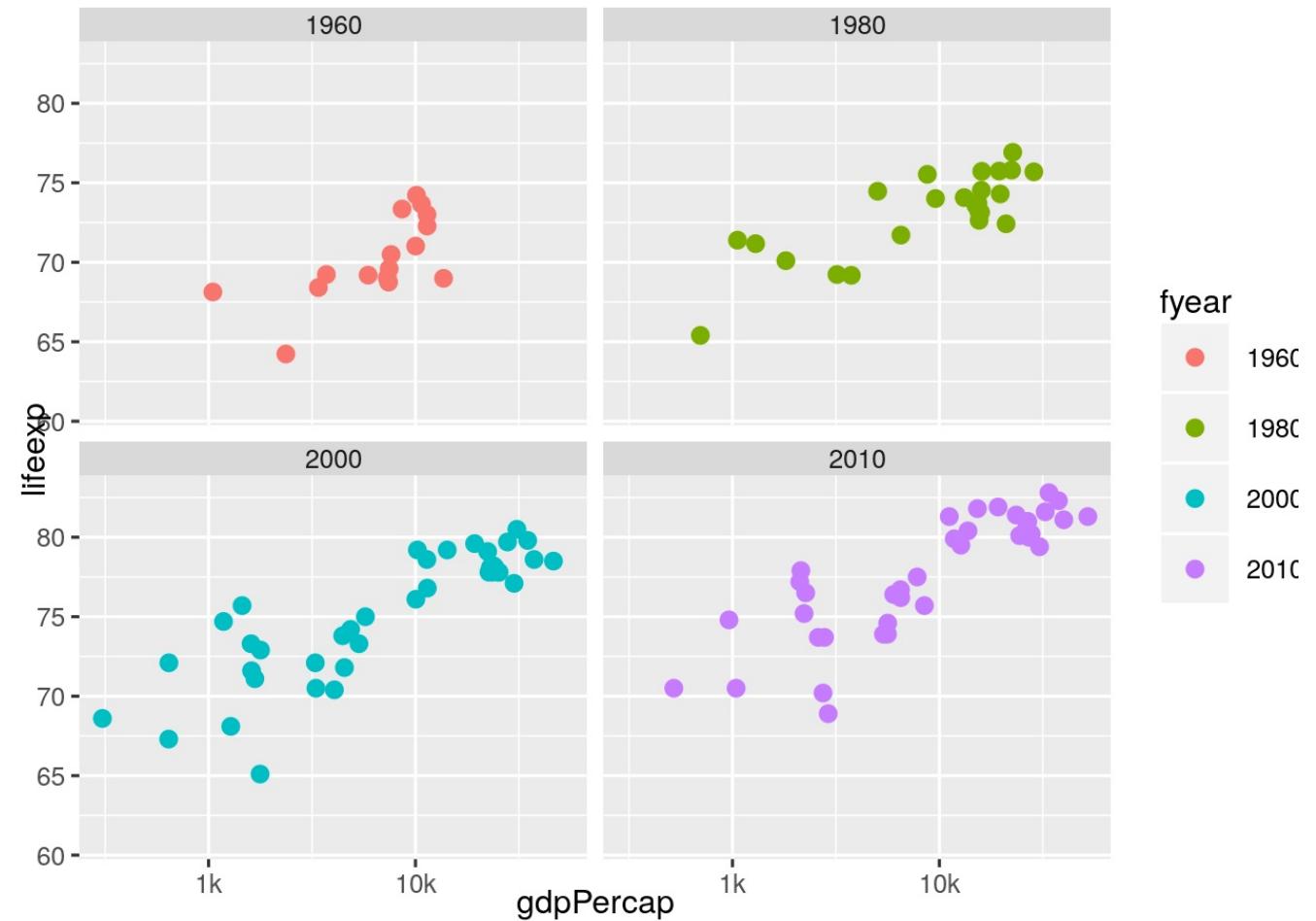


Health vs Wealth - Log Scale



Log scale x-axis

```
yrs <- c(1960, 1980, 2000, 2010)
gm[continent=="Europe" &
  year %in% yrs] %>%
  ggplot(aes(gdpPercap, lifeexp,
             colour=fyear)) +
  geom_point() +
  scale_x_log10(
    breaks = c(10^3, 10^4, 10^5),
    labels = c("1k", "10k", "100k")) +
  facet_wrap(~fyear)
```

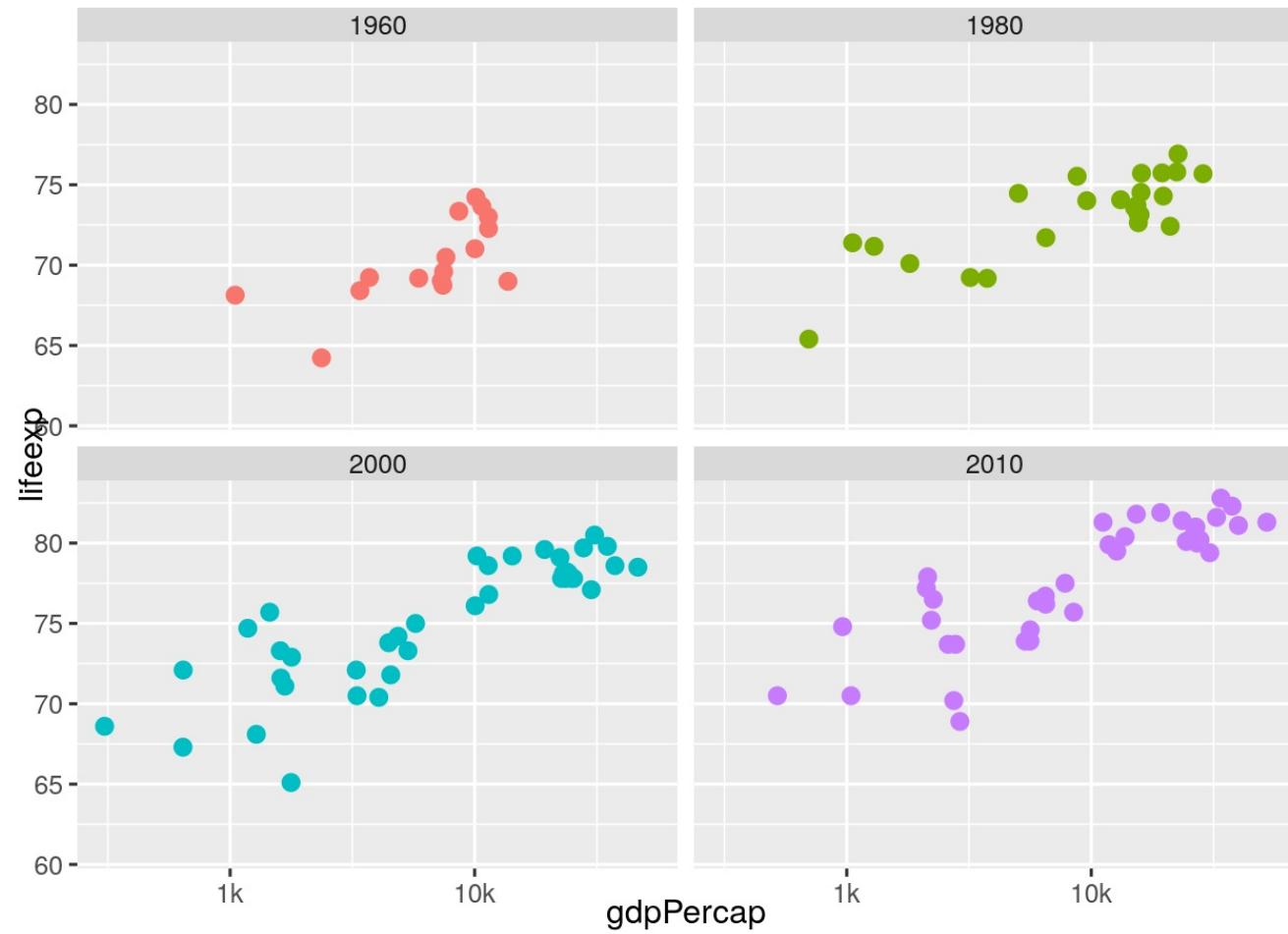


Health vs Wealth - Log Scale



Remove Legend

```
yrs <- c(1960, 1980, 2000, 2010)
gm[continent=="Europe" &
  year %in% yrs] %>%
  ggplot(aes(gdpPercap, lifeexp,
             colour=fyear)) +
  geom_point() +
  scale_x_log10(
    breaks = c(10^3, 10^4, 10^5),
    labels = c("1k", "10k", "100k")) +
  facet_wrap(~fyear) +
  theme(legend.position = "none")
```



Health vs Wealth - Log Scale



Point size = population

```
yrs <- c(1960, 1980, 2000, 2010)
gm[continent=="Europe" &
  year %in% yrs] %>%
  ggplot(aes(gdpPerCap, lifeExp)) +
  geom_point(aes(size=pop,
                 colour=fyear),
              shape = 21) +
  scale_x_log10(
    breaks = c(10^3, 10^4, 10^5),
    labels = c("1k", "10k", "100k")) +
  facet_wrap(~fyear)
```

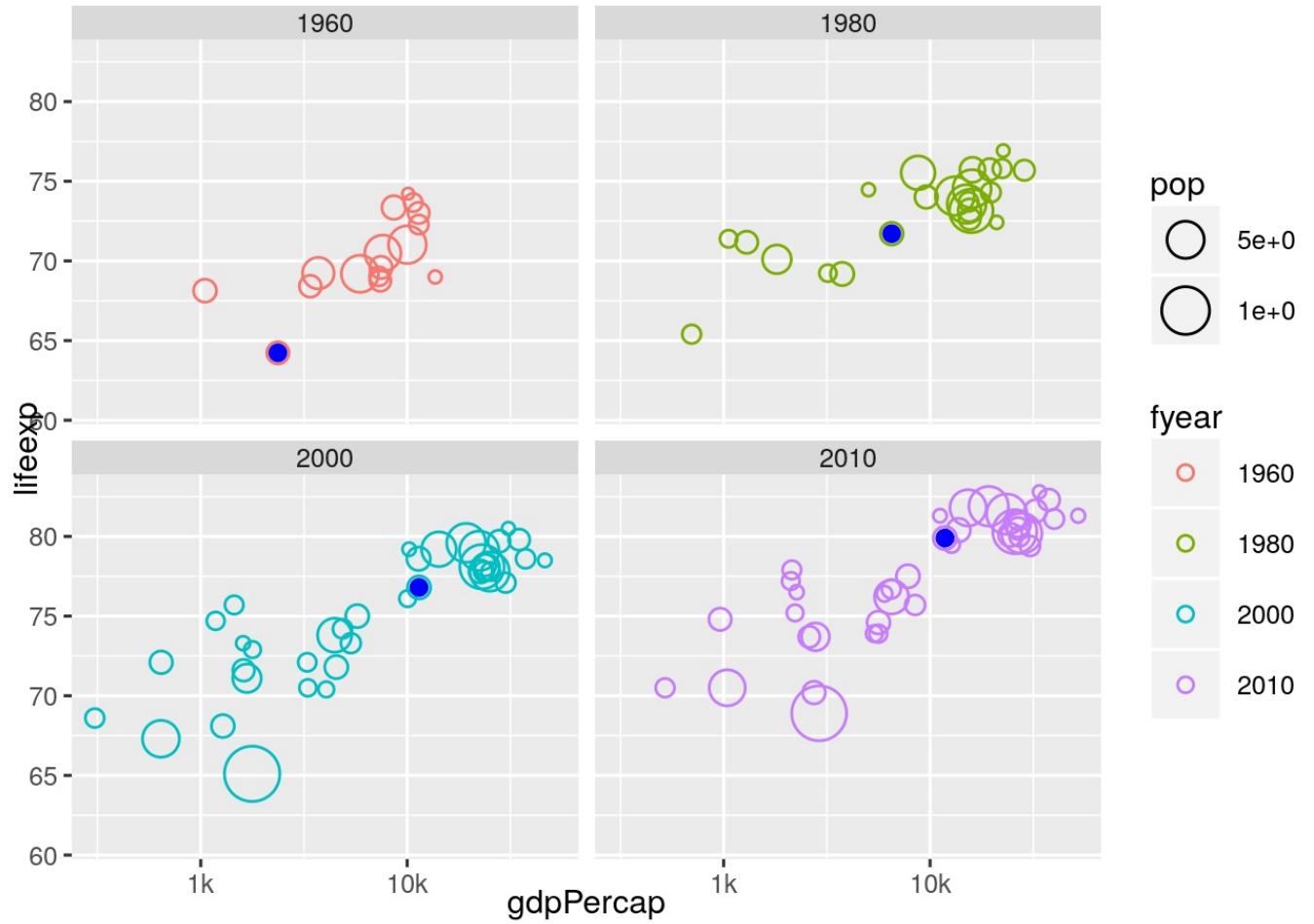


Health vs Wealth - Portugal



Add Portugal

```
yrs <- c(1960, 1980, 2000, 2010)
gm[continent=="Europe" &
  year %in% yrs] %>%
  ggplot(aes(gdpPerCap, lifeexp)) +
  geom_point(aes(size=pop,
                 colour=fyear),
              shape = 21) +
  scale_x_log10(
    breaks = c(10^3, 10^4, 10^5),
    labels = c("1k", "10k", "100k")) +
  facet_wrap(~fyear) +
  geom_point(data =
    gmPT[year %in% yrs],
    colour="blue")
```

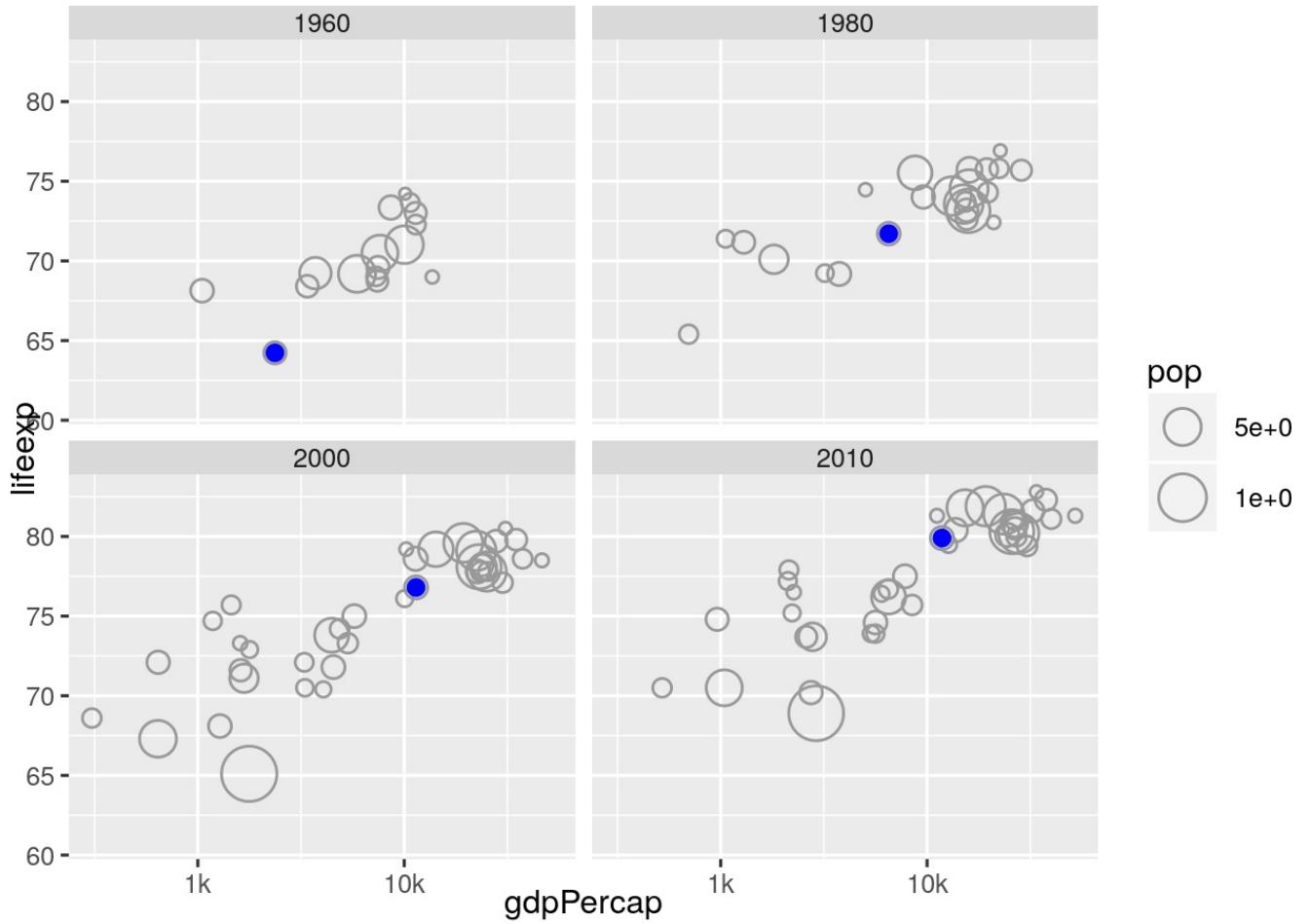


Health vs Wealth - Portugal



No need for year colours

```
yrs <- c(1960, 1980, 2000, 2010)
gm[continent=="Europe" &
  year %in% yrs] %>%
  ggplot(aes(gdpPerCap, lifeExp)) +
  geom_point(aes(size=pop),
             colour="grey60",
             shape = 21) +
  scale_x_log10(
    breaks = c(10^3, 10^4, 10^5),
    labels = c("1k", "10k", "100k")) +
  facet_wrap(~year) +
  geom_point(data =
    gmPT[year %in% yrs],
    colour="blue")
```

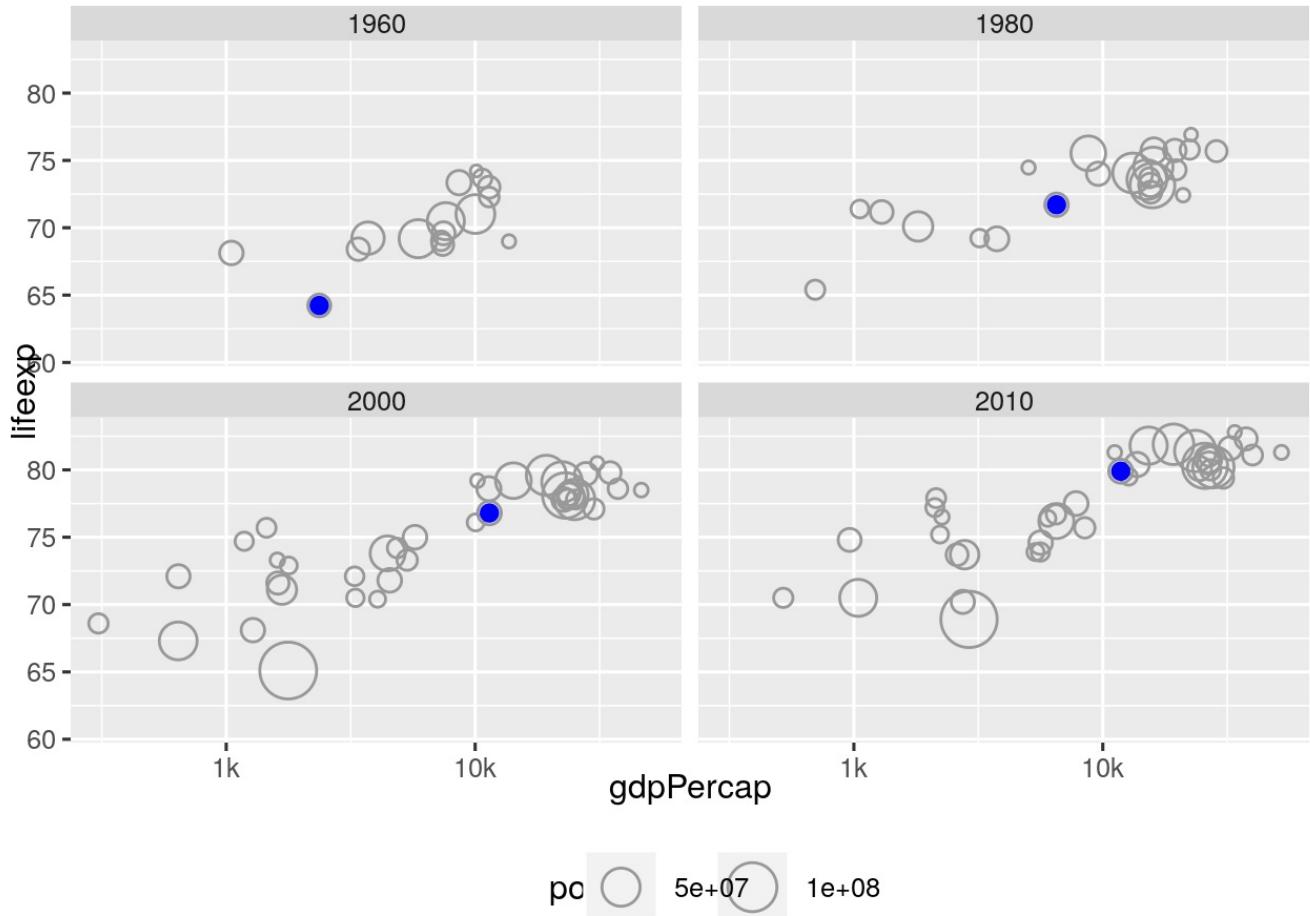


Health vs Wealth



Move the legend below

```
yrs <- c(1960, 1980, 2000, 2010)
gm[continent=="Europe" &
  year %in% yrs] %>%
  ggplot(aes(gdpPerCap, lifeexp)) +
  geom_point(aes(size=pop),
             colour="grey60",
             shape = 21) +
  scale_x_log10(
    breaks = c(10^3, 10^4, 10^5),
    labels = c("1k", "10k", "100k")) +
  facet_wrap(~fyear) +
  geom_point(data =
    gmPT[year %in% yrs],
    colour="blue") +
  theme(legend.position = "bottom")
```



Exercises

Double Click on "ggplot2-Exercises.Rproj"

Open file "ggplot2-Exercises.Rmd"

Complete "Exercise 3: Gapminder plot"



Summary

- Answer questions with data visualisations
- Define your plots and `ggplot2` does the rest
- Integrates well with R markdown
- Lots more than this 3 hour workshop could show
- Try it!

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