Life Tables: 1948-2006

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- **M1 MIDS MA7BY020**
- **Université Paris Cité**
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- Course Homepage

- Moodle

> **Objectives**

Loading

```
datafile <- 'tamed_life_table.Rds'
fpath <- str_c("../DATA/", datafile) # here::here('DATA', datafile)   # check getwd() if p

if (! file.exists(fpath)) {
  download.file("https://stephane-v-boucheron.fr/data/tamed_life_table.Rds",
                fpath,
                mode="wb")
}

life_table <- readr::read_rds(fpath)
```

Definitions

Check on http://www.mortality.org the meaning of the different columns.

See: *Demography: Measuring and Modeling Population Processes* by SH Preston, P Heuveline, and M Guillot. Blackwell. Oxford. 2001.

Document Tables de mortalité françaises pour les XIXe et XXe siècles et projections pour le XXIe siècle contains detailed information on the construction of Life Tables for France.

Period tables versus cohort tables

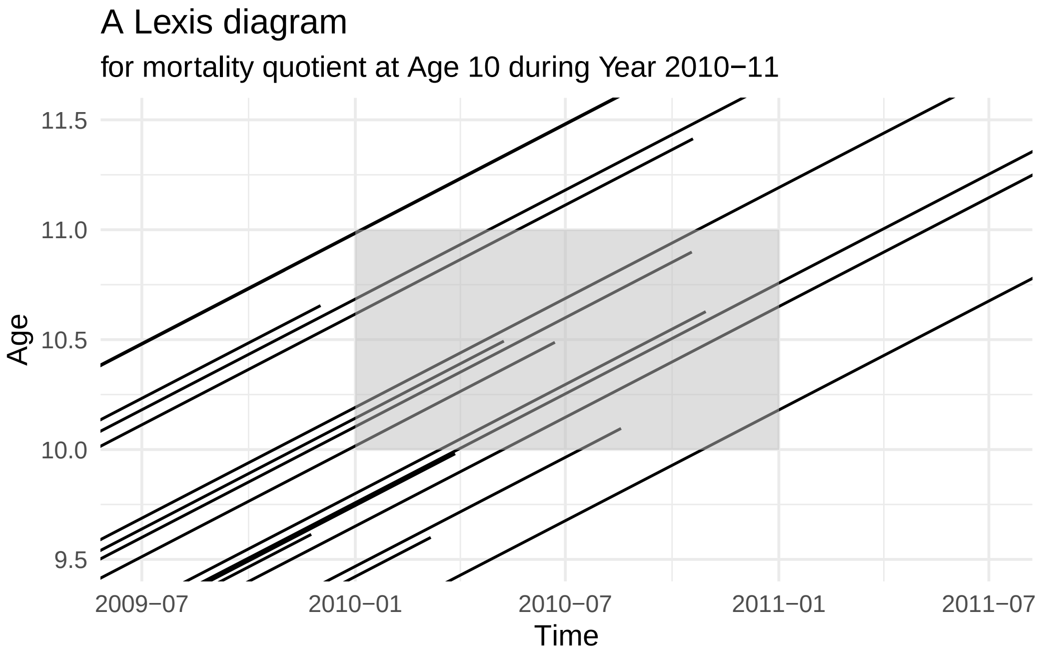
Two kinds of Life Tables can be distinguished: *Period tables* (*Table du moment*) which contain for each period (here a period is a calendar year), the mortality risks at different age ranges (here, we have one year ranges) for that very period; and *Tables de génération* which contain for a given birthyear, the mortality risks at which an individual born during that year has been exposed.

The life tables investigated in this lab are *Table du moment*. According to the document by Vallin and Meslé, building the life tables required ,decisions and doctoring.

Lexis diagrams

Lexis diagrams provide a graphical device that summarizes the construction of mortality quotients (and other rates in demography).

```
birth_dates <- as_date("1999-01-01") + duration(sample(2*365, size=20, replace=T),units="d
death_dates <- as_date("2009-07-01") + duration(sample(3*365, size=20, replace=T),units="d

b_period <- as_date("2010-01-01")
b_frame <-  as_date(b_period - duration(1, units = "year"))
b_age <- 10L

tb_ld <- tibble(birth=birth_dates, death=death_dates)

tb_ld |>
  ggplot() +
  geom_segment(aes(x=b_frame,
                   xend=death,
                   y=interval(birth, b_frame)/years(1),
                   yend=interval(birth, death)/years(1))
               ) +
  annotate(geom="rect",
           xmin=b_period,
           xmax=as_date(b_period + duration(1, units = "year")),
           ymin=b_age,
           ymax=b_age + 1L,
           fill="grey",
          alpha=.5) +
  ylab("Age") +
  xlab("Time") +
  coord_cartesian(xlim=c(as_date(b_period - duration(6, units = "months")),
                         as_date(b_period + duration(18, units = "months"))),
                  ylim=c(b_age - .5, b_age+1.5)) +
  labs(
    title="A Lexis diagram",
    subtitle = "for mortality quotient at Age 10 during Year 2010-11"
  )
```



Each line represents the *life line* of an individual born during years 1999 and 2000 and deceased beetween mid 2009 and mid 2012. In order to compute the mortality quotient at age 10 for year 2010, we have to compute the relevant *number of occurrences*, that is the number of segments ending in the grey rectangle, and the *sum of exposure times*, which is proportional to the sum of the lengths of the segments crossing the grey rectangle.

Have a look at Lexis diagram or at Preston *et al.*

Definitions can be obtained from www.lifeexpectancy.org. We translate it into mathematical (rather than demographic) language.

The mortality quotients define a probability distribution over $\mathbb{N}$. This probability distribution is a *construction* that reflects the health situation in a population at a given time. This probability distribution does not describe the sequence of sanitary situations experienced by a *cohort* (people born during a specific year).

> One works with a period, or current, life table (*table du moment*). This summarizes the mortality experience of persons across all ages in a short period, typically one year or three years. More precisely, the death probabilities q_x for every age x are computed for that short period, often using census information gathered at regular intervals. These q_x's are then applied to a hypothetical cohort of 100000 people over their life span to produce a life table.

```
small_tb <- life_table |>
  filter(Country=='France', Year== 2010, Gender=='Female', Age < 10 | between(Age, 80, 89)
  select(Age, qx, mx, lx, dx, Lx, Tx, ex)

small_tb
```

```
# A tibble: 20 x 8
    Age      qx      mx     lx    dx    Lx      Tx    ex
  <int>   <dbl>   <dbl>  <int> <int> <int>   <int> <dbl>
1     0 0.00324 0.00325 100000   324 99722 8465207  84.6
2     1 0.00032 0.00032  99676    32 99660 8365484  83.9
3     2 0.00015 0.00015  99645    15 99637 8265824  83.0
4     3 0.00011 0.00011  99630    11 99624 8166187  82.0
5     4 0.00008 0.00008  99619     8 99615 8066563  81.0
```

```
6       5 0.00005 0.00005  99611      5 99608 7966948 80.0
7       6 0.00008 0.00008  99606      8 99602 7867339 79.0
8       7 0.00008 0.00008  99598      8 99594 7767737 78.0
9       8 0.00008 0.00008  99590      8 99586 7668143 77
10      9 0.00007 0.00007  99582      7 99578 7568557 76
11     80 0.0298  0.0302   75619   2252 74493  802295 10.6
12     81 0.0346  0.0352   73367   2535 72099  727802  9.92
13     82 0.0398  0.0406   70832   2818 69423  655702  9.26
14     83 0.0464  0.0475   68014   3158 66435  586280  8.62
15     84 0.0539  0.0554   64856   3493 63109  519845  8.02
16     85 0.0610  0.0630   61362   3745 59490  456736  7.44
17     86 0.0699  0.0725   57617   4029 55603  397246  6.89
18     87 0.0793  0.0826   53588   4249 51464  341643  6.38
19     88 0.0922  0.0966   49339   4547 47066  290180  5.88
20     89 0.105   0.111    44792   4706 42440  243114  5.43
```

Question

The table above is not as readable as it should. Use package `gt` to get a more tunable outpout.
Reorder and filter the columns so that `Age` comes first (they identify rows), then `qx, mx` up to `ex`. You can use `select` or `relocate`, or both to do this. Note that `Gender, Country, Year` are constant in this tibble and need to be reported in the table header, but nowhere else.
Columns `qx` and `mx` (for mortality quotient and central death rate) should be dsplayed in scientific notation so that the fact that their range extends over several orders of magnitude shows up.
Columns `lx, dx, Lx, Tx` contain integer values.
Column `ex` (residual life expectancy) is a (fictional) decimal number of years

```r
small_tb |>
  gt() |>
  tab_header(
    title = "Life table (extract)",
    subtitle = "France, Women, 2010"
  ) |>
  fmt_integer(columns=c(lx, dx, Lx, Tx)) |>
  fmt_engineering(columns = c(qx,mx), exp_style = "e", drop_trailing_zeros = T ) |>
  tab_source_note(source_note = "From https://mortality.org")
```

Life table (extract)
France, Women, 2010

Age	qx	mx	lx	dx	Lx	Tx	ex
0	$3.24e-03$	$3.25e-03$	100,000	324	99,722	8,465,207	84.65
1	$320e-06$	$320e-06$	99,676	32	99,660	8,365,484	83.93
2	$150e-06$	$150e-06$	99,645	15	99,637	8,265,824	82.95
3	$110e-06$	$110e-06$	99,630	11	99,624	8,166,187	81.97
4	$80e-06$	$80e-06$	99,619	8	99,615	8,066,563	80.97
5	$50e-06$	$50e-06$	99,611	5	99,608	7,966,948	79.98
6	$80e-06$	$80e-06$	99,606	8	99,602	7,867,339	78.98
7	$80e-06$	$80e-06$	99,598	8	99,594	7,767,737	77.99
8	$80e-06$	$80e-06$	99,590	8	99,586	7,668,143	77.00

9	$70e-06$	$70e-06$	99,582	7	99,578	7,568,557	76.00
80	$29.78e-03$	$30.24e-03$	75,619	2,252	74,493	802,295	10.61
81	$34.55e-03$	$35.16e-03$	73,367	2,535	72,099	727,802	9.92
82	$39.78e-03$	$40.59e-03$	70,832	2,818	69,423	655,702	9.26
83	$46.44e-03$	$47.54e-03$	68,014	3,158	66,435	586,280	8.62
84	$53.86e-03$	$55.36e-03$	64,856	3,493	63,109	519,845	8.02
85	$61.03e-03$	$62.95e-03$	61,362	3,745	59,490	456,736	7.44
86	$69.93e-03$	$72.46e-03$	57,617	4,029	55,603	397,246	6.89
87	$79.29e-03$	$82.56e-03$	53,588	4,249	51,464	341,643	6.38
88	$92.15e-03$	$96.6e-03$	49,339	4,547	47,066	290,180	5.88
89	$105.05e-03$	$110.88e-03$	44,792	4,706	42,440	243,114	5.43

From https://mortality.org

Understanding the columns of the life table

In the sequel, we denote by F_t the *cumulative distribution function* for year t. We agree on $\overline{F}_t = 1 - F_t$ and $F_t(-1) = 0$. Henceforth, $\overline{F}$ is called the *survival* function.

`qx` (age-specific) `risk of death` at age x, or `mortality quotient` at given age x for given year t.

About the definition of `q_{t,x}`

Defining and computing `q_{t,x}` does not boil down to knowing the number of people at age x at the beginning of ear t and knowing how many of them died during year t. If we want to be rigorous, we need to know all life lines in the Lexis diagram, or equivalently, how many people at Age x were alive on each day of Year t.

Mortality quotients define a probability distribution

For a given year t, the sequence of mortality quotients define a survival function $\overline{F}_t$ using the following recursion:

$$q_{t,x} = \frac{\overline{F}_t(x) - \overline{F}_t(x+1)}{\overline{F}_t(x)}$$

with boundary condition $\overline{F}_t(-1) = 1$.
This recursion can also be read as:

$$\overline{F}_t(x+1) = \overline{F}_t(x) \times (1 - q_{t,x+1}) .$$

This artificial probability distribution is used to define and compute life expectancies.

$q_{t,x}$ is the *hazard rate* of $\overline{F}_t$ at age x.

`mx` *central death rate* at age x during year t. This is connected with $q_{t,x}$ by

$$m_{t,x} = -\log(1 - q_{t,x}) ,$$

or equivalently

$$q_{t,x} = 1 - \exp(-m_{t,x})$$

> **About central death rate**
>
> If we want to define a continuous probability distribution G over $[0, \infty)$ so that G and F coincide over integers and G has piecewise constant hazard rate, we can pick $m_{t,x}$ as the piecewise constant hazard rate.

lx the so-called *survival function*: the scaled proportion of persons alive at age x. These values are computed recursively from the $q_{t,x}$ values using the formula

$$l_t(x+1) = l_t(x) \times (1 - q_{t,x}) \, ,$$

with $l_{t,0}$, the *radix* of the table, (arbitrarily) set to 100000. In the table `lx` is rounded to the next integer

Function $l_{t,\cdot}$ and $\overline{F}_t$ are connected by

$$l_{t,x+1} = l_{t,0} \times \overline{F}_t(x) \, .$$

dx $d_{t,x} = q_{t,x} \times l_{t,x}$. The fictitious number of deaths occurring at age x during year t. Again this is a rounded quantity.

Tx Total number of person-years lived by the cohort from age x to $x+1$. This is the sum of the years lived by the $l_{t,x+1}$ persons who survive the interval, and the $d_{t,x}$ persons who die during the interval. The former contribute exactly 1 year each, while the latter contribute, on average, approximately half a year, so that $L_{t,x} = l_{t,x+1} + 0.5 \times d_{t,x}$. This approximation assumes that deaths occur, on average, half way in the age interval x to x+1. Such is satisfactory except at age 0 and the oldest age, where other approximations are often used.

Compare with the denominator in the definition of `qx` and its description using the Lexis diagram.

We will stick to a simplified vision $L_{t,x} = l_{t,x+1}$

ex: Residual Life Expectancy at age x and year t

This is the expectation of $X - x$ for a random variable X distributed according to $\overline{F}_t$ conditionnally on the event $\{X \geq x\}$. That is $e_{t,x}$ is the expectation of the probability distribution defined by $\overline{F}_t(\cdot + x - 1)/\overline{F}_t(x-1)$.

> **Question**
>
> Check dependencies between columns

```r
life_table |>
  filter( Year>=1948, Age < 90, Gender != "Both") |>
  group_by(Country, Year, Gender) |>
  summarise(m1 =max(abs(lx -dx -lead(lx))/lx, na.rm = T),
            m2 =max(abs(lx * qx -dx)/dx, na.rm=T),
            m3 =max(abs(Lx -lx * (1 + qx * (ax-1)))/Lx, na.rm=T),
            m4 =max(abs(1-exp(-mx)-qx)/qx, na.rm=T),
            .groups = "drop") |>
  select(Year, Country, Gender, m1, m2, m3, m4) |>
  rename(lx=m1, dx=m2, Lx=m3, qx=m4) |>
  group_by(Country, Gender) |>
  slice_max(order_by = desc(qx), n = 1)  |>
```

```
  ungroup() |>
  gt() |>
  tab_header(
    title = "Life table (relative discrepancies)",
    subtitle = ""
  ) |>
  fmt_engineering(columns = ends_with("x"),
                  decimals=2,
                  drop_trailing_zeros = T ) |>
  tab_source_note(source_note = "From https://mortality.org")
```

Life table (relative discrepancies)

Year	Country	Gender	lx	dx	Lx	qx
2015	Spain	Female	17×10^{-6}	10.9×10^{-3}	11.22×10^{-6}	2.16×10^{-3}
2016	Spain	Male	31.74×10^{-6}	33.98×10^{-3}	21.2×10^{-6}	2.14×10^{-3}
2010	Italy	Female	19.78×10^{-6}	49.96×10^{-3}	16.84×10^{-6}	1.5×10^{-3}
2012	Italy	Male	31.08×10^{-6}	95.38×10^{-3}	27.53×10^{-6}	2.31×10^{-3}
2005	France	Female	10.7×10^{-6}	31.67×10^{-3}	12.56×10^{-6}	1.93×10^{-3}
2007	France	Male	34.2×10^{-6}	105.17×10^{-3}	28.96×10^{-6}	2.22×10^{-3}
2013	England & Wales	Female	20.33×10^{-6}	77.95×10^{-3}	10.96×10^{-6}	1.51×10^{-3}
2002	England & Wales	Male	55.97×10^{-6}	41.69×10^{-3}	31.12×10^{-6}	3.15×10^{-3}
2008	Netherlands	Female	21.37×10^{-6}	85.69×10^{-3}	14.31×10^{-6}	2.08×10^{-3}
2009	Netherlands	Male	25.74×10^{-6}	65.96×10^{-3}	27.43×10^{-6}	2.74×10^{-3}
2004	Sweden	Female	19.22×10^{-6}	25.87×10^{-3}	19.81×10^{-6}	1.87×10^{-3}
2005	Sweden	Male	28.5×10^{-6}	32.16×10^{-3}	26.8×10^{-6}	2.88×10^{-3}
2012	USA	Female	25.87×10^{-6}	17.3×10^{-3}	14.73×10^{-6}	1.98×10^{-3}
2010	USA	Male	40.17×10^{-6}	62×10^{-3}	36.57×10^{-6}	2.53×10^{-3}

From https://mortality.org

Western countries in 1948

Several pictures share a common canvas:

Question

Plot mortality quotients (`qx`) against age using a logarithmic scale on the y axis. Countries are identified by aesthetics (`shape`, `color`, `linetype`).

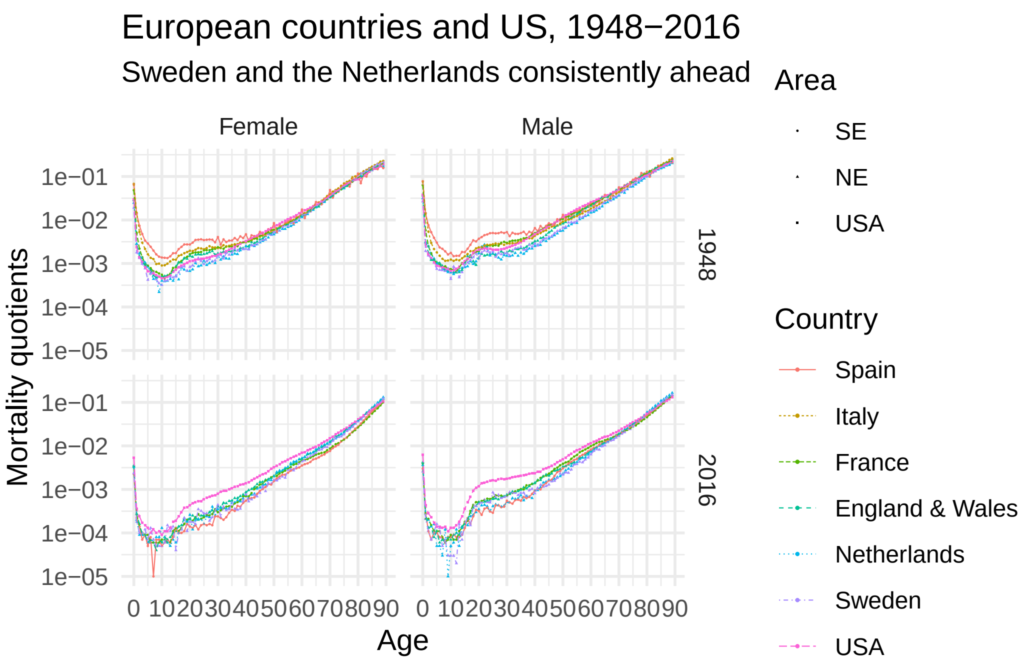
1. Use facetting to plot `qx` of all countries at all ages for years 1950, 1960, …, 2010.
2. Use `plotly` to build an animated plot using `Year` for the `frame` aesthetics.

Abiding to the DRY principle, define a prototype `ggplot` (alternatively `plotly`) object.
The prototype will then be fed with different datasets and decorated and arranged for the different figures.

```
dummy_data <- filter(life_table, FALSE)

proto_plot <- dummy_data |>
```

```
  ggplot() +
    aes(x=Age,
        y=qx,
        col=Country,
        linetype=Country,
        shape=Area) +
    scale_y_log10() +
    scale_x_continuous(breaks = c(seq(0, 100, 10), 109)) +
    ylab("Mortality quotients") +
    labs(linetype="Country") +
    theme_minimal()
```

```
p_1
```




```
proto_plt2 <-
  ggplot() +
  aes(x=Age, y=qx, colour=Area, frame=Year, linetype=Country) +
  geom_point(size=.1) +
  geom_line(size=.1) +
  scale_y_log10() +
  labs(linetype=c("Country")) +
  scale_x_continuous(breaks = c(seq(0, 100, 10), 109)) +
  xlab("Age") +
  ylab("Mortality quotients") +
  facet_grid(cols=vars(Gender)) +
  theme_minimal()
```

```
p_2 <- with(params,
  (proto_plt2 %+%
    (life_table |>
      filter(between(Year, year_p, year_e),
             Year %% 10 == 0,
             Gender != 'Both',
             Age < 90))  +
    ggtitle(glue("Mortality quotient {{year_p}}-{{year_e}}: Europe catches up")))
```

```
)
```

In 1948, NE and the USA exhibit comparable mortality quotients at all ages for the two genders, the USA looking like a more dangerous place for young adults. Spain lags behind, Italy and France showing up at intermediate positions.

By year 1962, SE has almost caught up the USA. Italy and Spain still have higher infant mortality while mortality quotients in the USA and France are almost identical at all ages for both genders. Mortality quotients attain a minimum around 10-12 for both genders. In Spain the minium central death rate has been divided by almost ten between 1948 and 1962.

If we dig further we observe that the shape of the male mortality quotients curve changes over time. In 1962, in the USA and France, mortality quotients exhibit a sharp increase between years 12 and 18, then remain almost constant between 20 and 30 and afterwards increase again. This pattern shows up in other countries but in a less spectacular way.

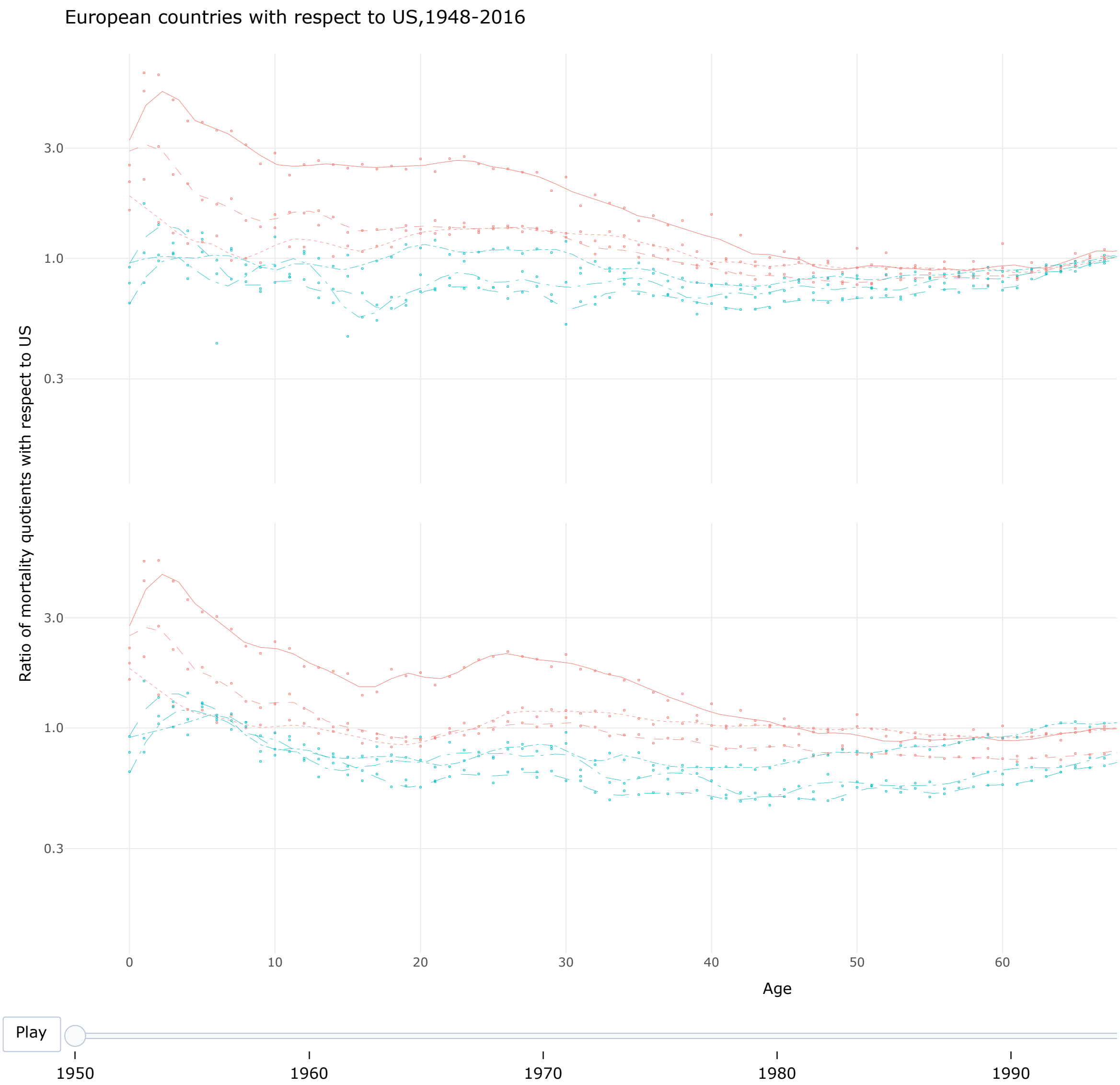
Twenty years afterwards, during years 1980-1985, death rates at age 0 have decreased at around 1% in all countries while it was 7% in Spain in 1948. The male central death curve exhibits a plateau between ages 20 and 30. Mortality quotients at this age look higher in France and the USA.

By year 2000, France is back amongst European countries (at least with respect to mortality quotients). Young adult mortality rates are higher in the USA than in Europe. This phenomenon became more pregnant during the last decade.

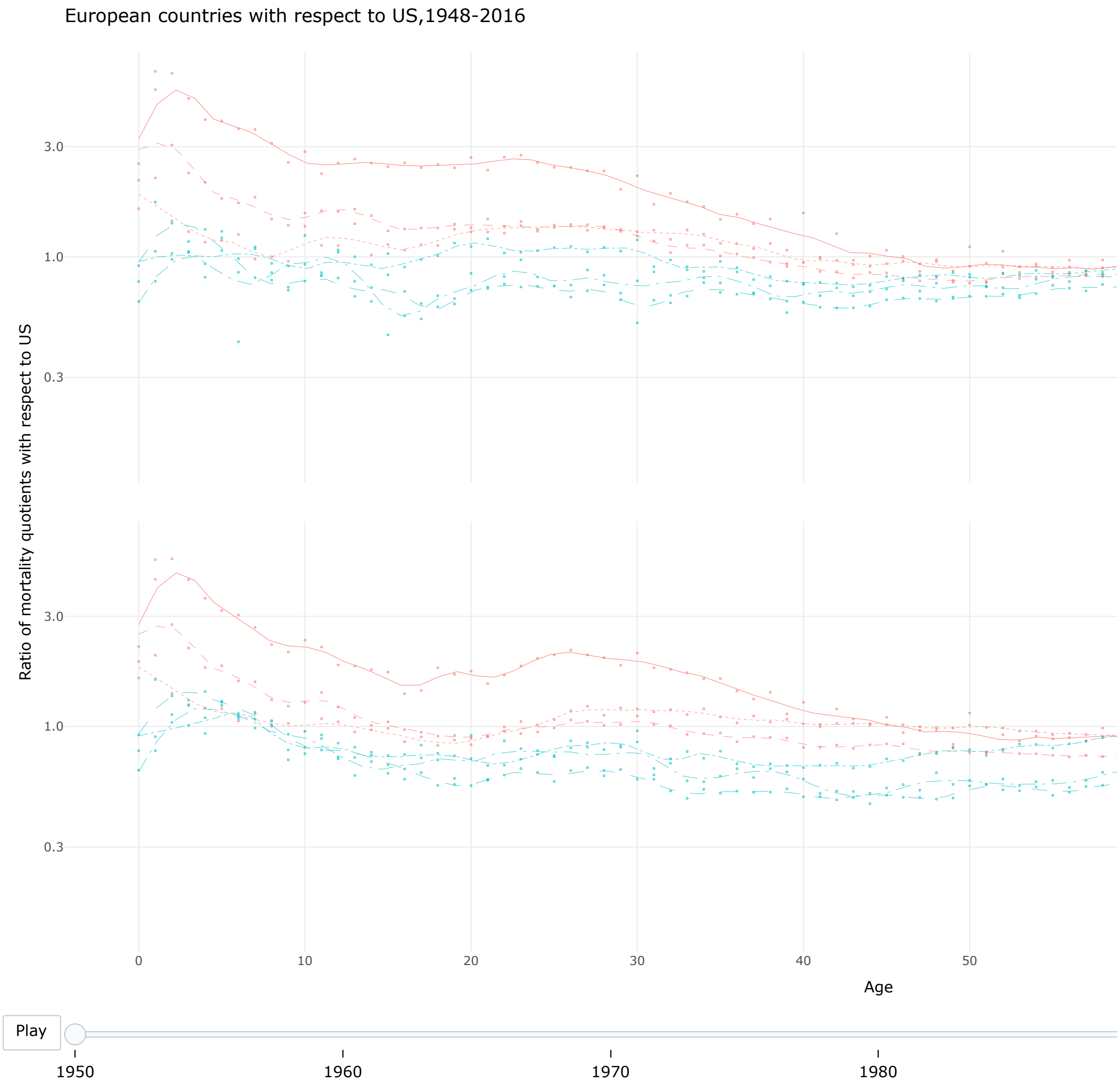
> **Question**
>
> Plot ratios between mortality quotients (`qx`) in European countries and mortality quotients in the USA in 1948.

```r
p <- with(params,
  (filter(eur_us_table, Year %% 10==0)  |>
    ggplot() +
    aes(x=Age,
        y=Ratio,
        frame=Year) +
    aes(linetype=Country, show.legend = FALSE) +
    aes(color=Area, show.legend = FALSE) +
    scale_y_log10() +
    scale_x_continuous(breaks = c(seq(0, 100, 10), 109)) +
    geom_point(size=.1) +
    geom_smooth(method="loess",
                formula= 'y~ x',
                se=FALSE,
                span=.1,
                size=.1) +
    ylab("Ratio of mortality quotients with respect to US") +
    ggtitle(label = glue("European countries with respect to US,{year_p}-{year_e}"),
            subtitle = "Sweden consistently ahead") +
   facet_grid(rows = vars(Gender))
  ))

gp <- p |>
  ggplotly()
```

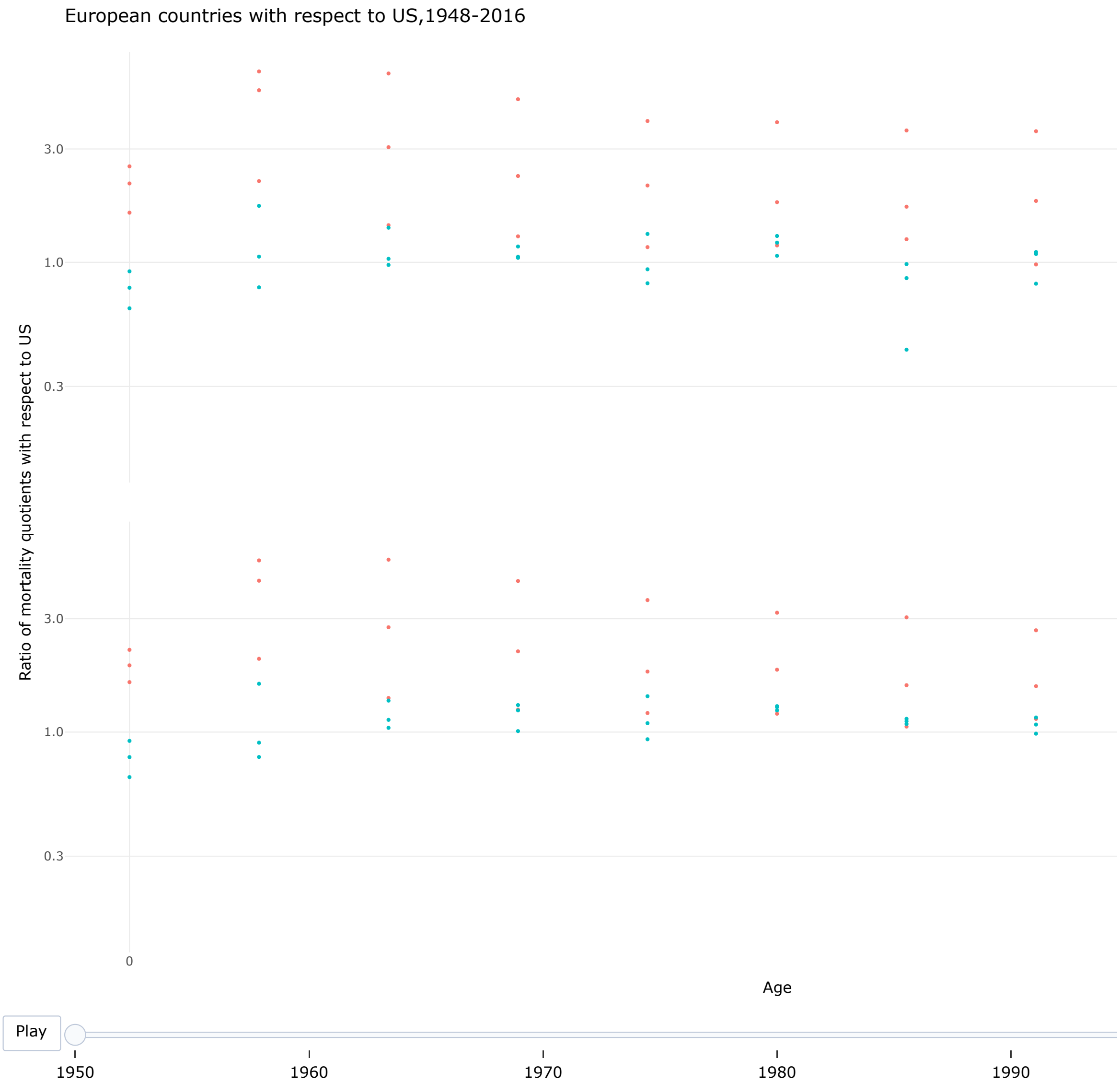
```r
gp
```



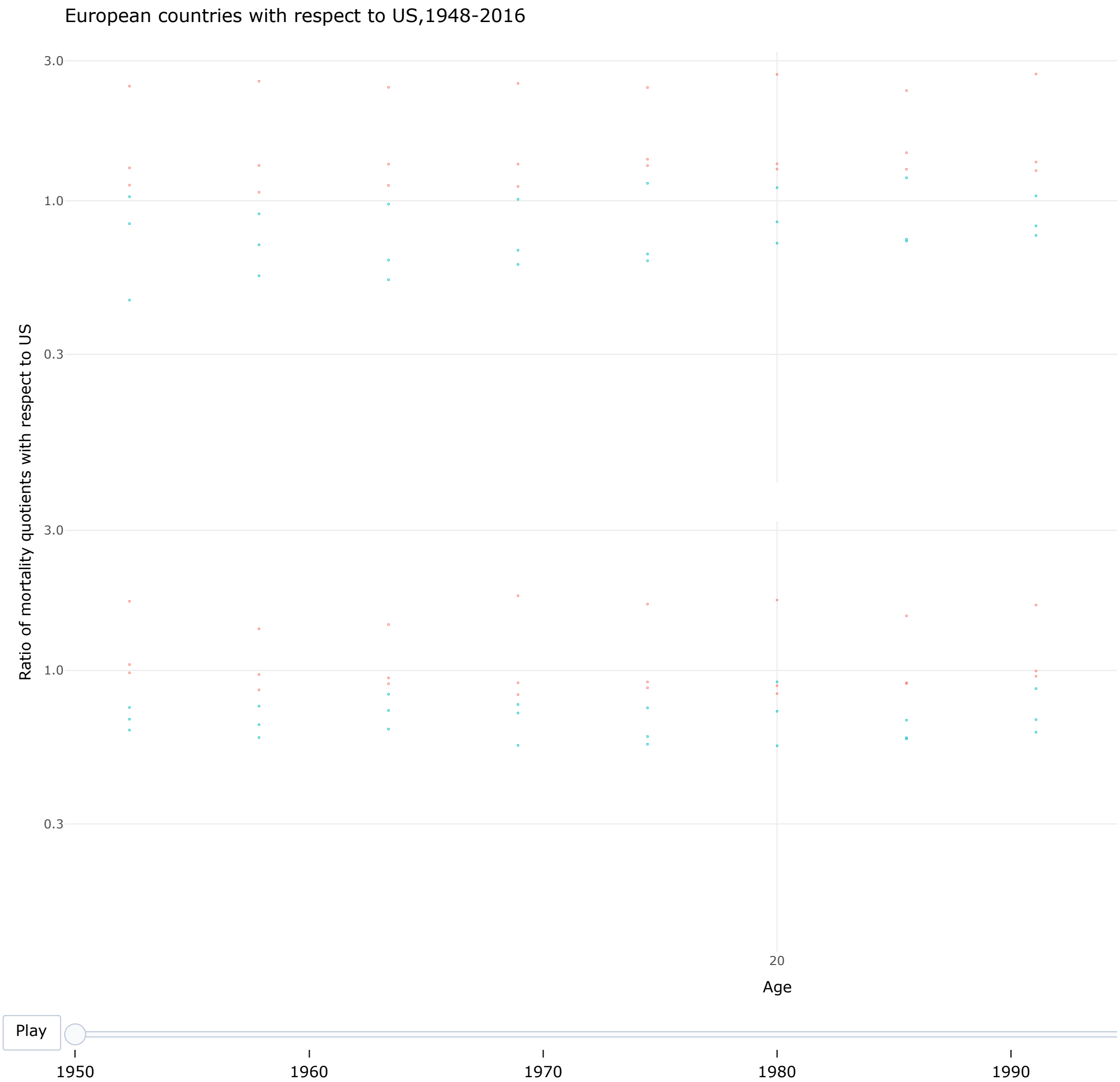

```r
for (i in seq_along(gp$x$data)) {
  gp$x$data[[i]]$showlegend <- FALSE
}

gp
```




```
(p %+% with(params,
  filter(eur_us_table, Year %% 10==0, Age <= 10)) +
  geom_point(size=.5) ) |>
  ggplotly()
```




```
(p %+% with(params,
  filter(eur_us_table, Year %% 10==0, between(Age, 15, 25))) ) |>
  ggplotly()
```



> **Comment**
>
> This animation reveals less than the preceding one since we just have ratios with respect to the USA. But the patterns followed by European societies emerge in a more transparent way. The divide between northern and southern Europe at the onset of the period is even more visible. The ratios are important across the continent: there is a factor of 10 between spanish and swedish infant mortality rates. But the ratios at ages 50 and above tend to be similar. By the early 60s, the gap between southern and northern Europe has shrinked. By now, the ratios between mortality quotients tend to be within a factor of 2 across all ages, and even less at ages 50 and above.

Death rates evolution since WW II

Question

Plot mortality quotients (column `qx`) for both genders as a function of `Age` for years `1946, 1956, ...` up to `2016` . Use aesthetics to distinguish years. You will need to categorize the `Year` column (`forcats::` may be helpful).

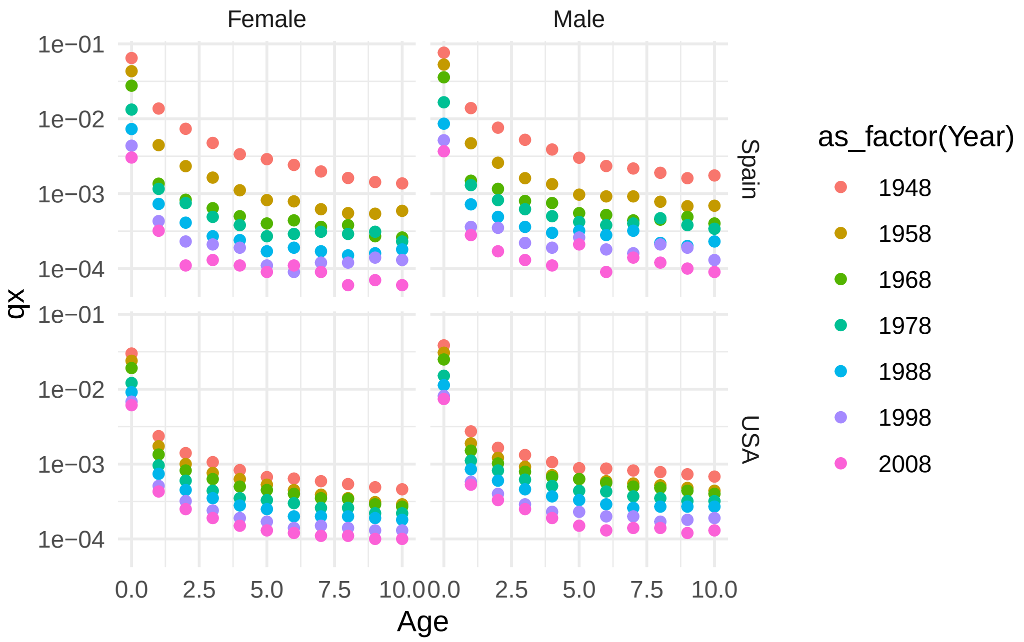
1. Facet by `Gender` and `Country`

2. Pay attention to axes labels, to legends. Assess logarithmic scales.

```
p_3 <- (p  %+%
  filter(life_table,
    Year %in% post_ww_II,
    Gender!="Both",
    Age < 90,
    Country %in% c('Spain', 'USA')) +
  labs(title="Mortality quotient per Age",
    subtitle = "Post WW II")
)
```

```
p_3
```


```
filter(life_table,
    Year %in% post_ww_II,
    Gender!="Both",
    Age < 11,
    Country %in% c('Spain', 'USA')) |>
ggplot() +
  aes(x=Age,
      y=qx,
      col=as_factor(Year),
      linetype=as_factor(Year)) +
  geom_point() +
#  geom_smooth(se=FALSE, method="loess", span= .1, size=.2) +
#  labs(colour="Year", linetype="Year")    +
  scale_y_log10() +
  facet_grid(rows=vars(Country), cols=vars(Gender))
```



Question

Write a function `ratio_mortality_rates` with signature `function(df, reference_year=1946, target_years=seq(1946, 2016, 10))` that takes as input:

- a dataframe with the same schema as `life_table`,
- a reference year `ref_year` and
- a sequence of years `target_years`

and that returns a dataframe with schema:

Column Name	Column Type
Year	integer
Age	integer
mx	double
mx.ref_year	double
Country	factor
Gender	factor

where `(Country, Year, Age, Gender)` serves as a *primary key*, `mx` denotes the central death rate at `Age` for `Year` and `Gender` in `Country` whereas `mx_ref_year` denotes central death rate at `Age` for argument `reference_year` in `Country` for `Gender`.

```r
ratio_mortality_rates <- function(df,
                                  reference_year=1946,
                                  target_years=seq(1946, 2016, 10)){

  jbe <- join_by(Age, Gender, Country)

  right_df <- df |>
    filter(Year==reference_year) |>
    select(Age, Gender, Country, qx)

  df |>
    filter(Year %in% target_years, Age <90) |>
```

```
    select(Age, Area, Gender, Country, qx, Year) |>
    inner_join(right_df, by = jbe)

}
```

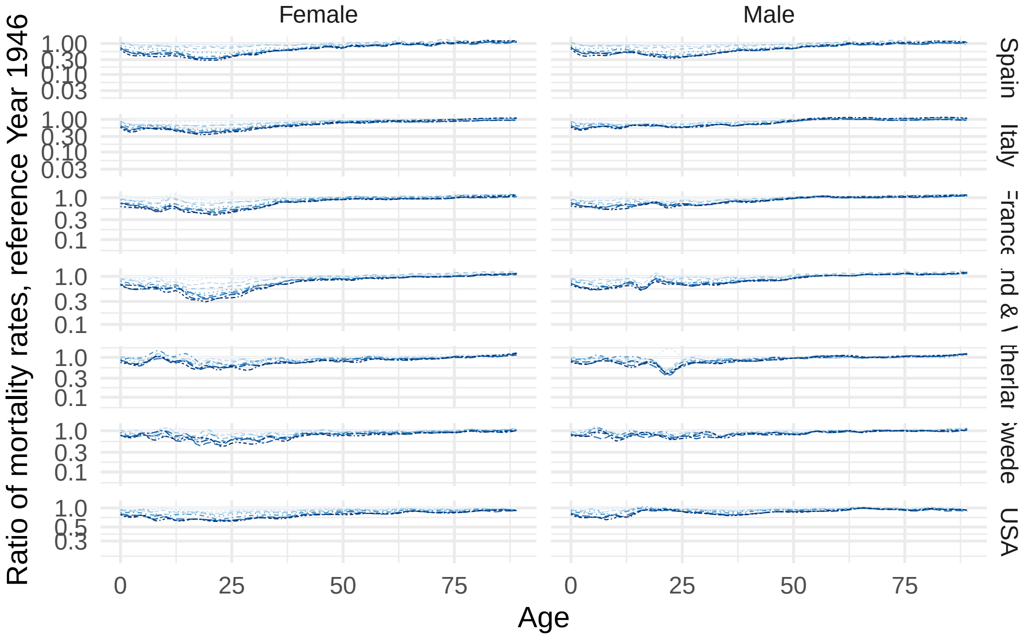
Question

Draw plots displaying the ratio $q_{x,t}/q_{x,1946}$ for ages $x \in 1, \ldots, 90$ and year t for $t \in 1946, \ldots, 2013$ where $q_{x,t}$ is the mortality quotient at age x during year t.

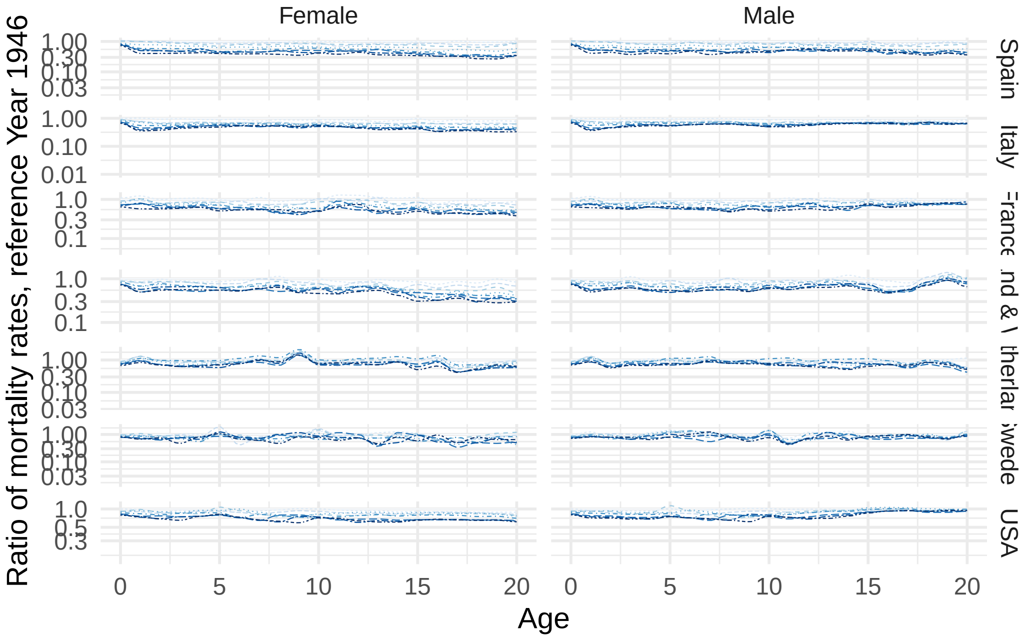
1. Handle both genders and all countries
2. One properly facetted plot is enough.

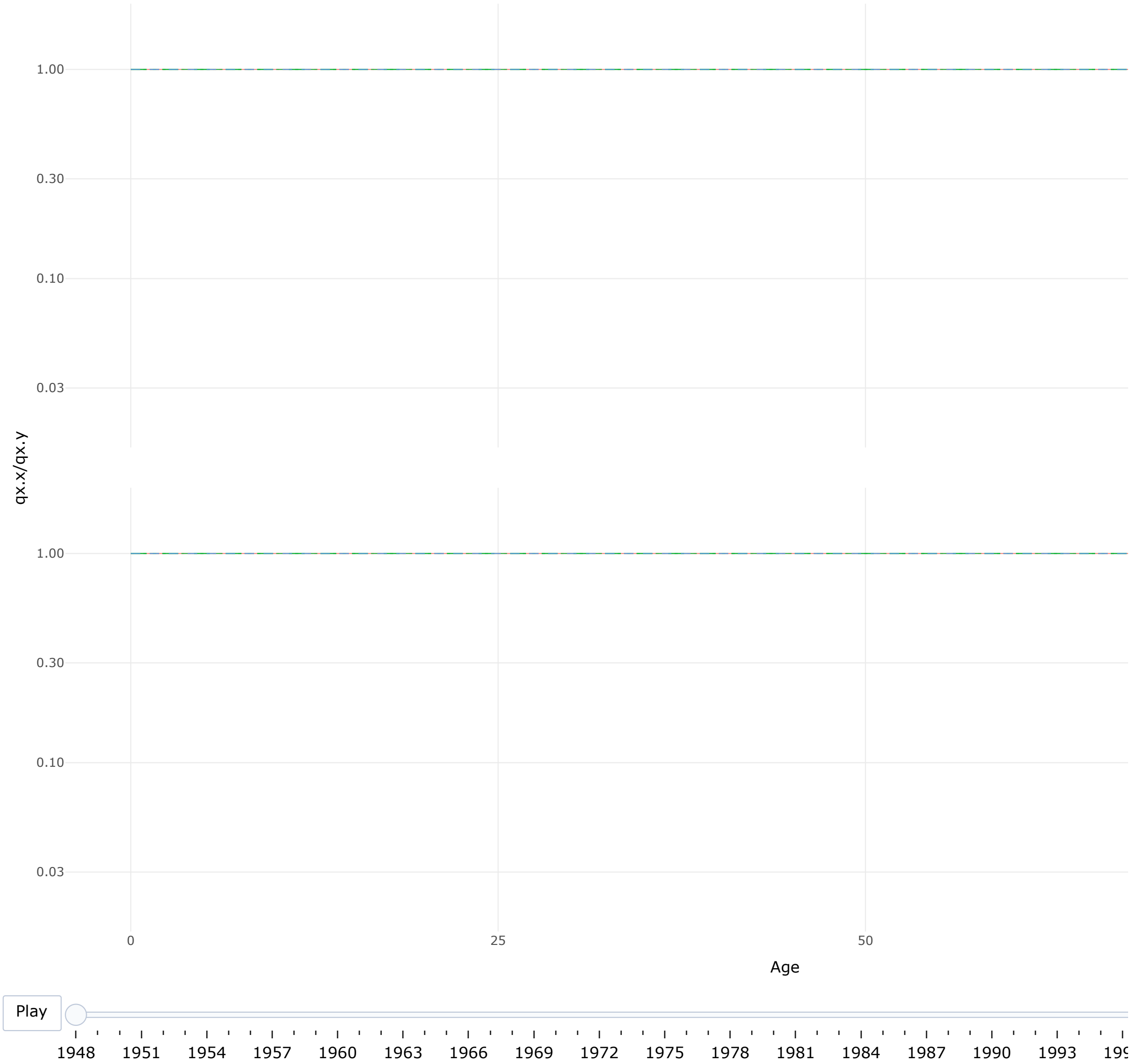
```
geom_smooth_line <- geom_smooth(method="loess",
  formula = y ~ x,
  se= FALSE,
  size =.2,
  span= .1
)
```

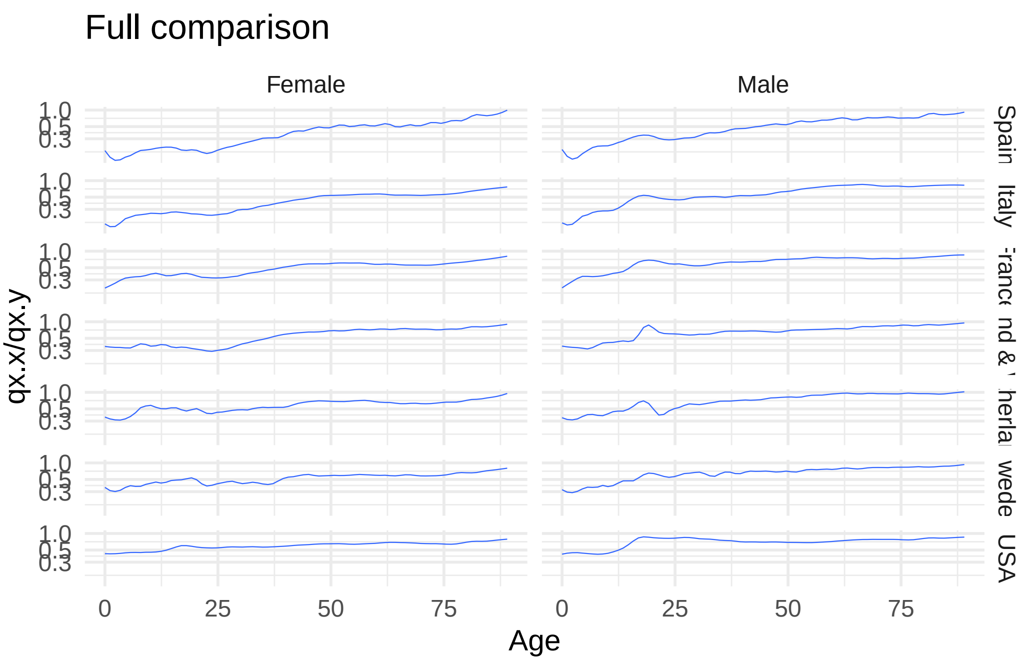
```
q <- df_ratios |>
  ggplot() +
  aes(x=Age,
      y=qx.x/qx.y) +
  geom_smooth_line +
  scale_y_log10()

q1 <- q +
  aes(linetype=as_factor(Year),
      col=as_factor(Year)) +
  ylab("Ratio of mortality rates, reference Year 1946") +
  labs(linetype="Year", col="Year") +
  scale_colour_brewer() +
  theme(legend.position = "none") +
  facet_grid(
    rows = vars(Country),
    cols =vars(Gender),
    scales = "free_y"
  )

q1
```




```r
q1 %+% (
  df_ratios |>
    filter(Age <= 20)
)
```




1.00
0.30
0.10
0.03
qx.x/qx.y
0
25
50
Age
Play
1948
1951
1954
1957
1960
1963
1966
1969
1972
1975
1978
1981
1984
1987
1990
1993


Full comparison
Female
Male
1.0
0.5
0.3
qx.x/qx.y
Spain
Italy
USA
0
25
50
75
Age

Comment.

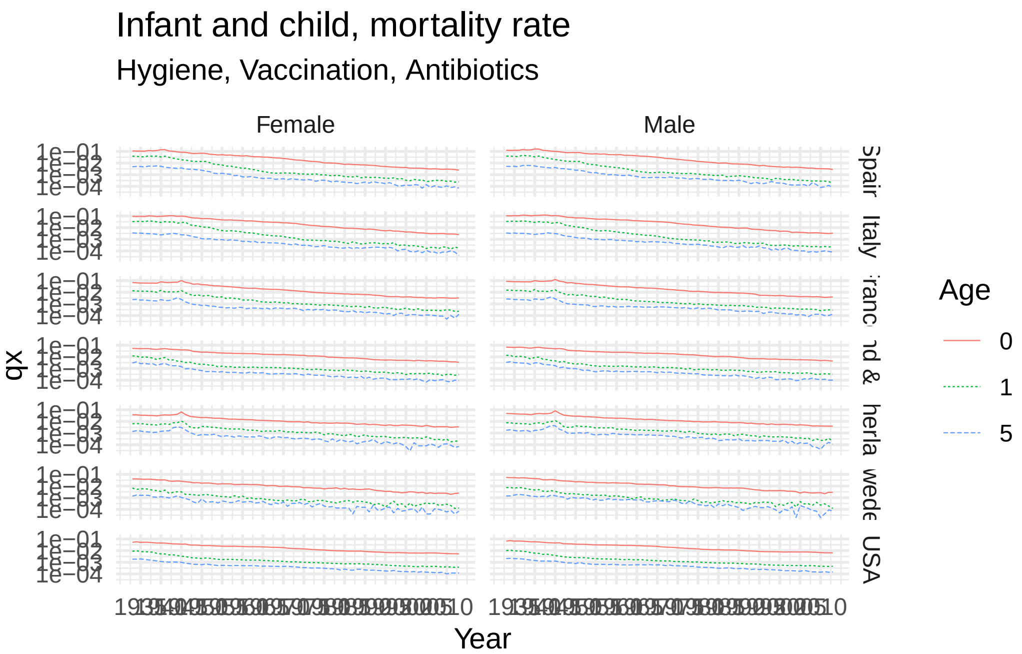
During the last seventy years, death rates decreased at all ages in all seven countries.This progress has not been uniform across ages, genders and countries. Across most countries, infant mortality dramatically improved during the first post-war decade while death rates at age 50 and above remained stable until the mid seventies.

Trends

We noticed that mortality quotients did not evolve in the same way across all ages: first, the decay has been much more significant at low ages; second, the decay of mortality quotients at old ages (above 60) mostly took place during the last four decades. It is worth digging separately at what happened for different parts of life.

Question

Plot mortality quotients at ages $0, 1, 5$ as a function of time. Facet by Gender and Country



Comment

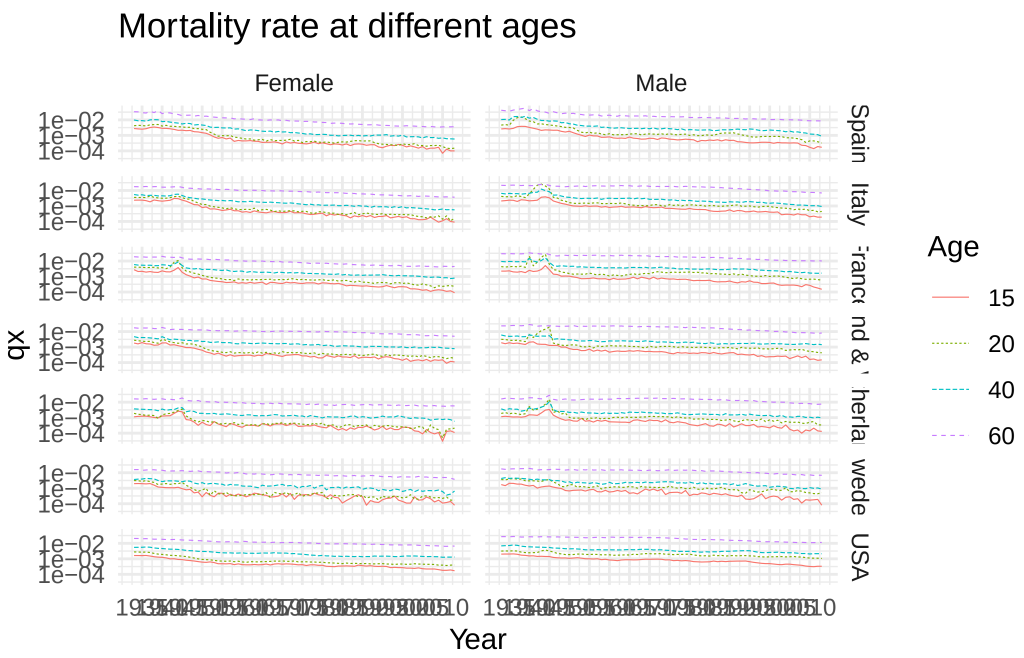
All European countries achieved the same infant mortality rates after year 2000. The USA now lag behind.
During years 1940-1945, in the Netherlands and France, gains obtained before 1940 were reversed. Year 1945 was particularly difficult in the Netherlands.

Question

Plot mortality quotients at ages $15, 20, 40, 60$ as a function of time. Facet by `Gender` and `Country`

```r
ages <- c(15, 20, 40, 60)
```

```r
p_children %+%
  filter(life_table,
         Age %in% ages,
         Gender != "Both",
         Year %in% 1933:2013) +
  ggtitle("Mortality rate at different ages")
```



Comment.

While death rates at ages 15 and 20 among women are close across all societies, death rates are higher at age 20 than at age 15 among men. In France, at age 20, death rates declined from 1945 until 1960, and then increased back to their initial level until 1980. Male death rates at age 60 started to decline around 1980. Female death rates at age 60 declined steadily throughout the 7 decades. Years 1940-1945 exhibit disruptions with different shapes and intensities in Italy, France, England & Wales, and the Netherlands.