Measures of health

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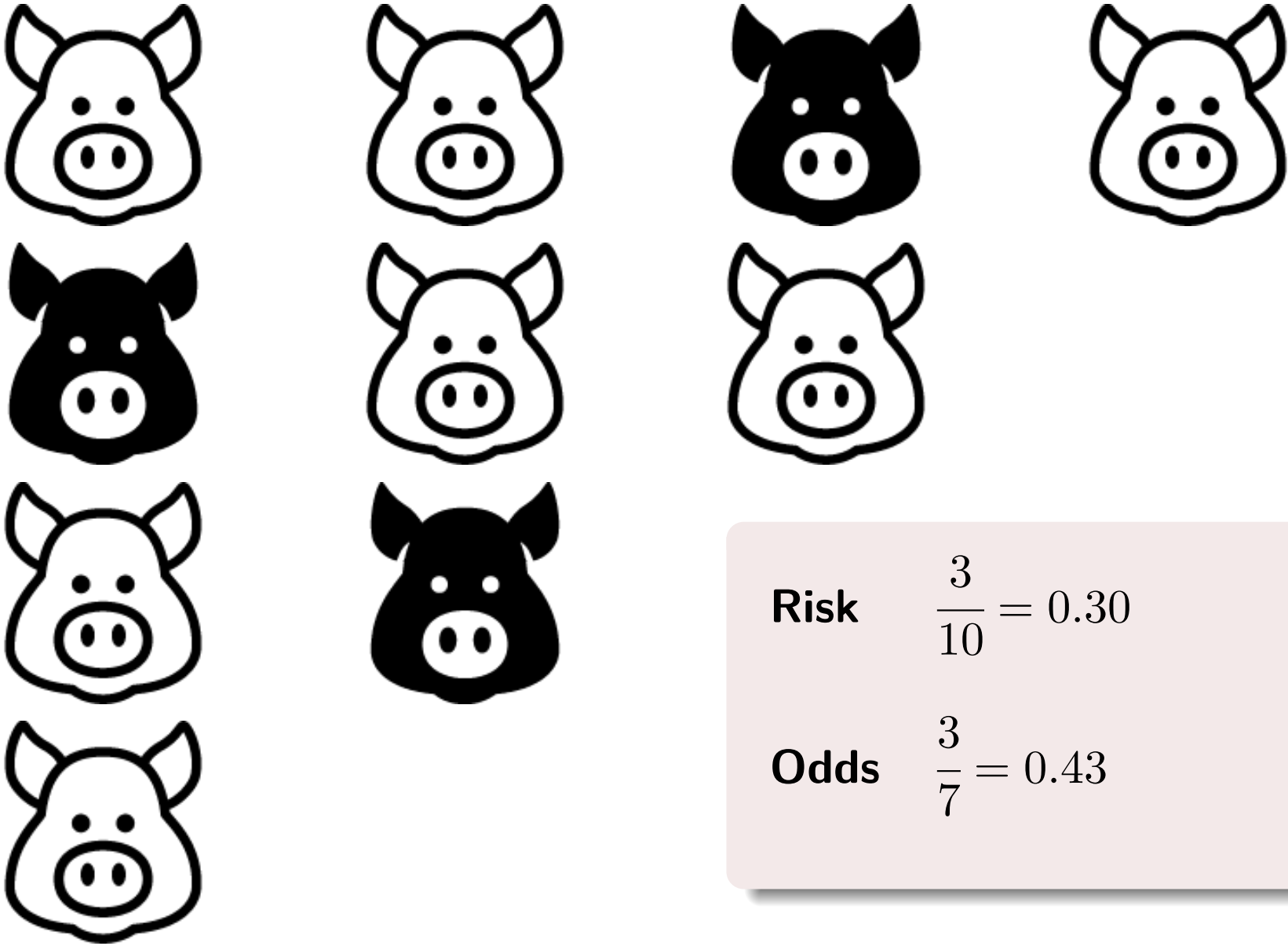


Risk $\frac{3}{10} = 0.30$

Odds $\frac{3}{7} = 0.43$

The two widely used measures to describe the disease occurence in the populations are **incidence** and **prevalence**

The purpose of the first measure is to quantify the number of the new cases in the population within a ceratin time period. The number of **new cases** is the **incidence**.

When our goal is to quantify the the number of affected animals in a population at a certain time point (or in a time period) then we use the **prevalence**.

Usually the raw case numbers are normalized by any denominator to be comparable. In most of the cases the size of the **population at risk** is applied.

The **population at risk** that part of the population that **might be affected** by the given disorder.

COVID-19 Dashboard at Johns Hopkins

Cumulative incidence (CI) in **closed** population:

$$CI = \frac{\text{number of new cases in the period}}{\text{size of the population at risk at the begining of period}}$$

In **open** populations the size of the population is changing during the study period (selling, death, birth, import) the denominator:

- the population size at the half time of study period
- $N_{\text{start}} + \frac{1}{2}N_{\text{new}} - \frac{1}{2}N_{\text{lost}}$
- $N_{\text{start}} + \frac{1}{2}N_{\text{new}} - \frac{1}{2}N_{\text{lost}} + \frac{1}{2}N_{\text{cases}}$

The cumulative incidence is a proportion, without dimension, ranged between 0 and 1.

e.g. a closed population with 100 animal population at risk

Week	New cases	CI
1	20	0.20
2	15	0.35
3	10	0.45
4	5	0.50
5	1	0.51

For the 5 weeks period, the cumulative incidence is 0.51. At the end of the period, the probability of a randomly chosen animal is affected 51%.

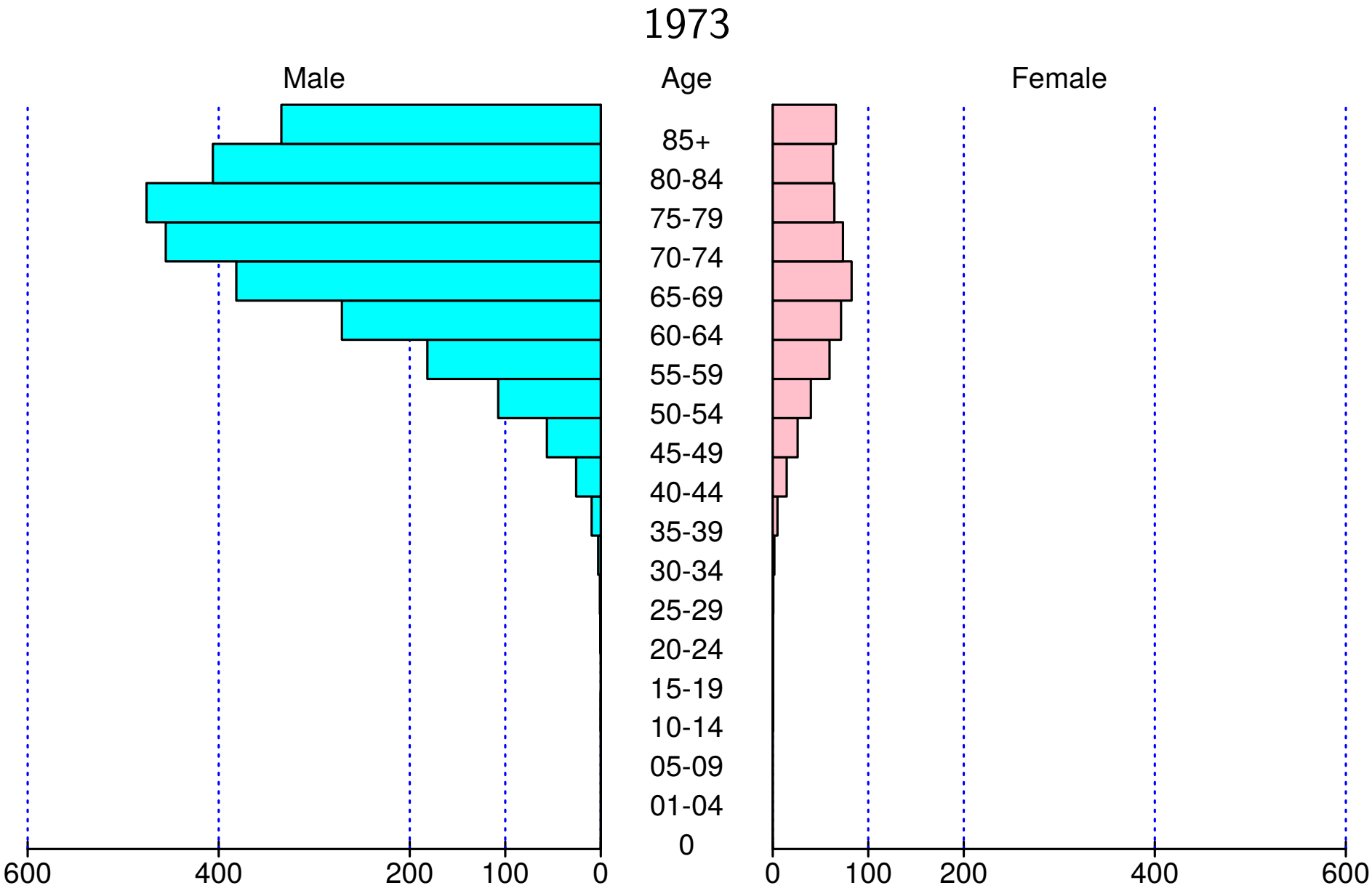
The **length** of the study period has strong influence on the CI, the longer has higher.

Effectiveness of insecticide-impregnated collars for the control of canine visceral leishmaniasis

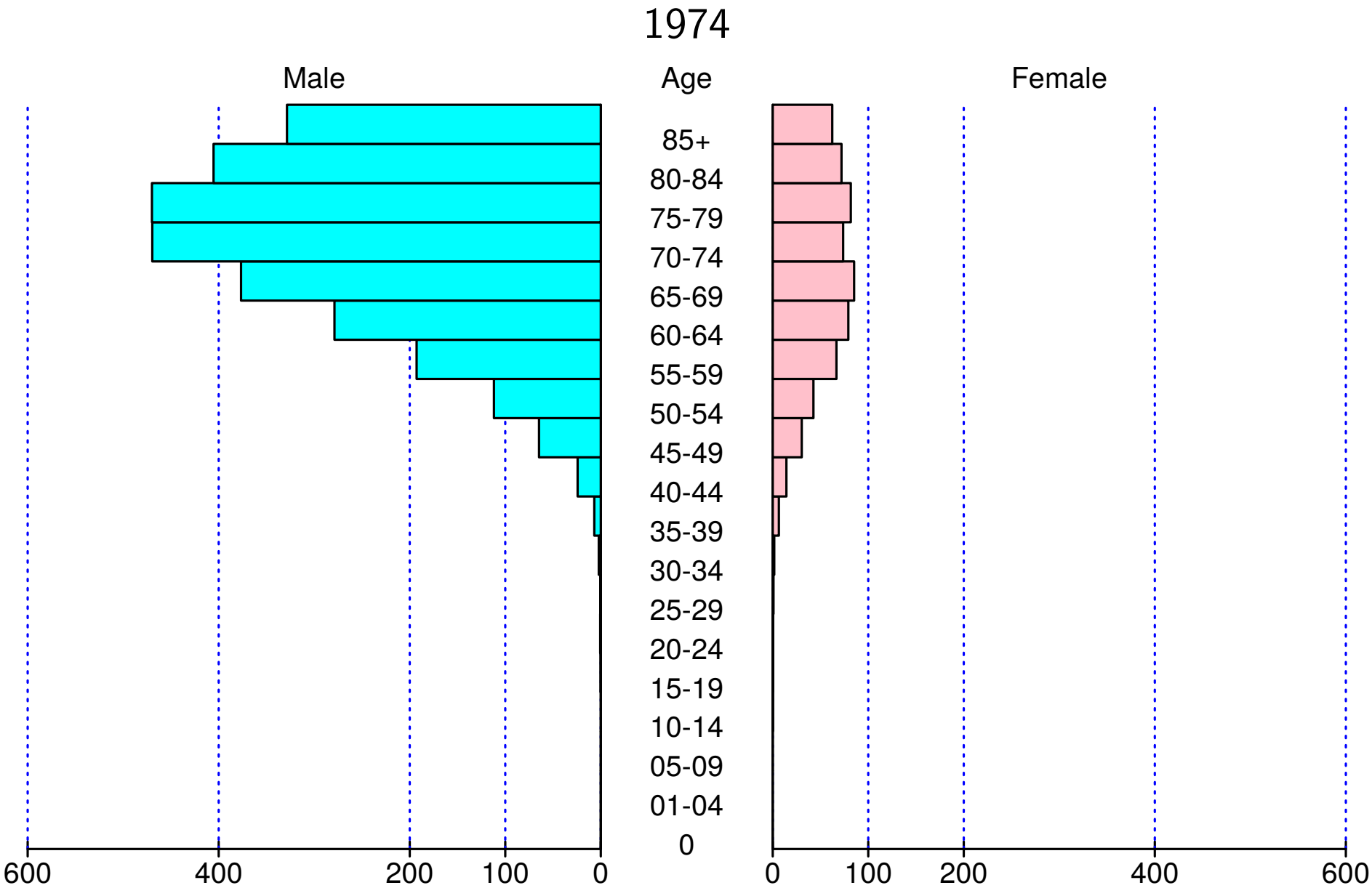
Abstract

Visceral leishmaniasis is a neglected tropical disease widely distributed worldwide. In Brazil, the control measures adopted in the last decades have not been able to prevent the spread of the disease. This study aimed to evaluate the effectiveness of a population-based intervention using 4% deltamethrin-impregnated dog collars on the incidence of canine visceral leishmaniasis.
A community intervention study was carried out in two areas of the city of Montes Claros, State of Minas Gerais, Brazil. In the control area, the preventive measures recommended by the Brazilian Program for Surveillance and Control of Visceral Leishmaniasis were implemented (culling of infected dogs and vector control with residual insecticides). In the intervention area, deltamethrin-impregnated collars were fit to domiciled dogs, in addition to the above mentioned preventive measures. At the beginning of the study, a census survey was carried out among domiciled dogs to detect the prevalence of L. infantum infection. Dogs found seronegative at recruitment were longitudinally followed-up to evaluate the incidence of infection. Monitoring of canine infection (control and intervention areas) and replacement of collars (intervention area) occurred through sequential surveys at 12, 18, and 24 months after the initial survey. At each survey, dogs were tested, and the owner answered a questionnaire about the general characteristics of the animal. Multilevel logistic regression models were used to test the effect of collars on the risk of canine infection, with households considered as aggregation units. Associations were expressed as odds ratios (OR) and respective 95% confidence intervals (95%CI).
The prevalence of infection in the initial survey was 9.7% and 9.9% in the intervention and control areas, respectively ($p = 0.732$). Among a total of 20,477 dogs participating in the study, 9,770 were seronegative at recruitment. The **cumulative incidence** of infection was 4.1% in the intervention area and 7.9% in the control area ($p < 0.001$). In the multivariable analysis, the risk of infection was 52% lower in the intervention area as compared to the control area (OR = 0.48, 95%CI:0.39-0.59), after adjusting for the number of dogs in the house, period of recruitment, time of dog ownership, and age, sex, length of fur and breed.
The use of 4% deltamethrin-impregnated dog collars was effective in reducing the incidence of canine leishmaniasis. Cost-effectiveness studies are recommended before the incorporation of collars in the arsenal of control measures of the Brazilian Program for Surveillance and Control of Visceral Leishmaniasis.

Alves et al. (2020)



SEER: yearly lung cancer incidence / 100 000 persons



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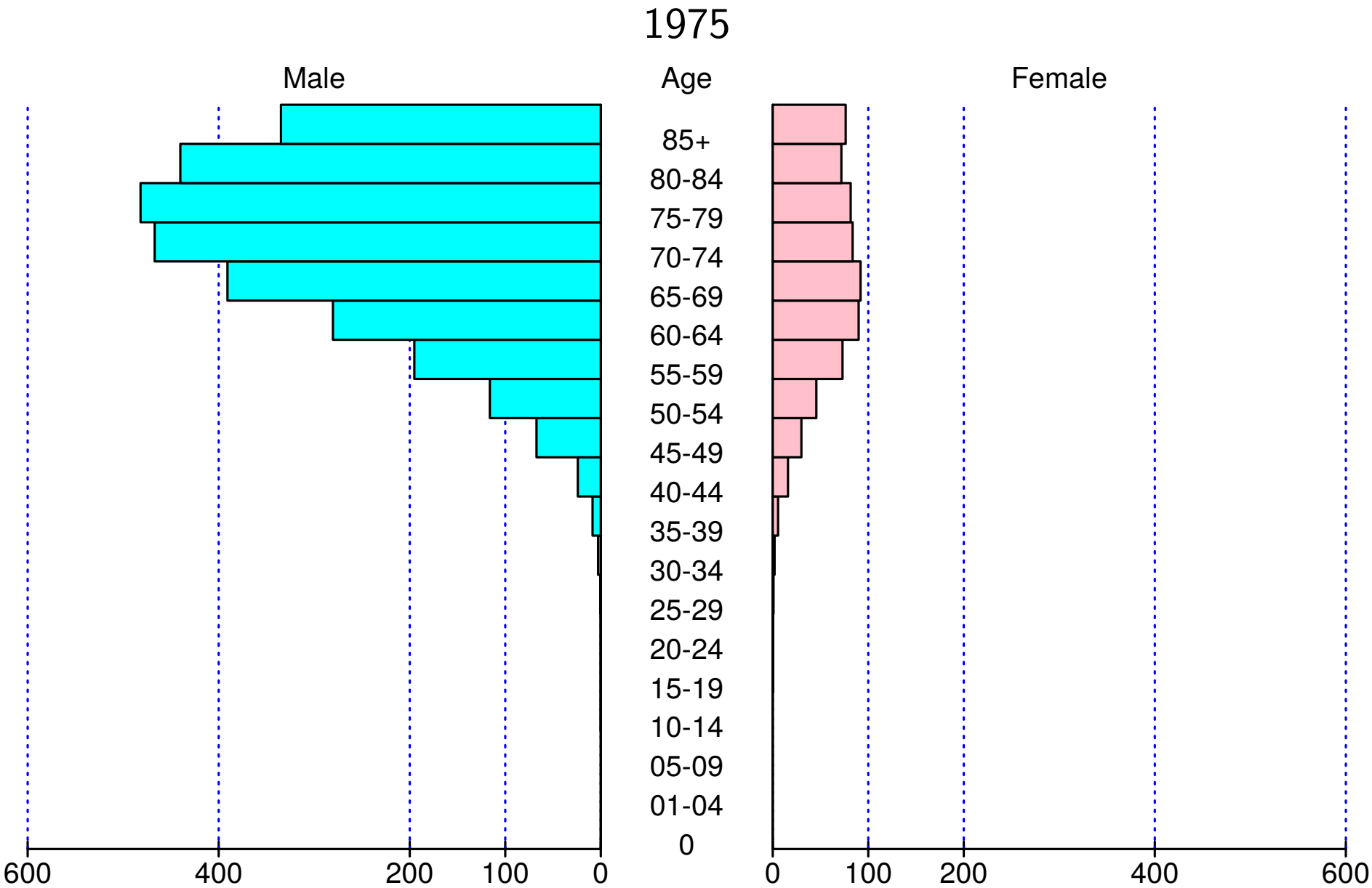

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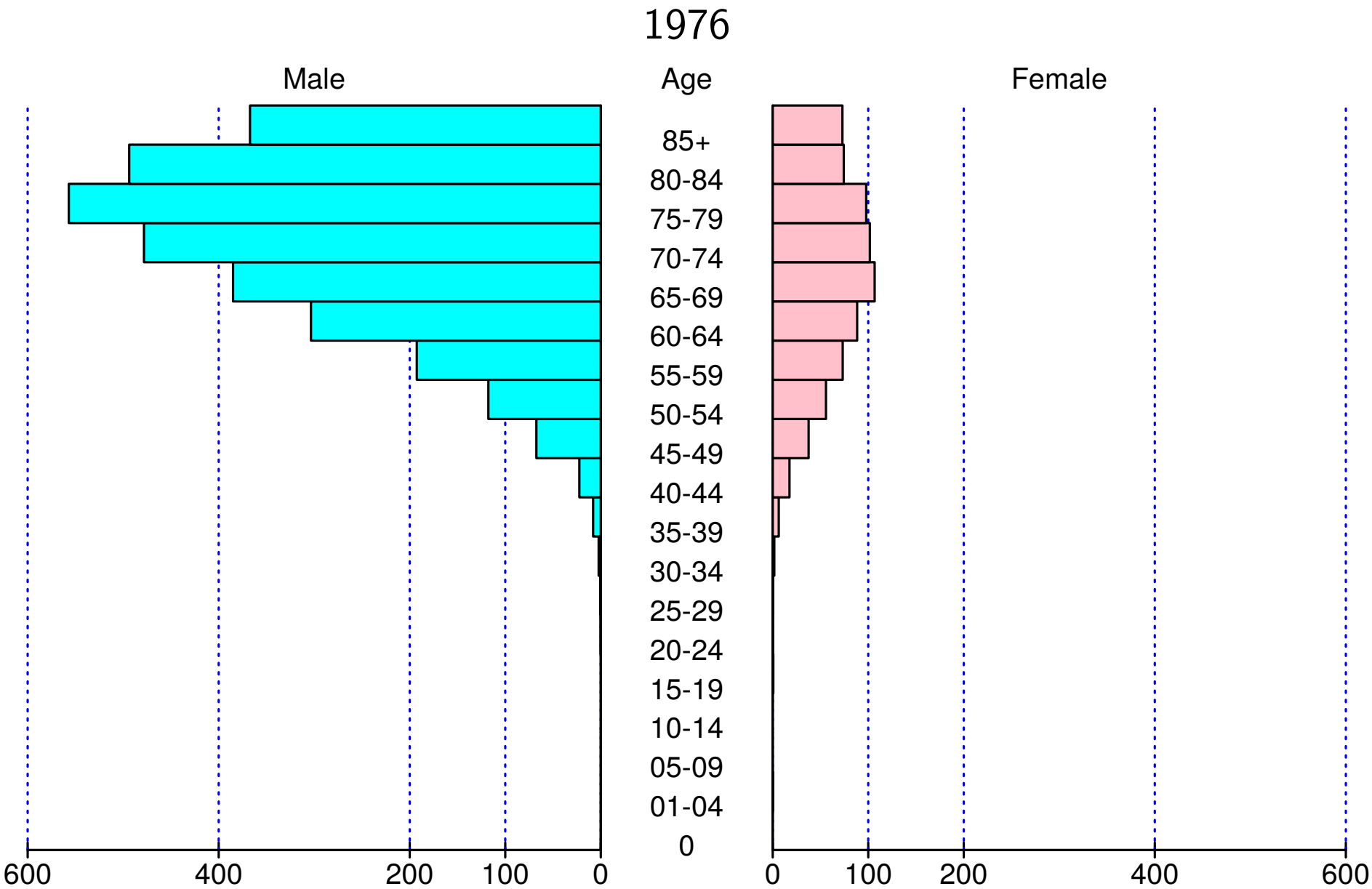

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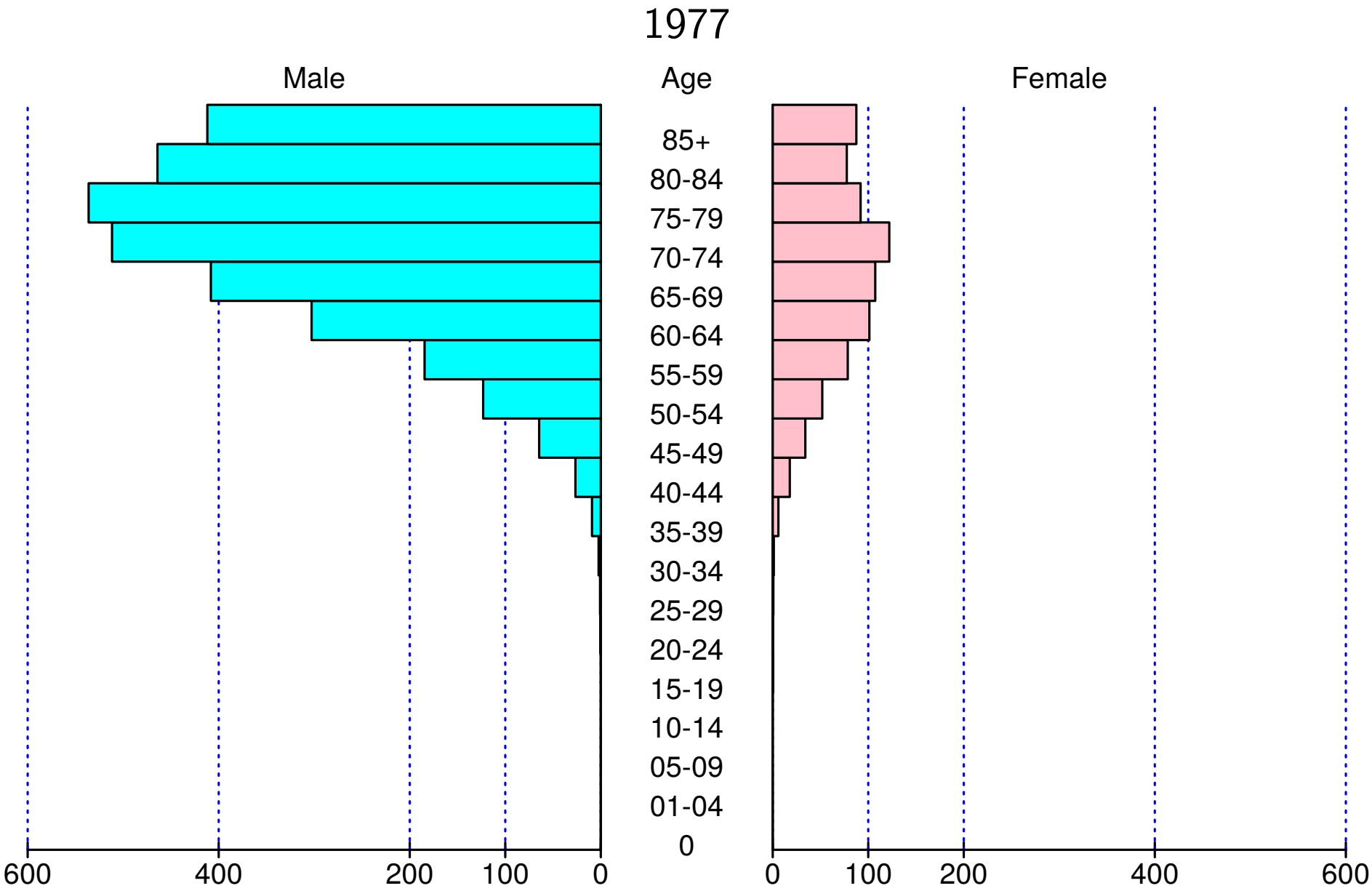

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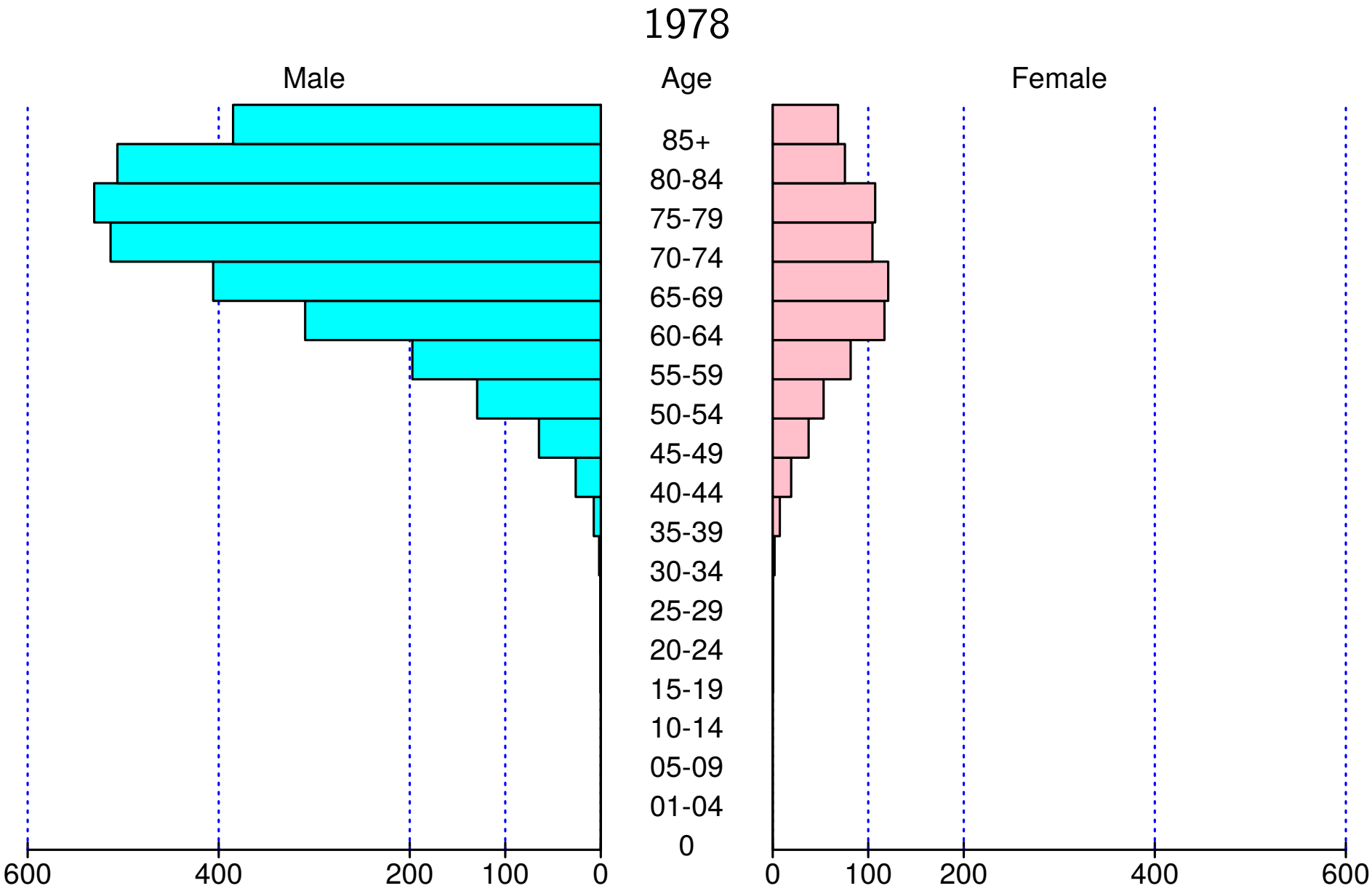

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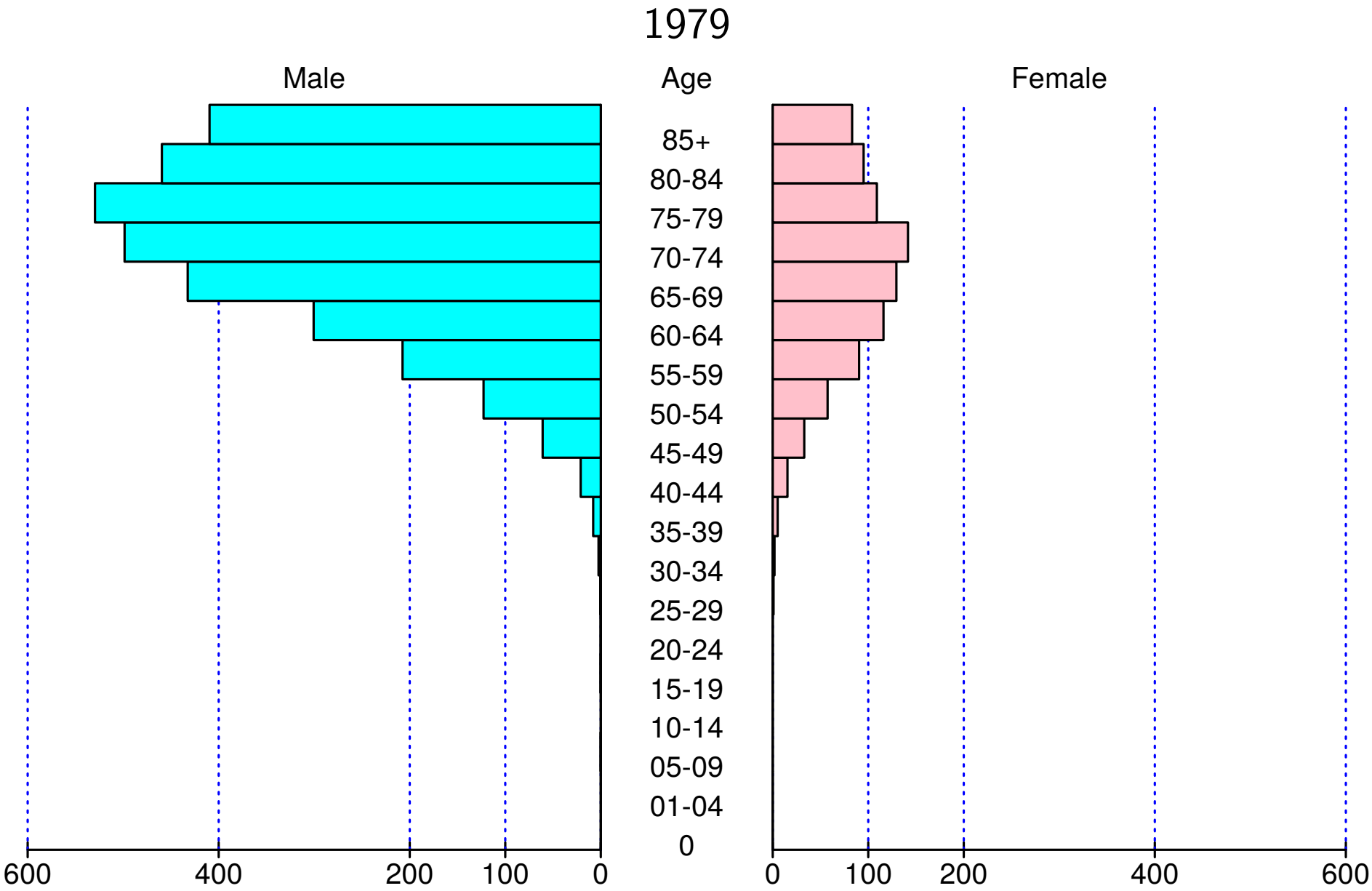

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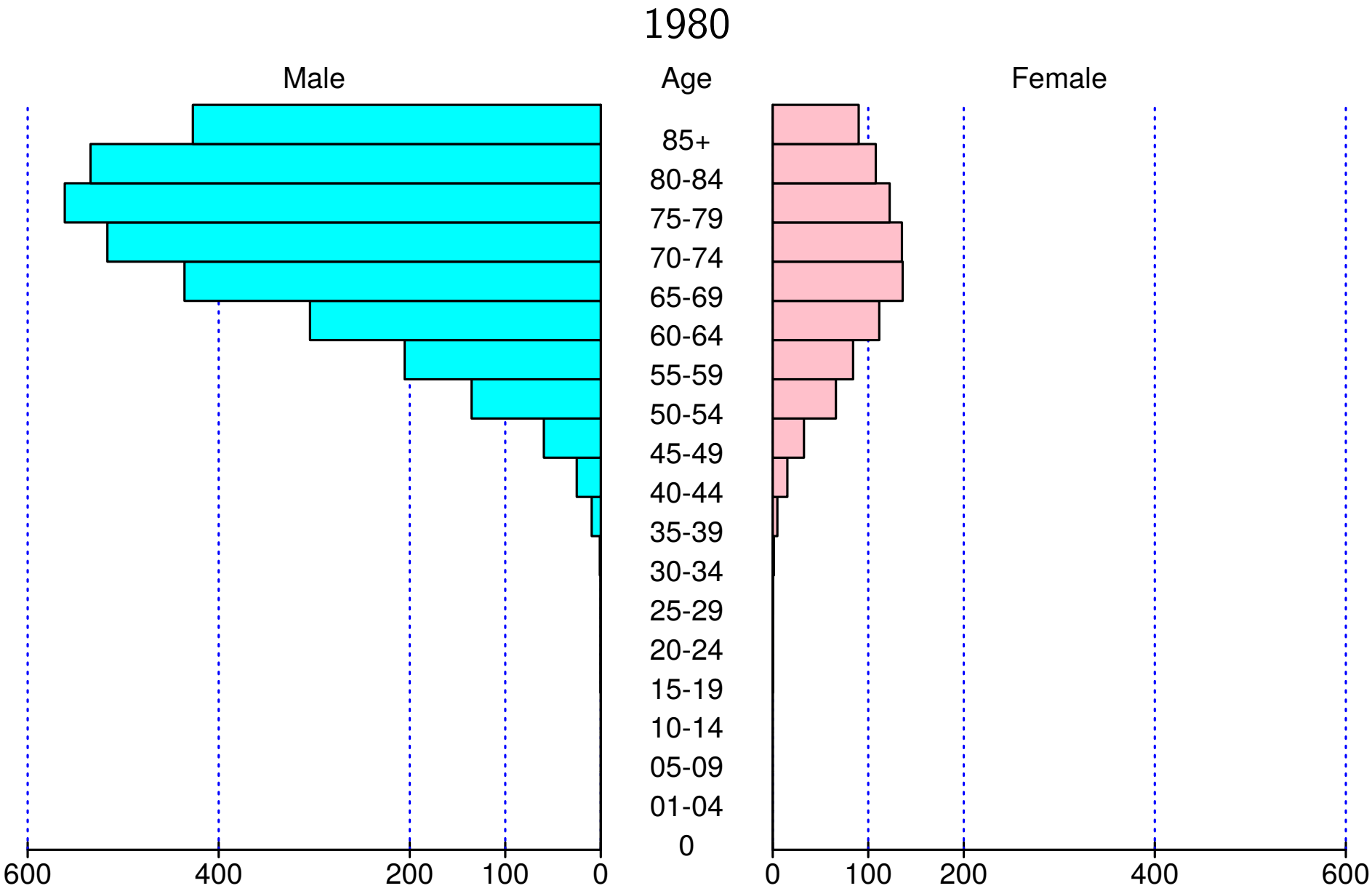

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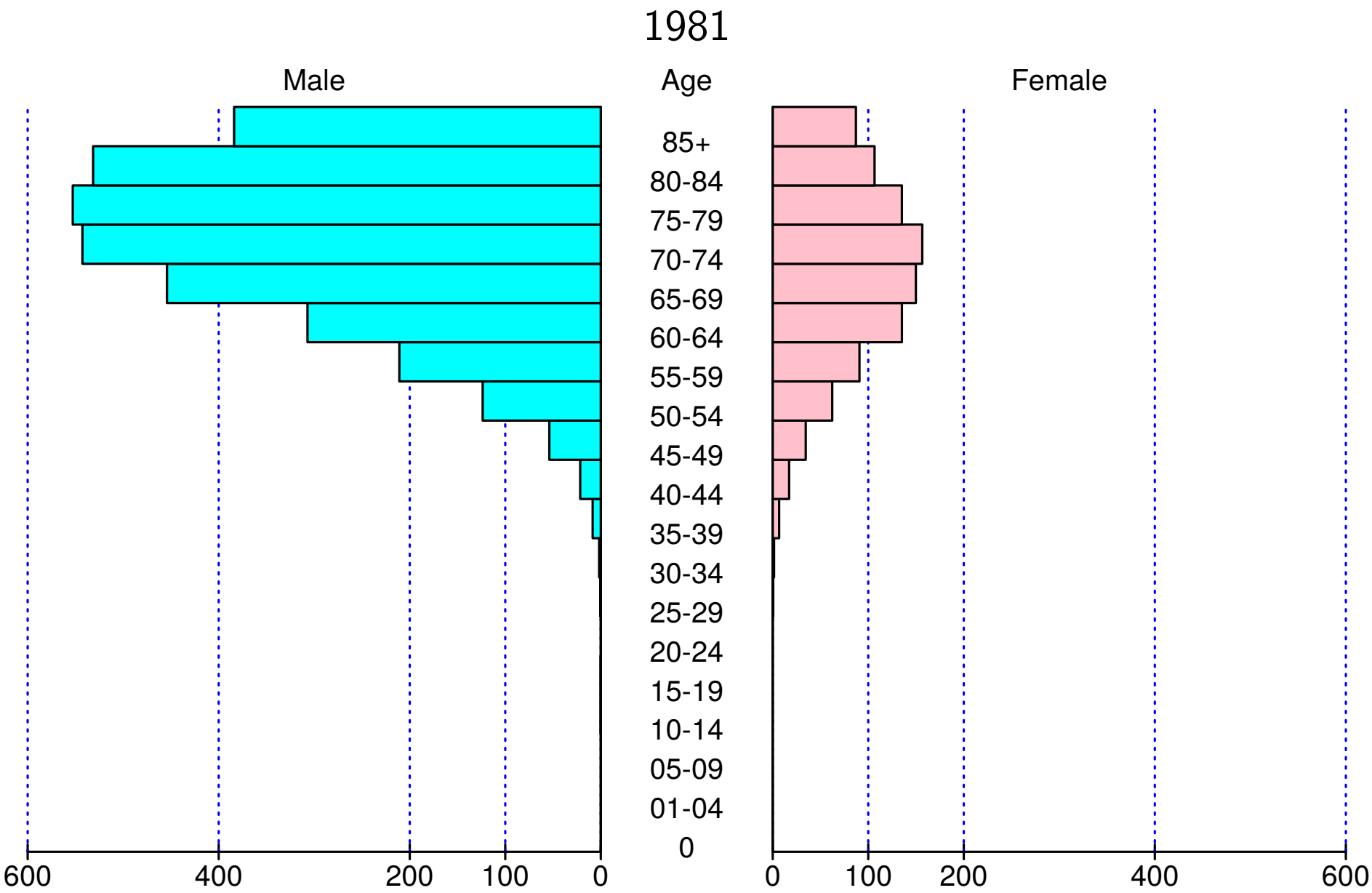

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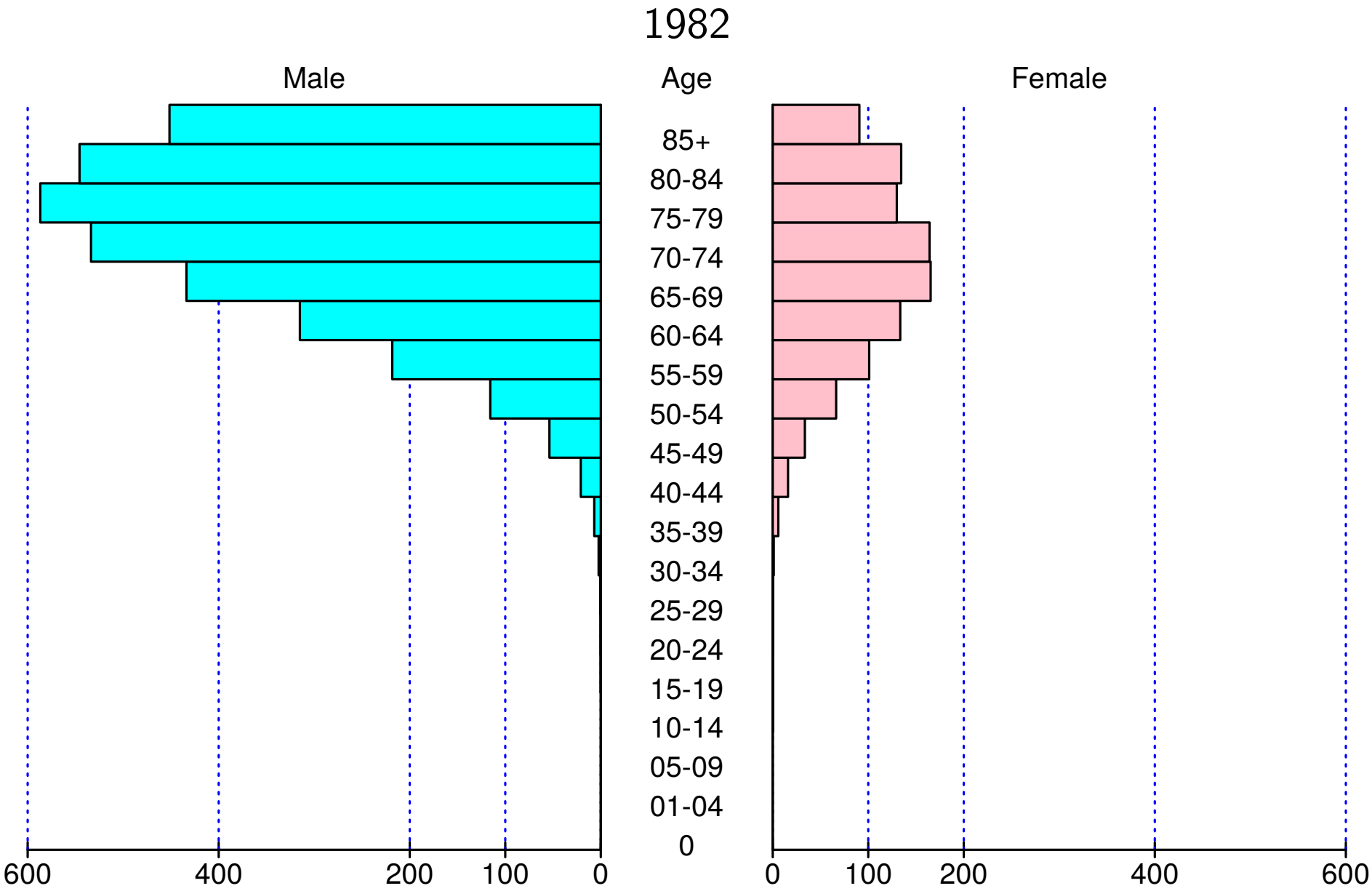

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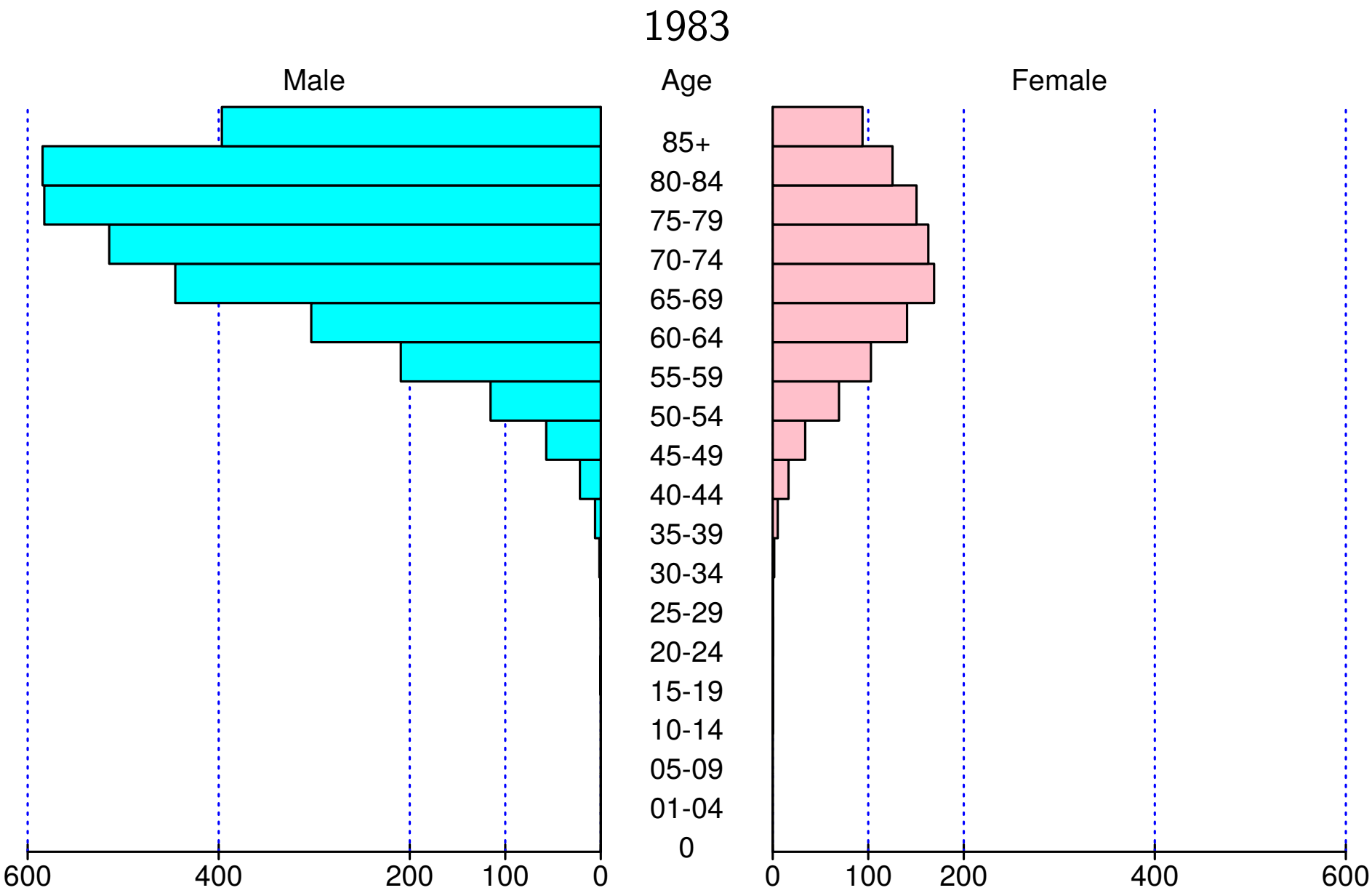

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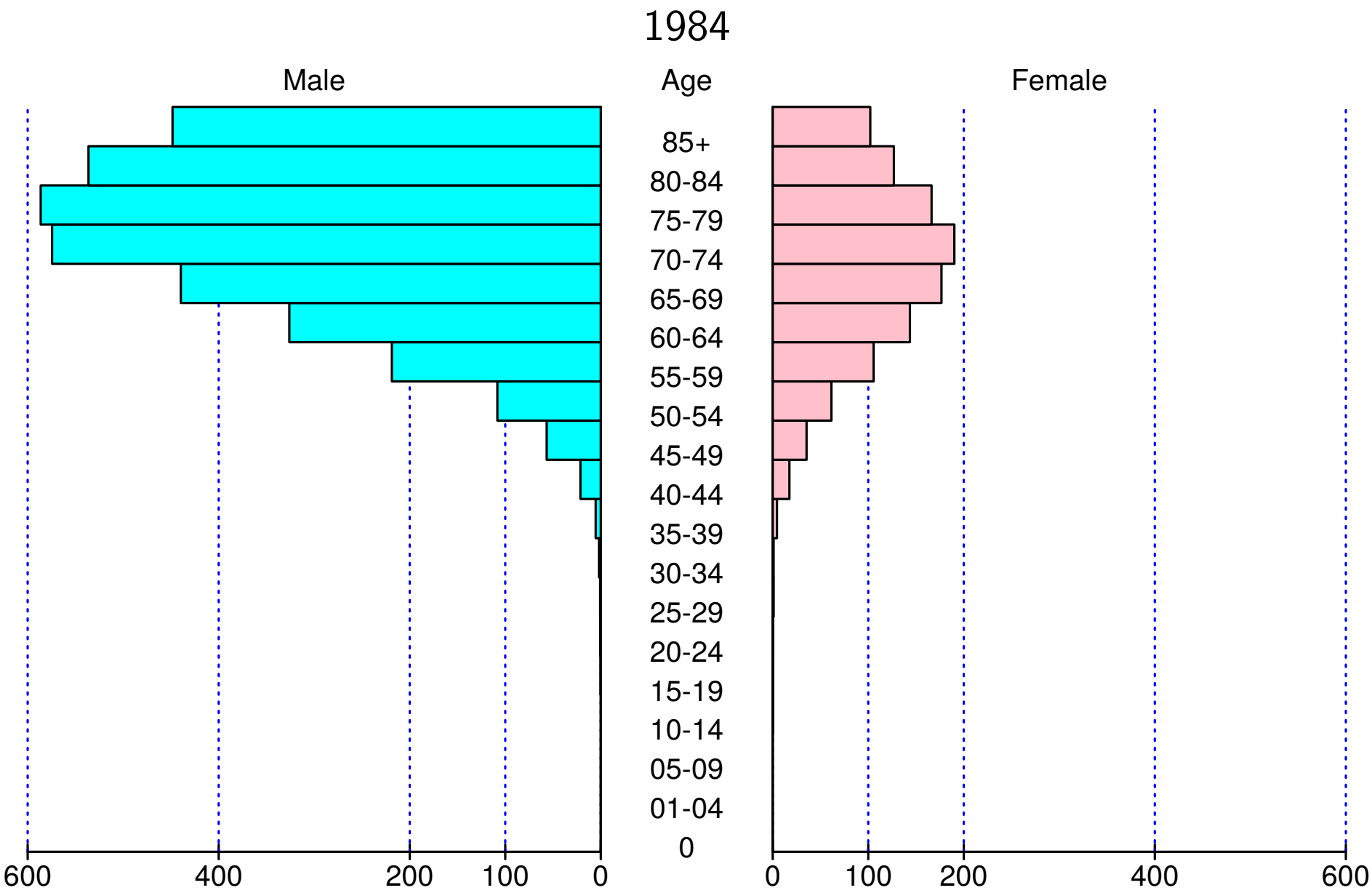

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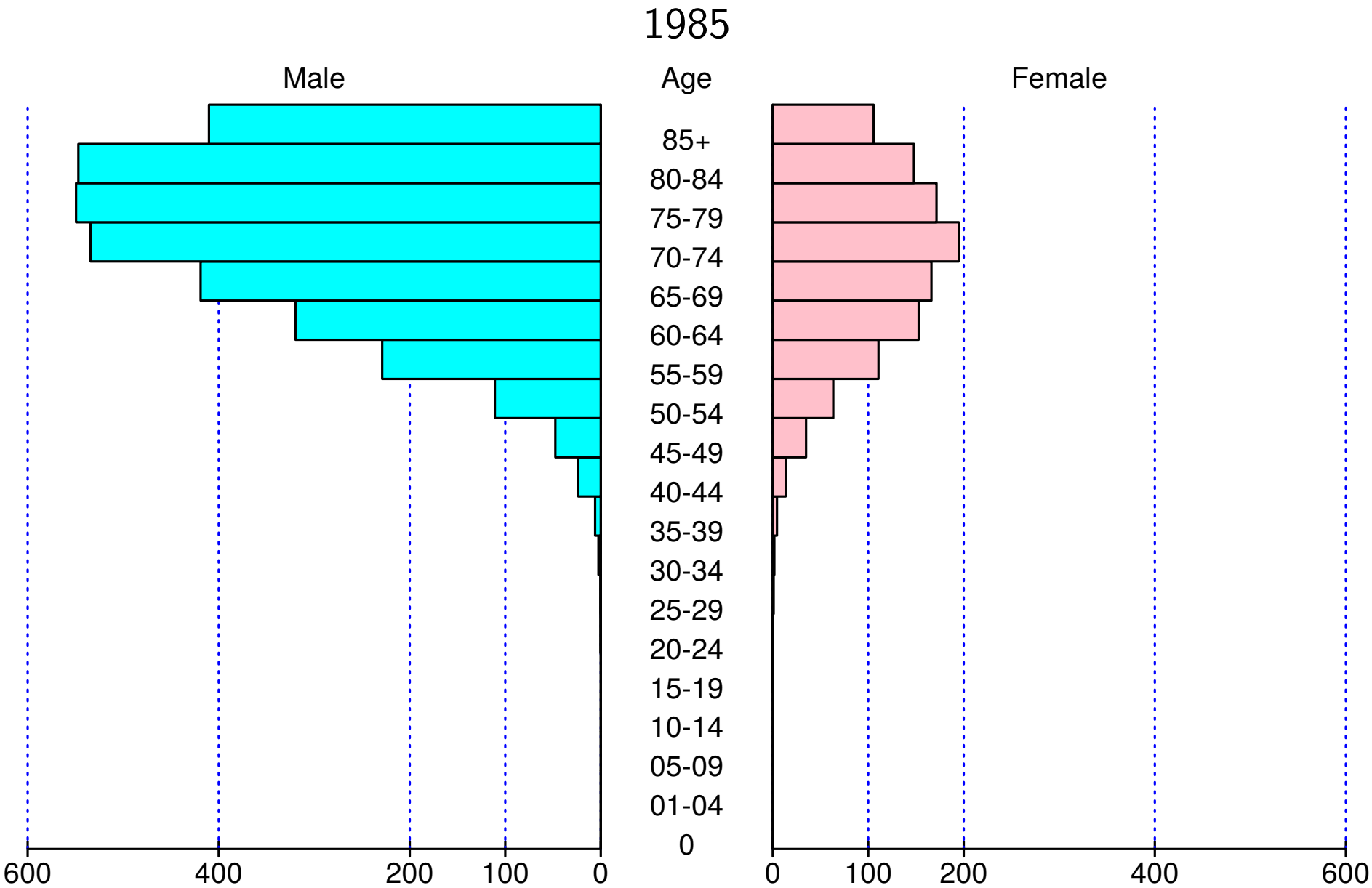

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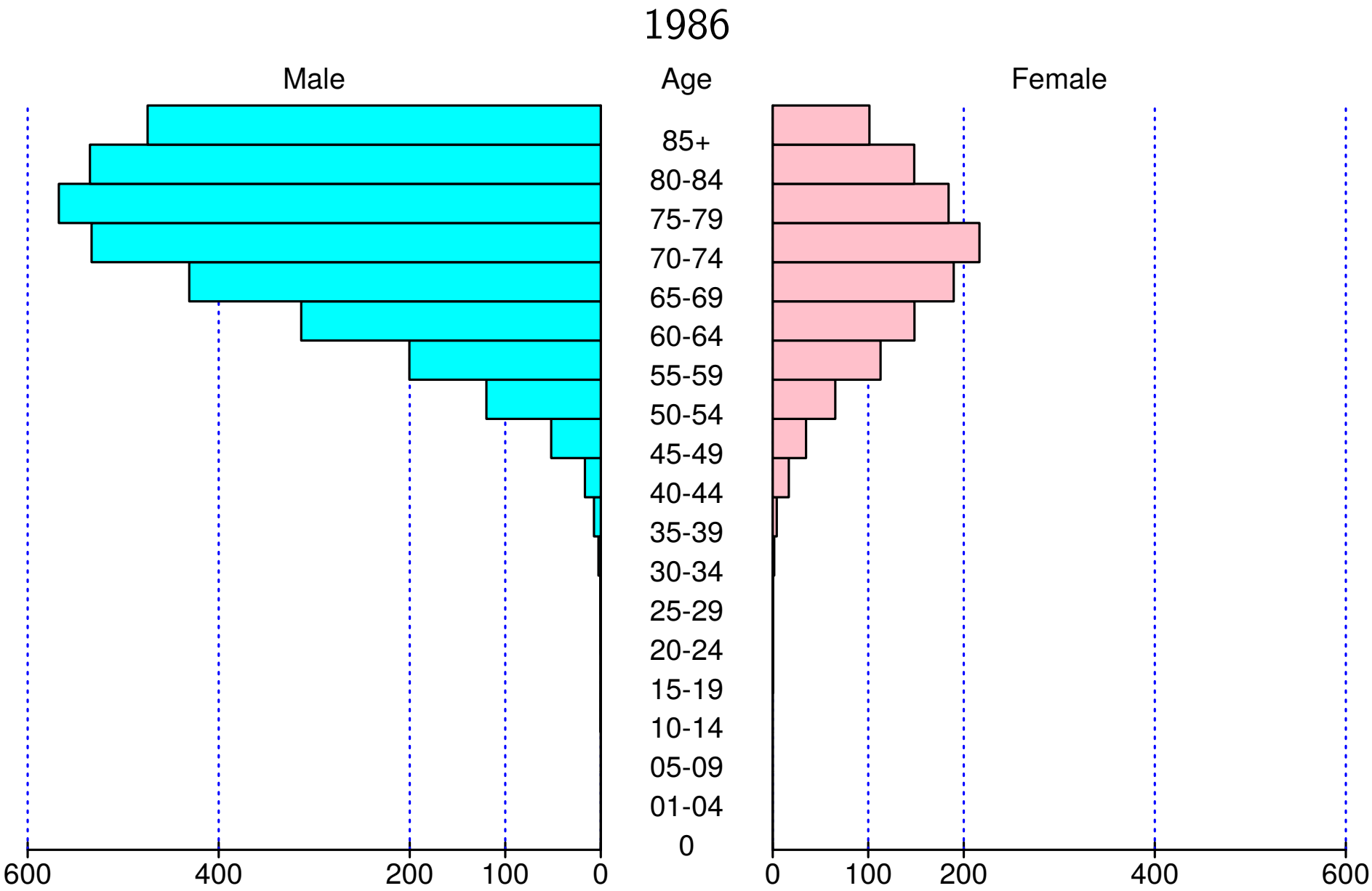

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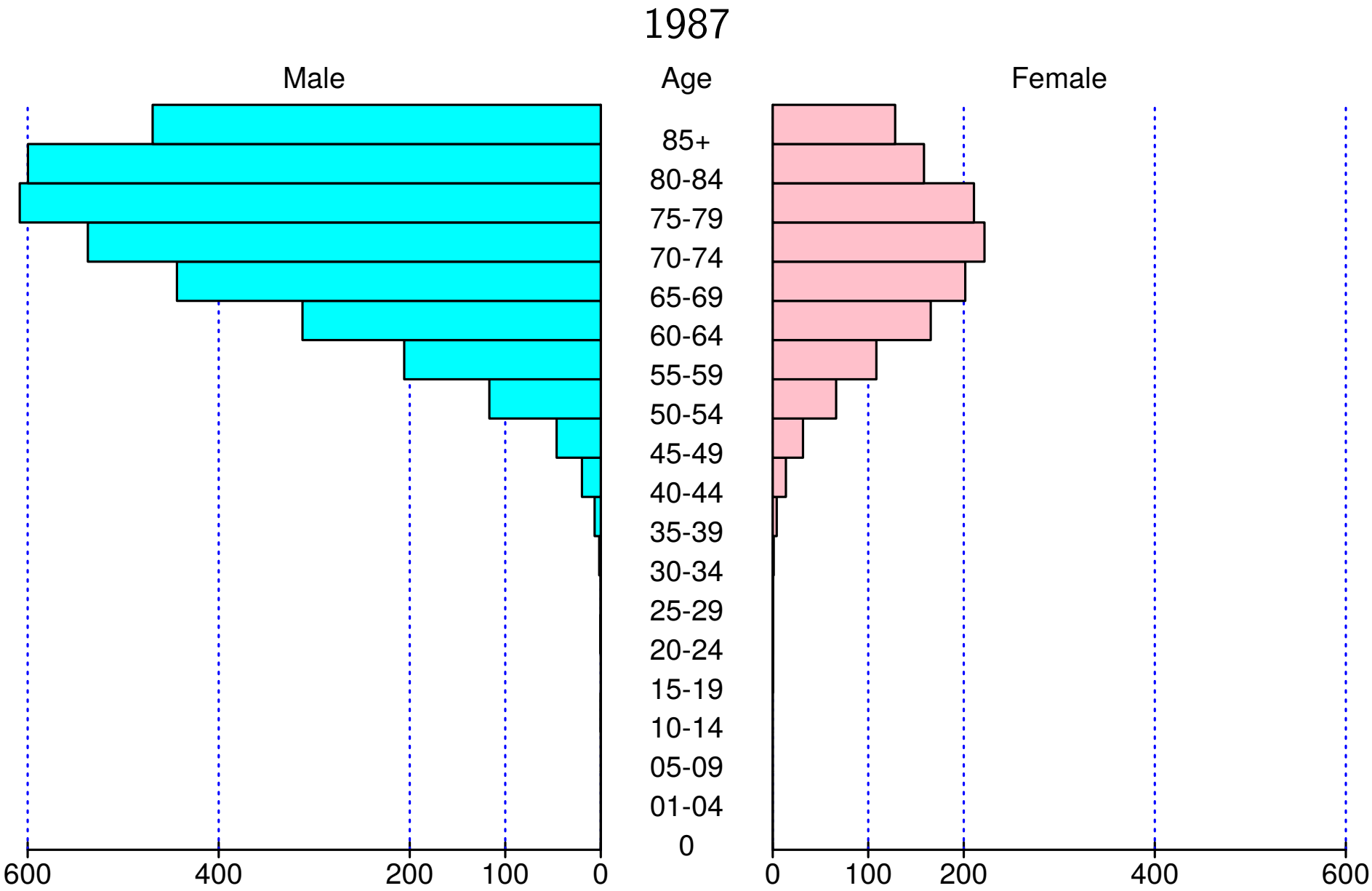

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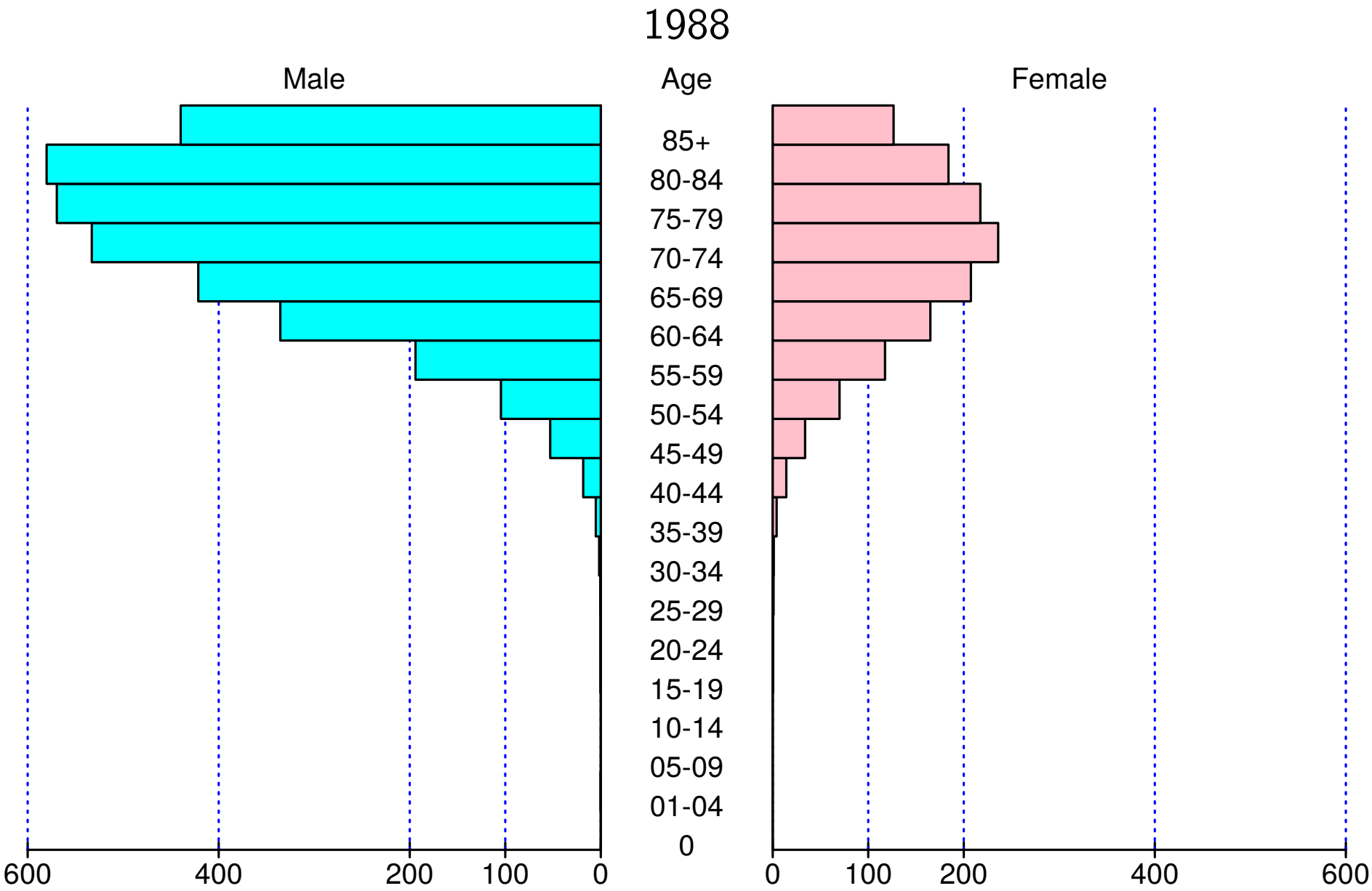

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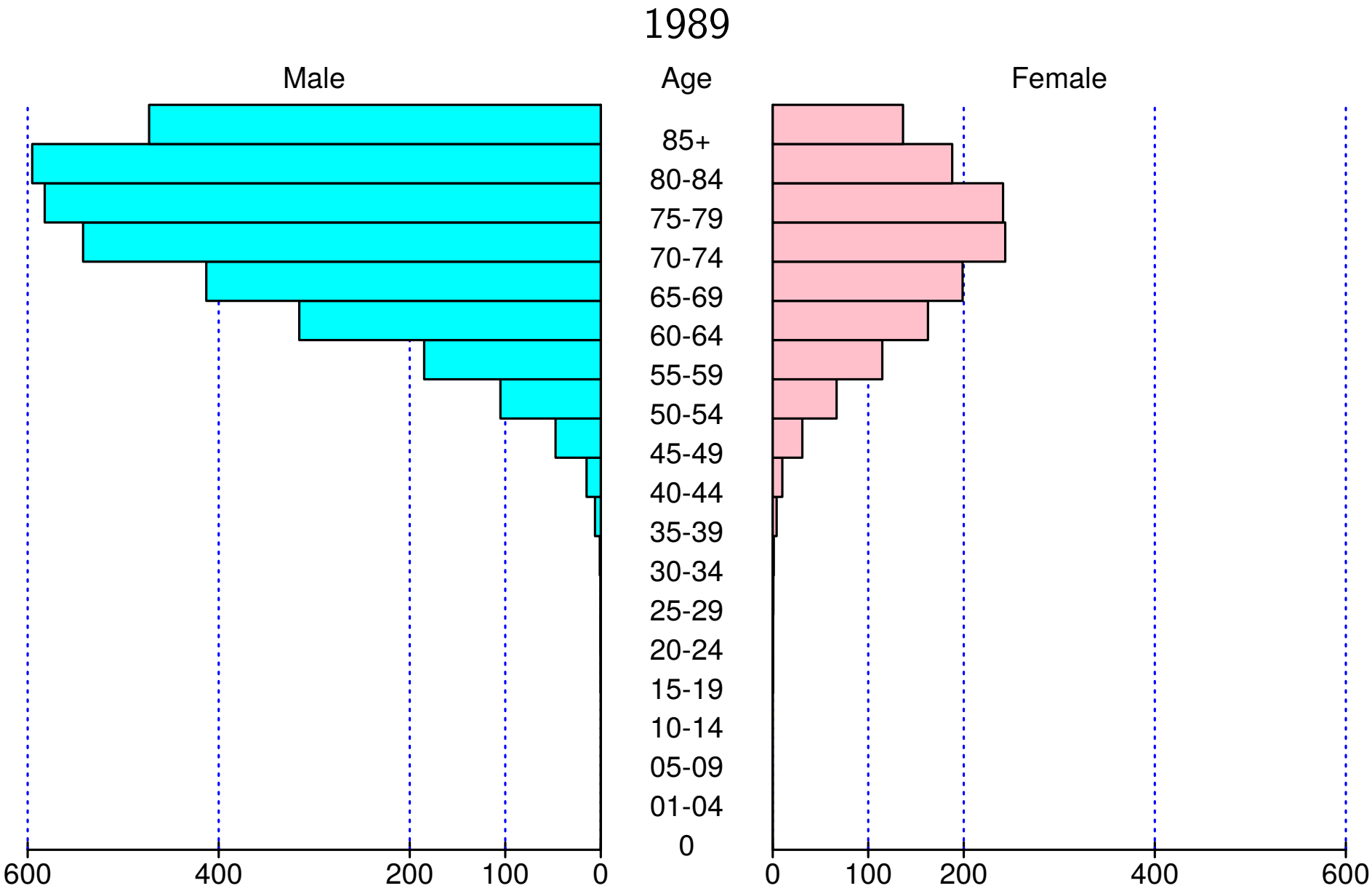

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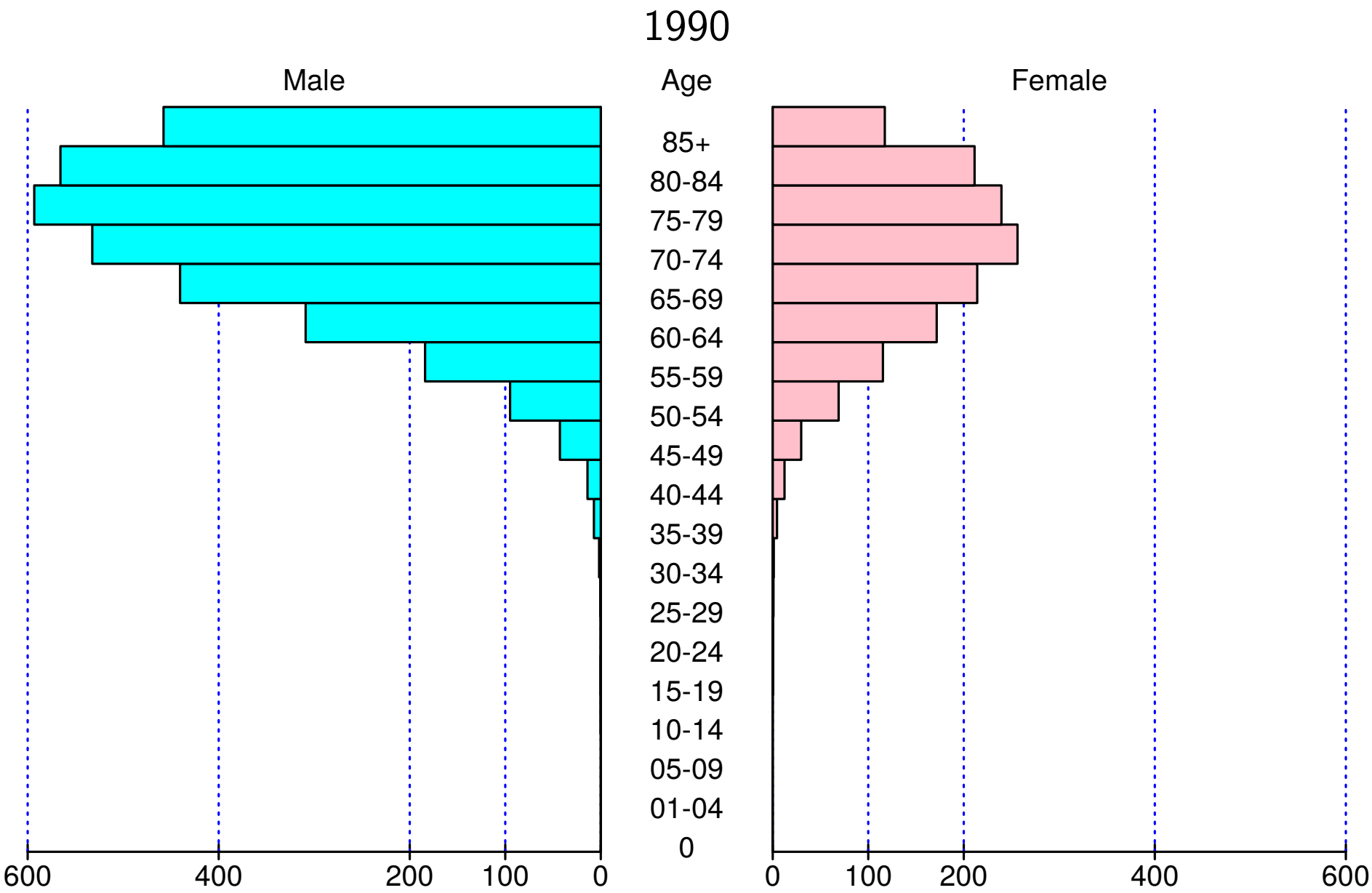

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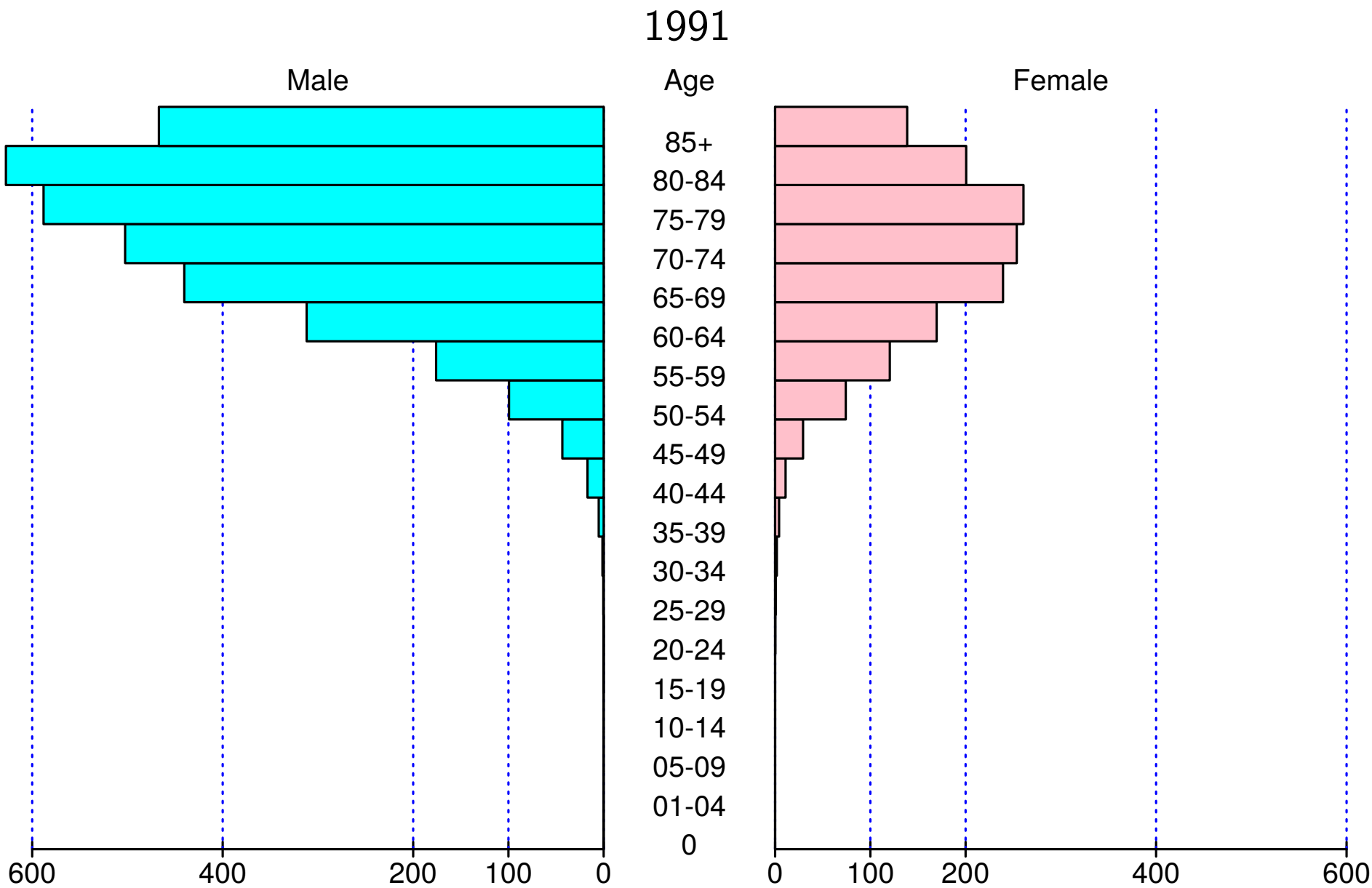

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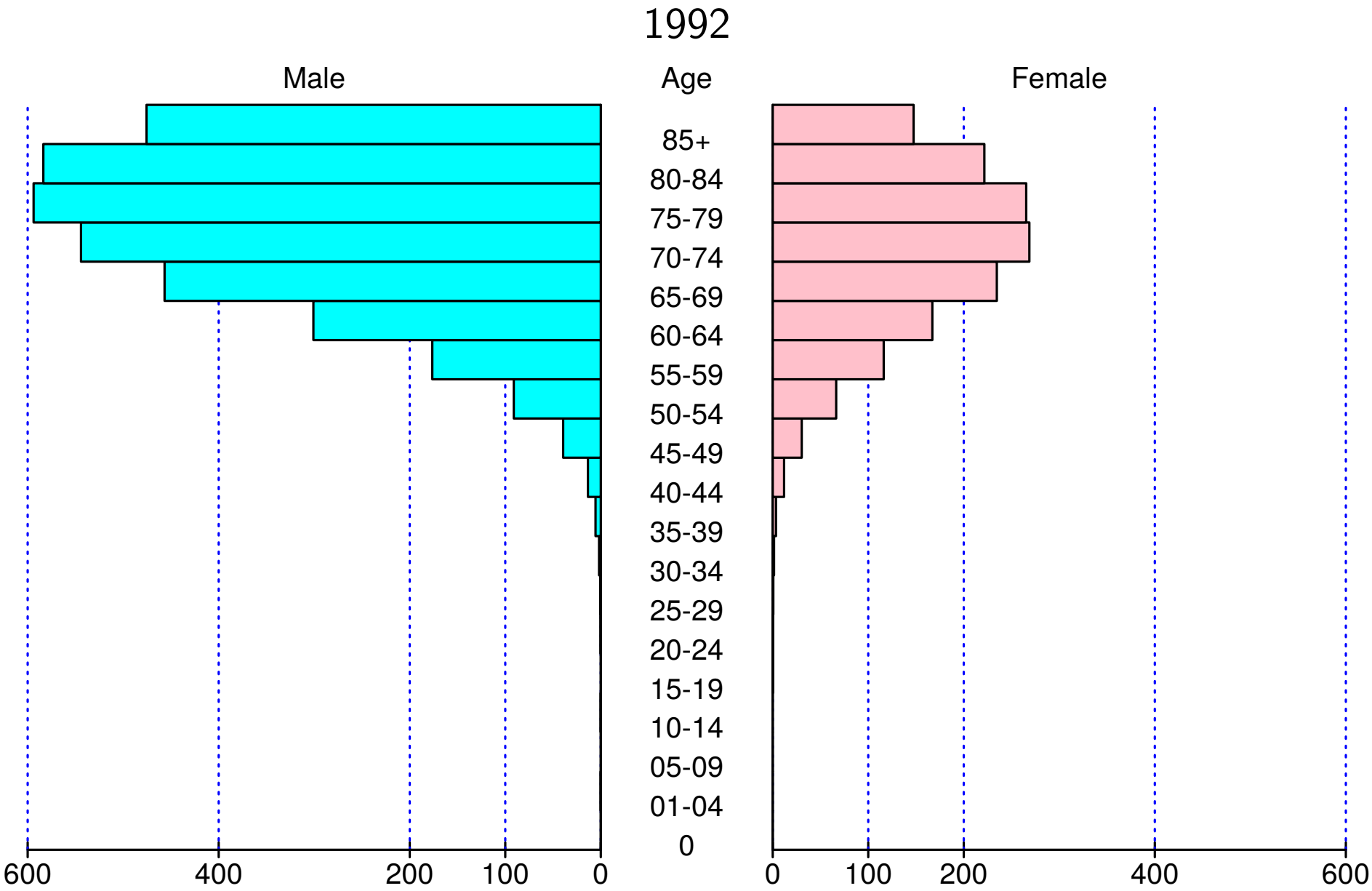

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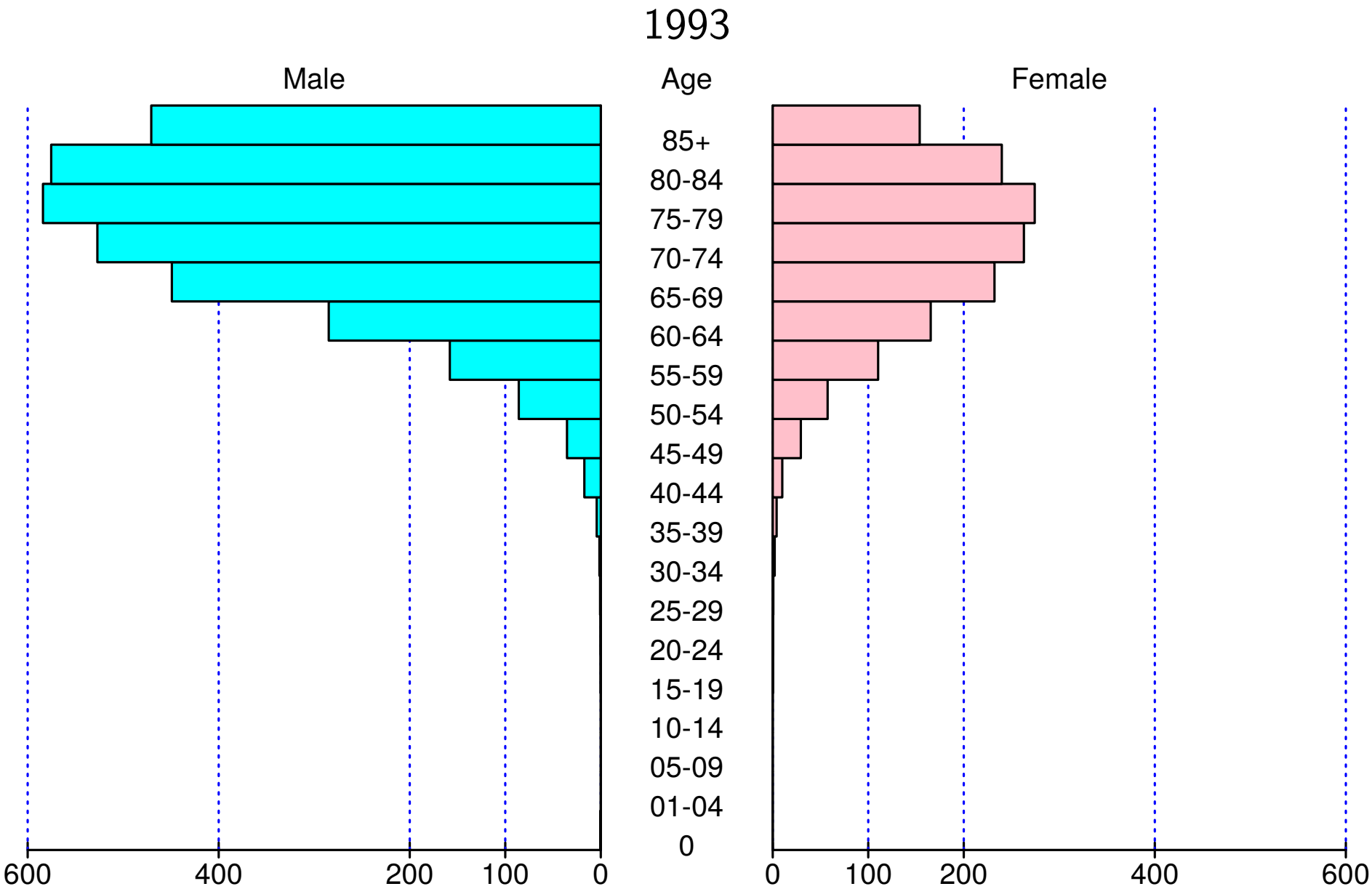

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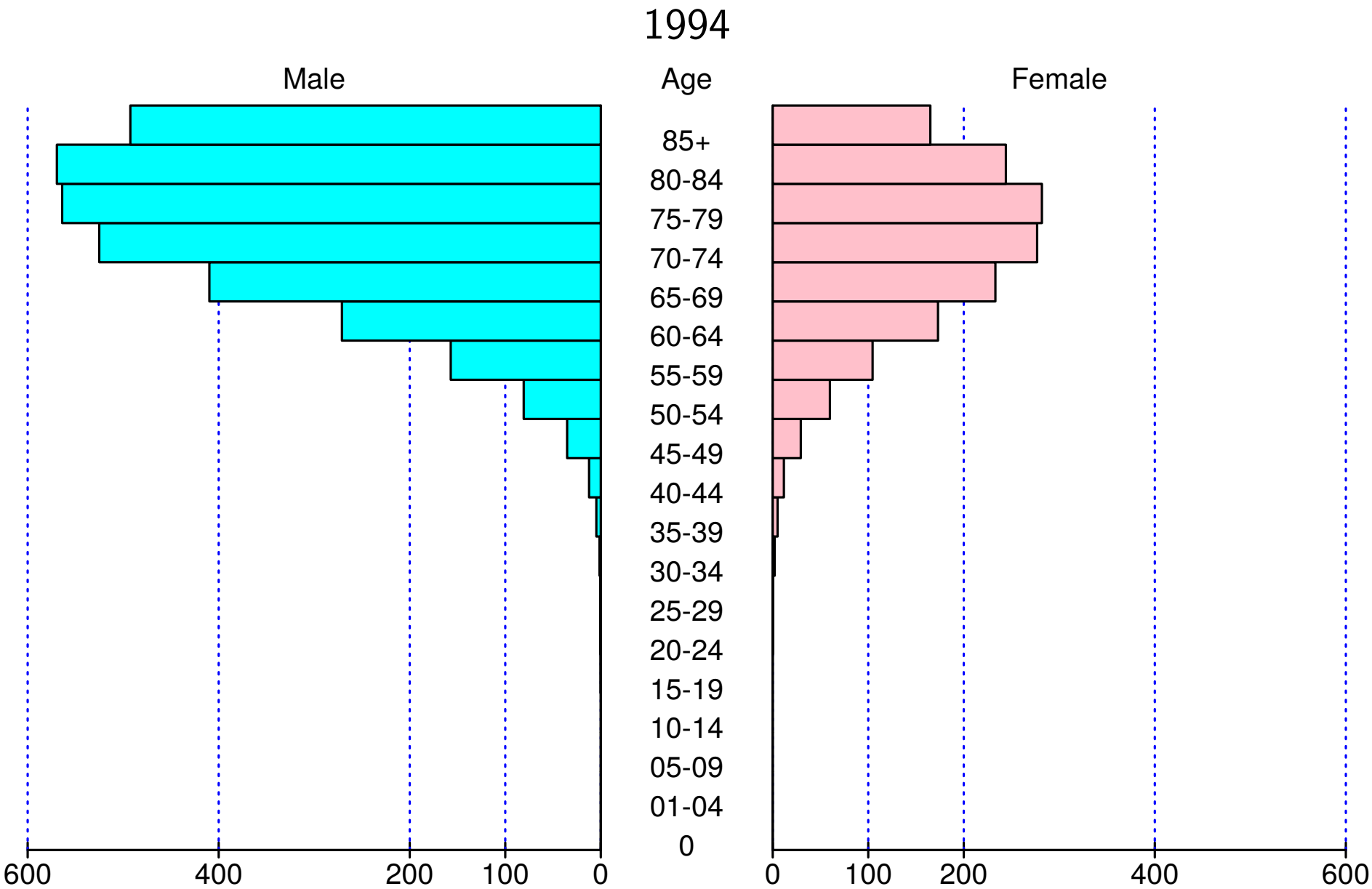

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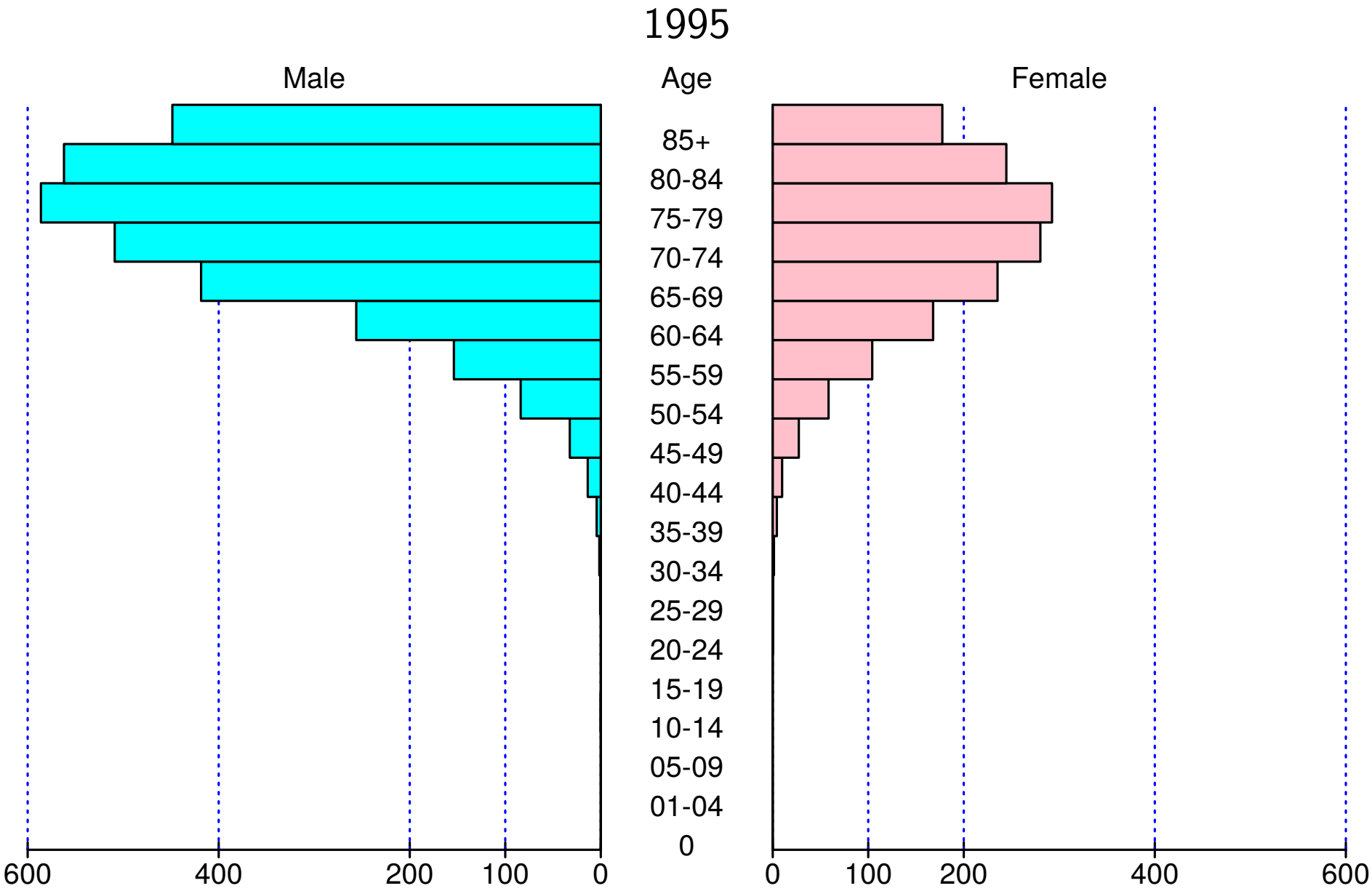

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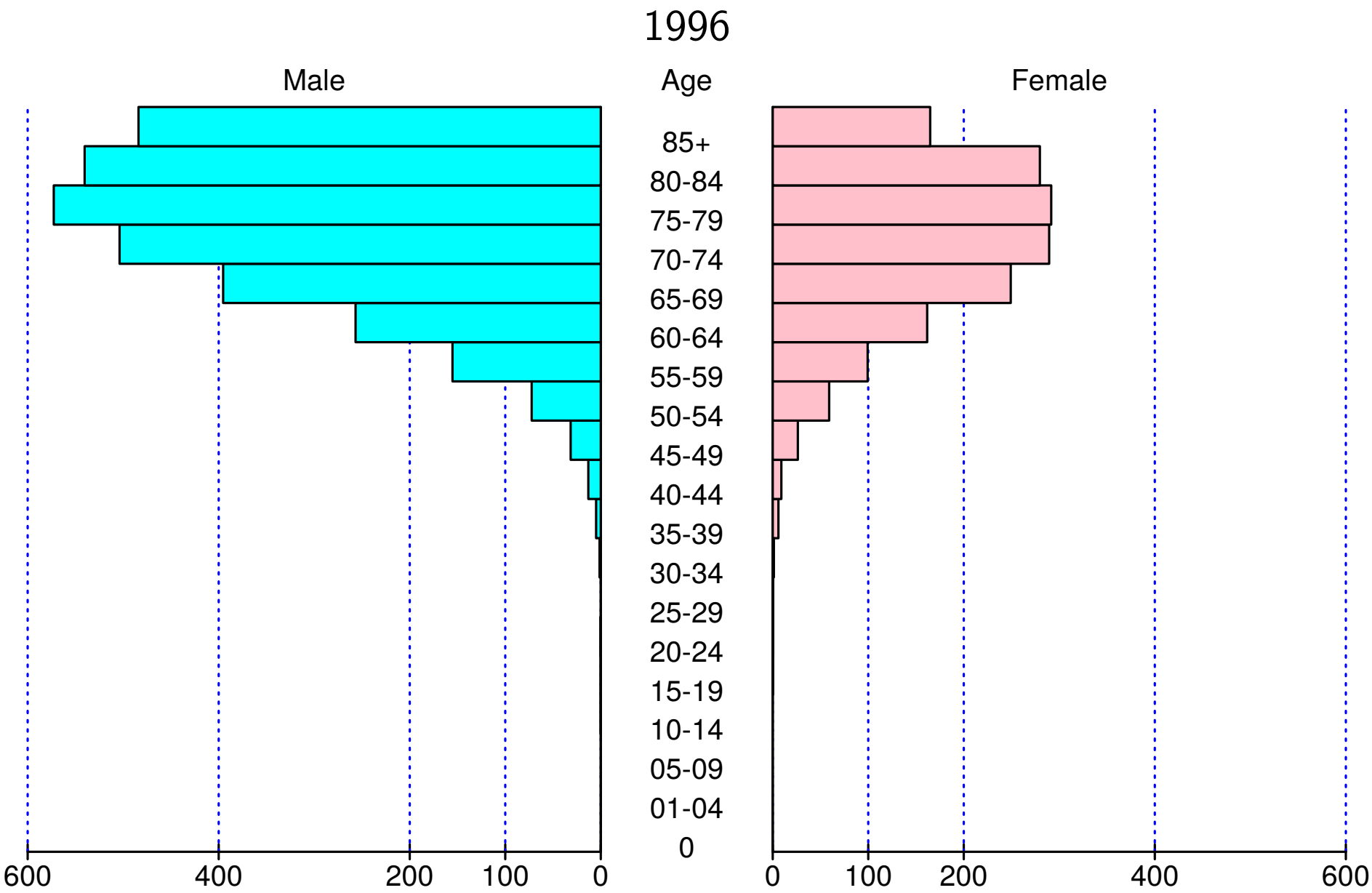

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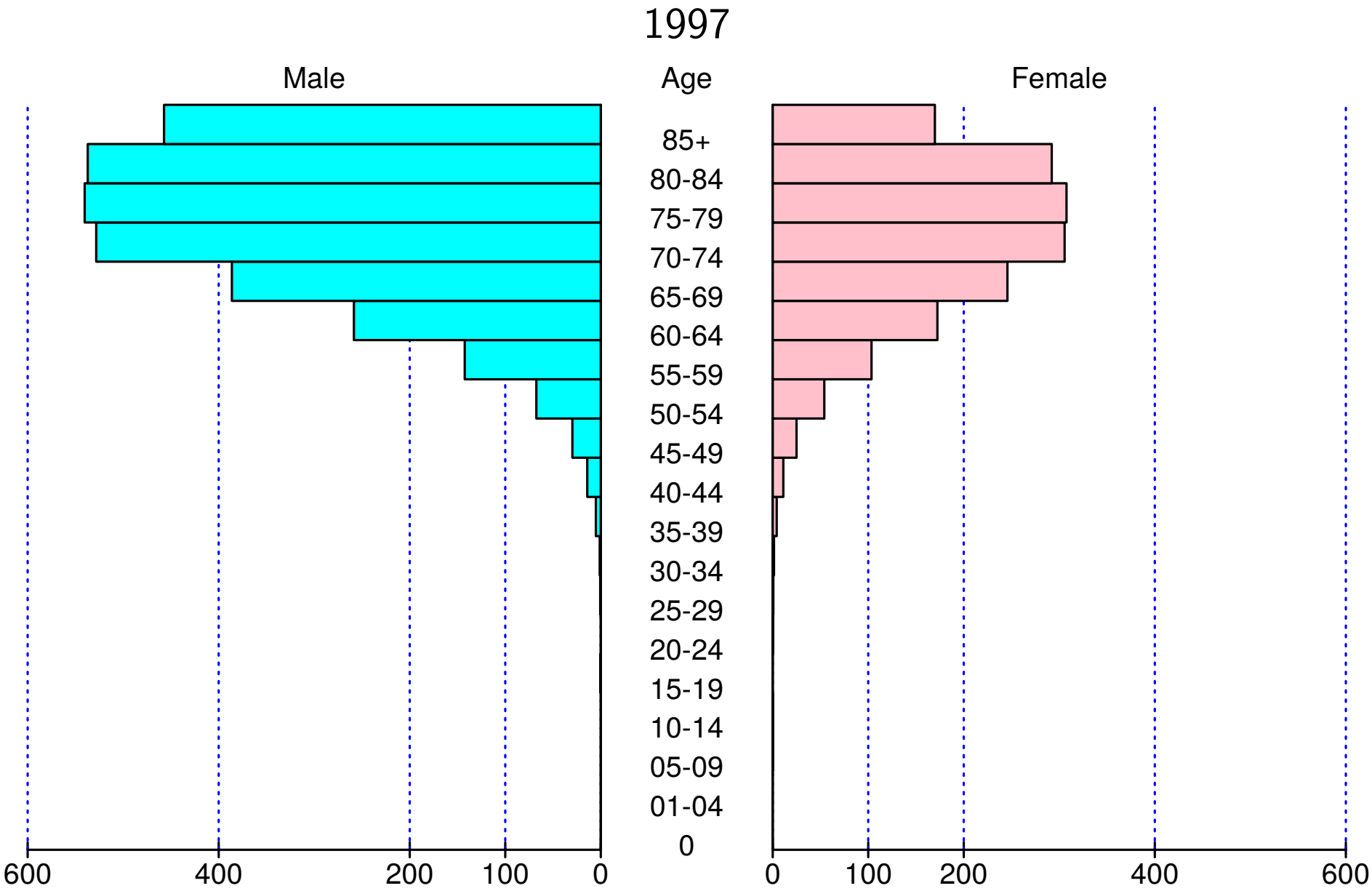

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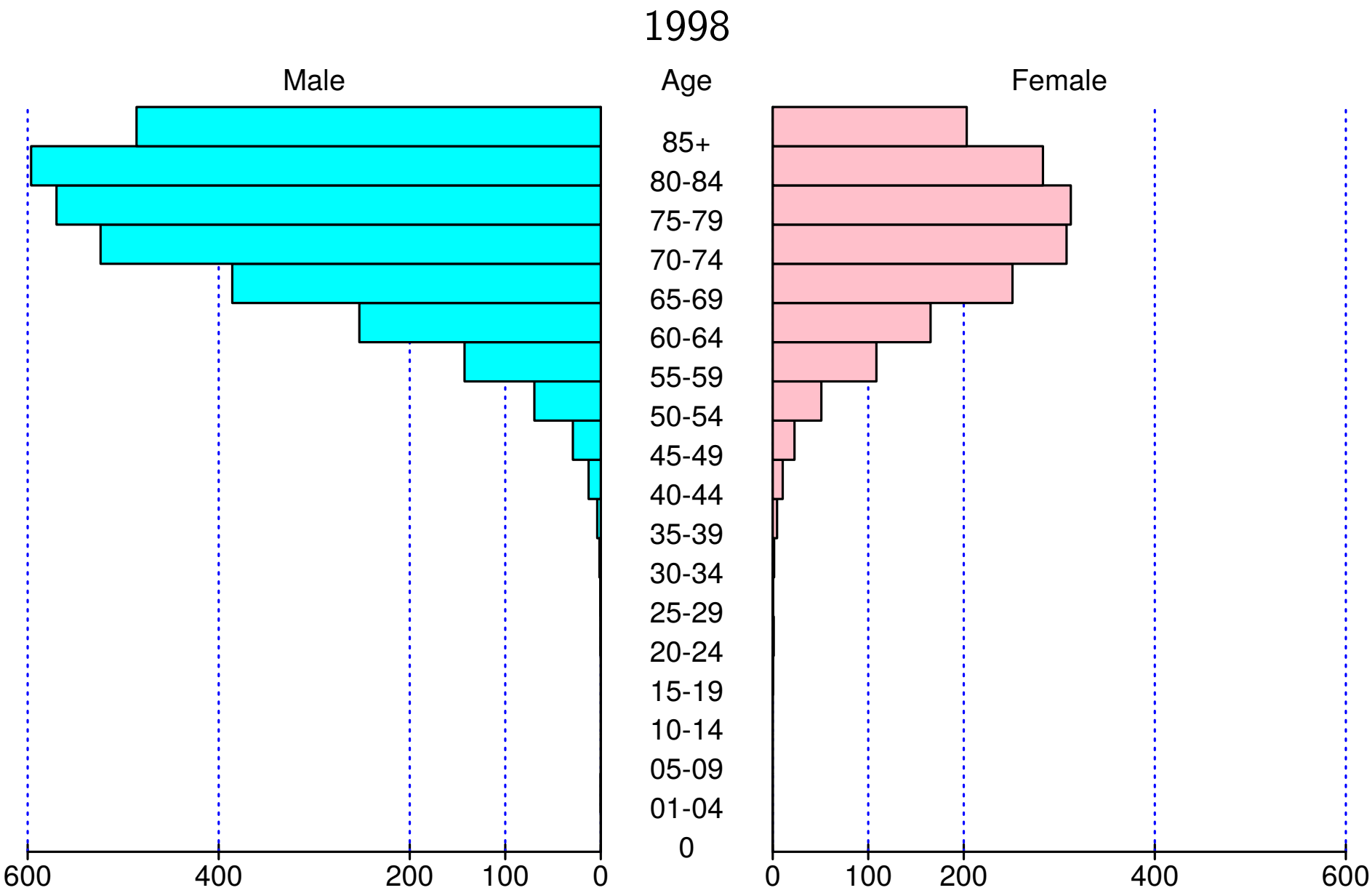

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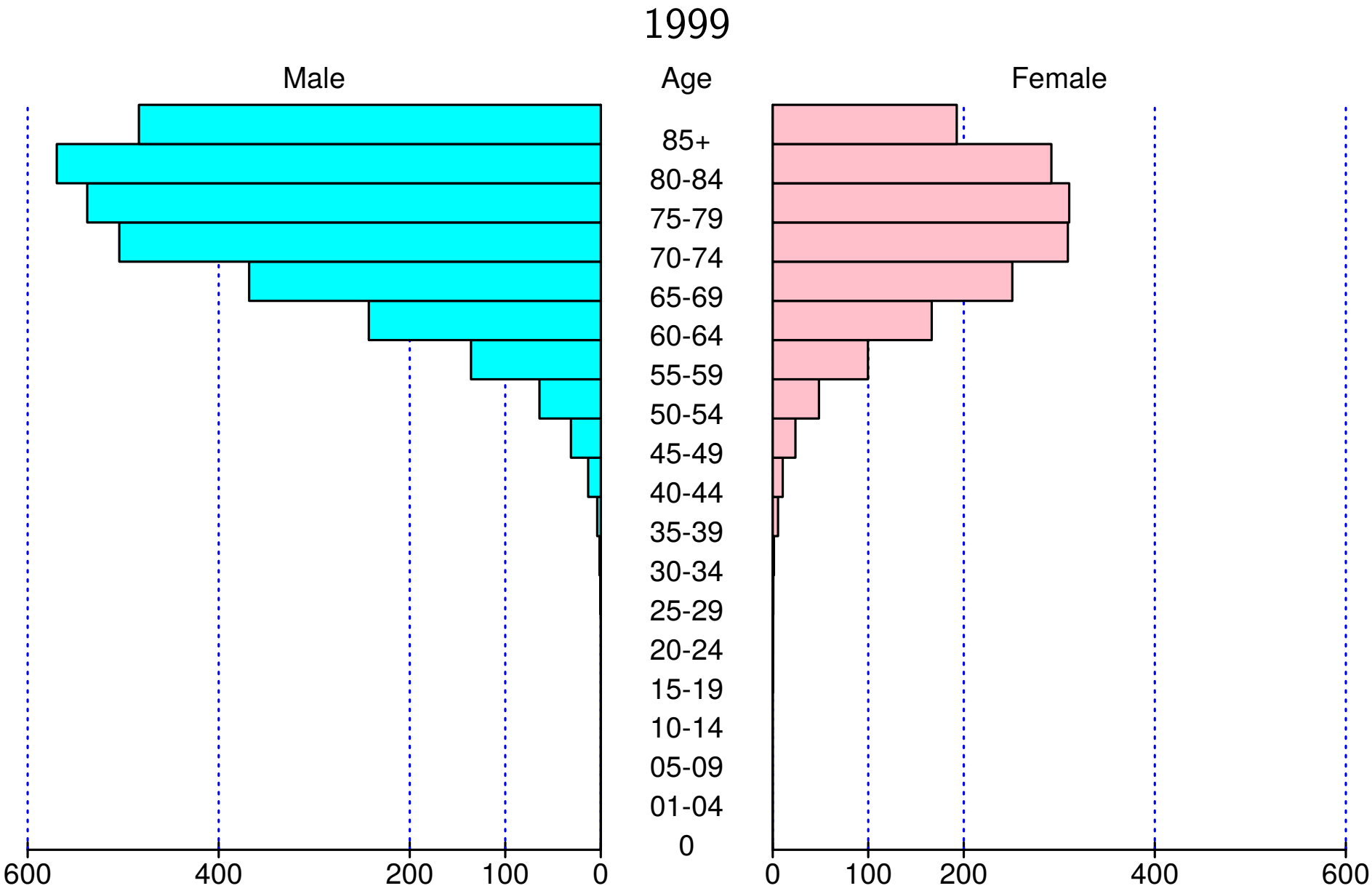

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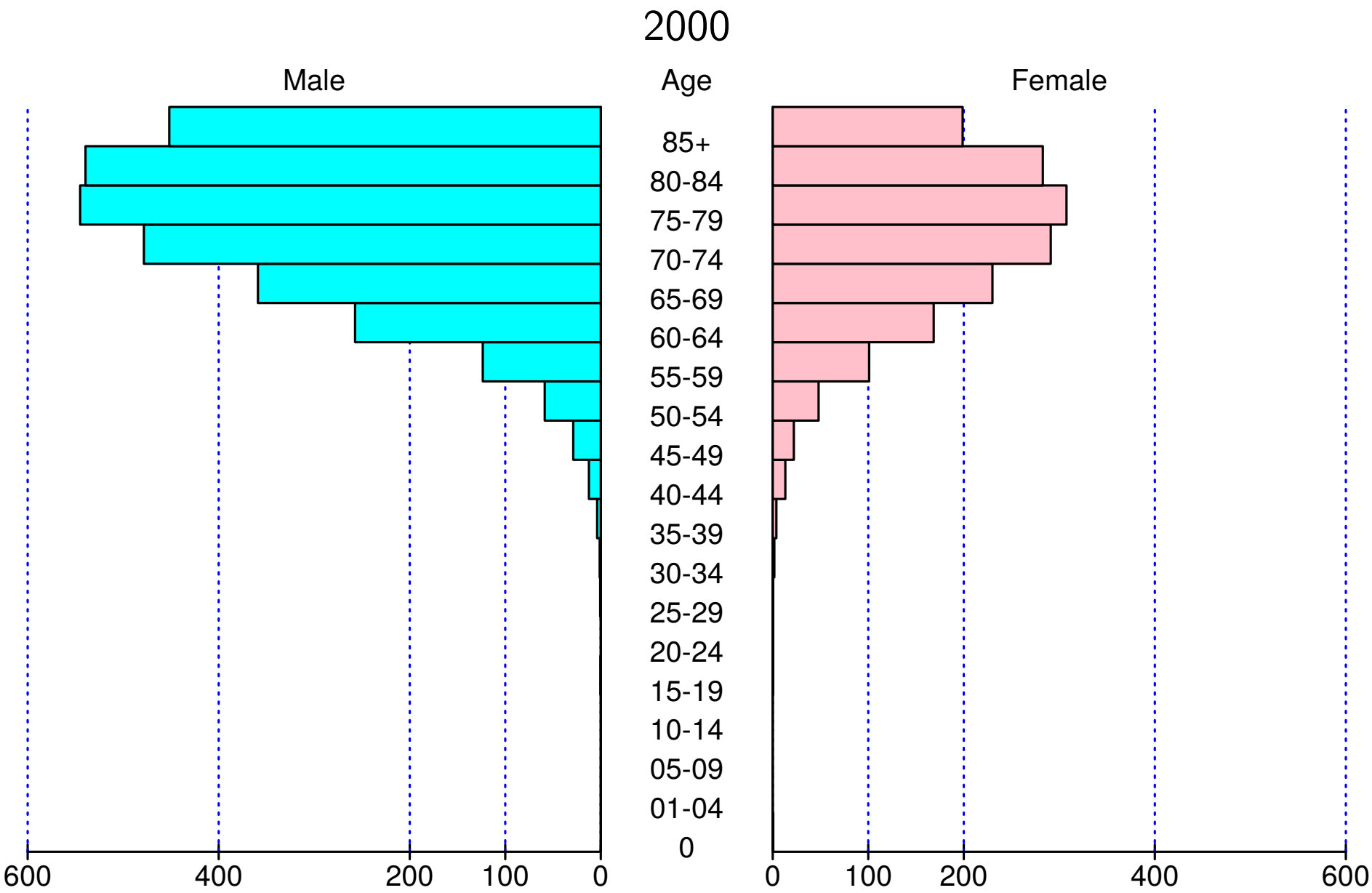

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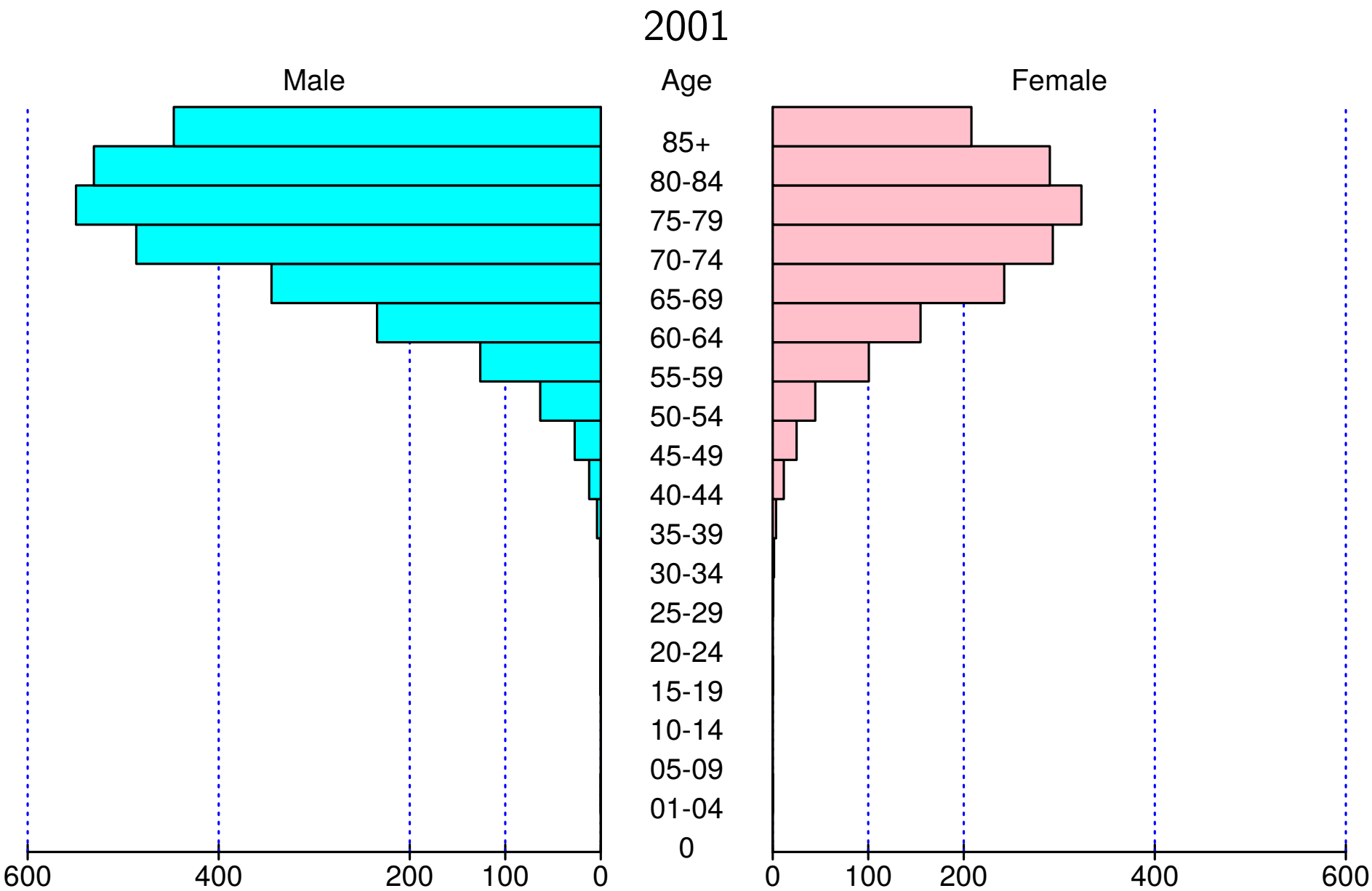

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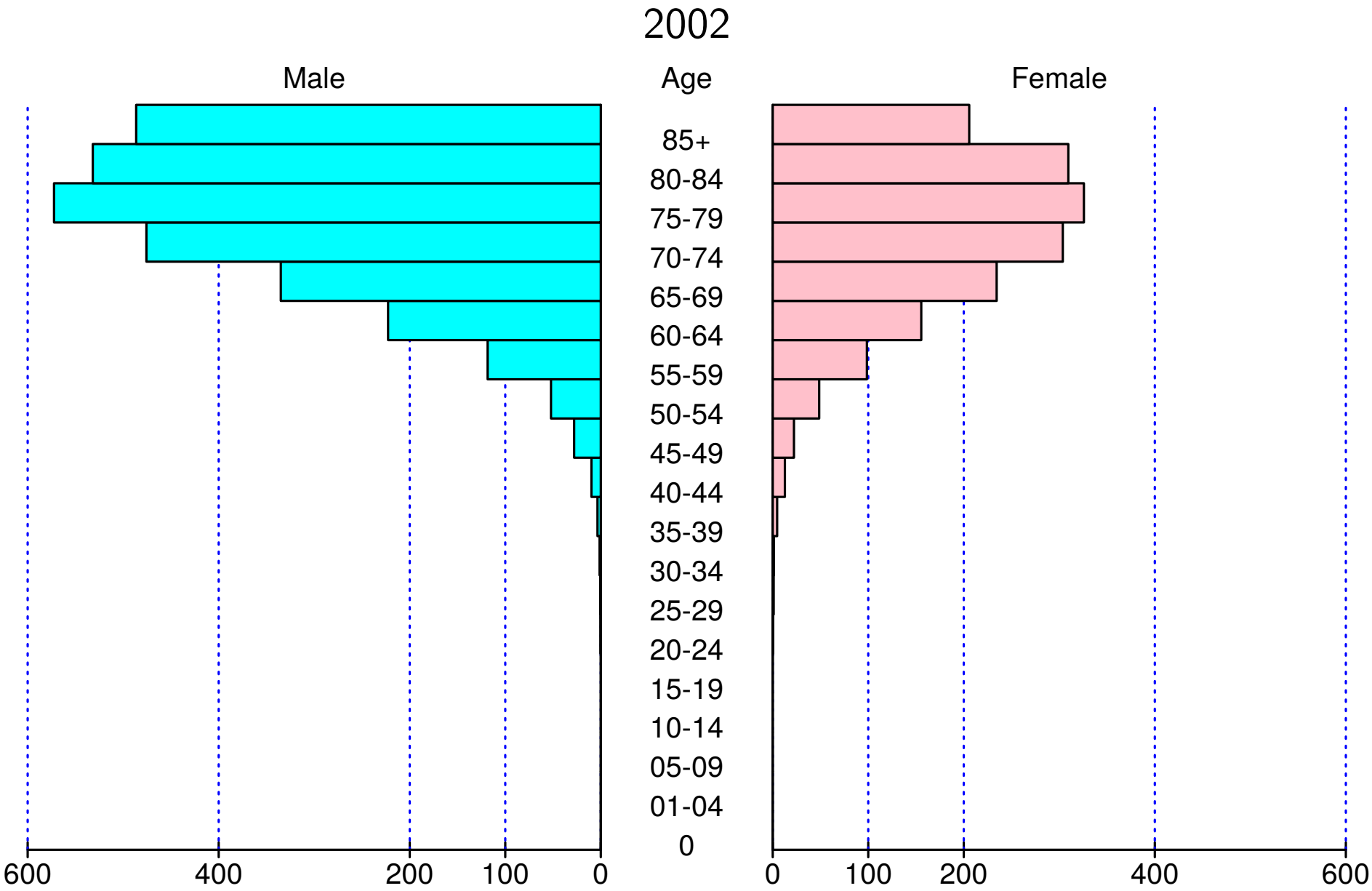

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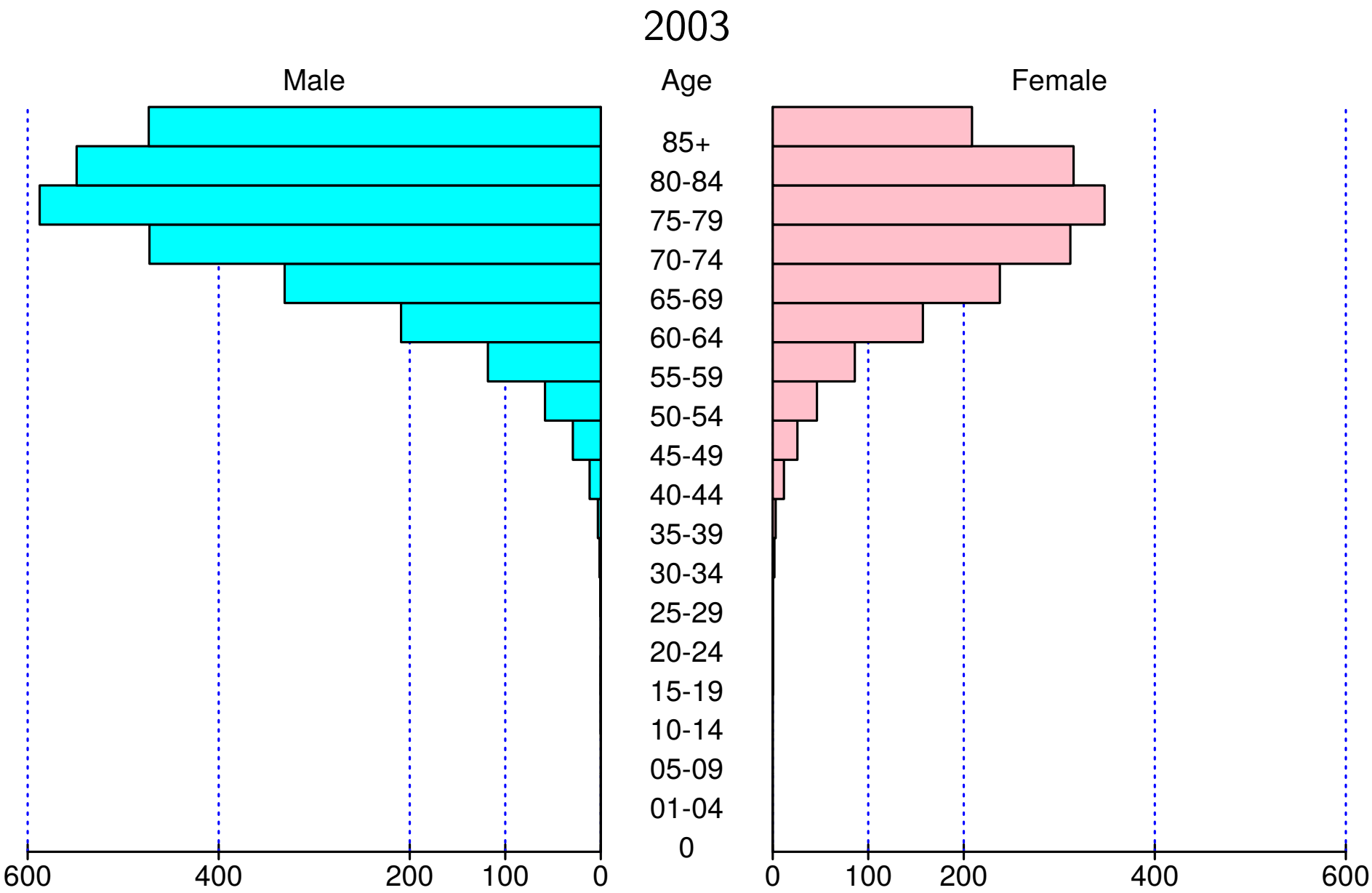

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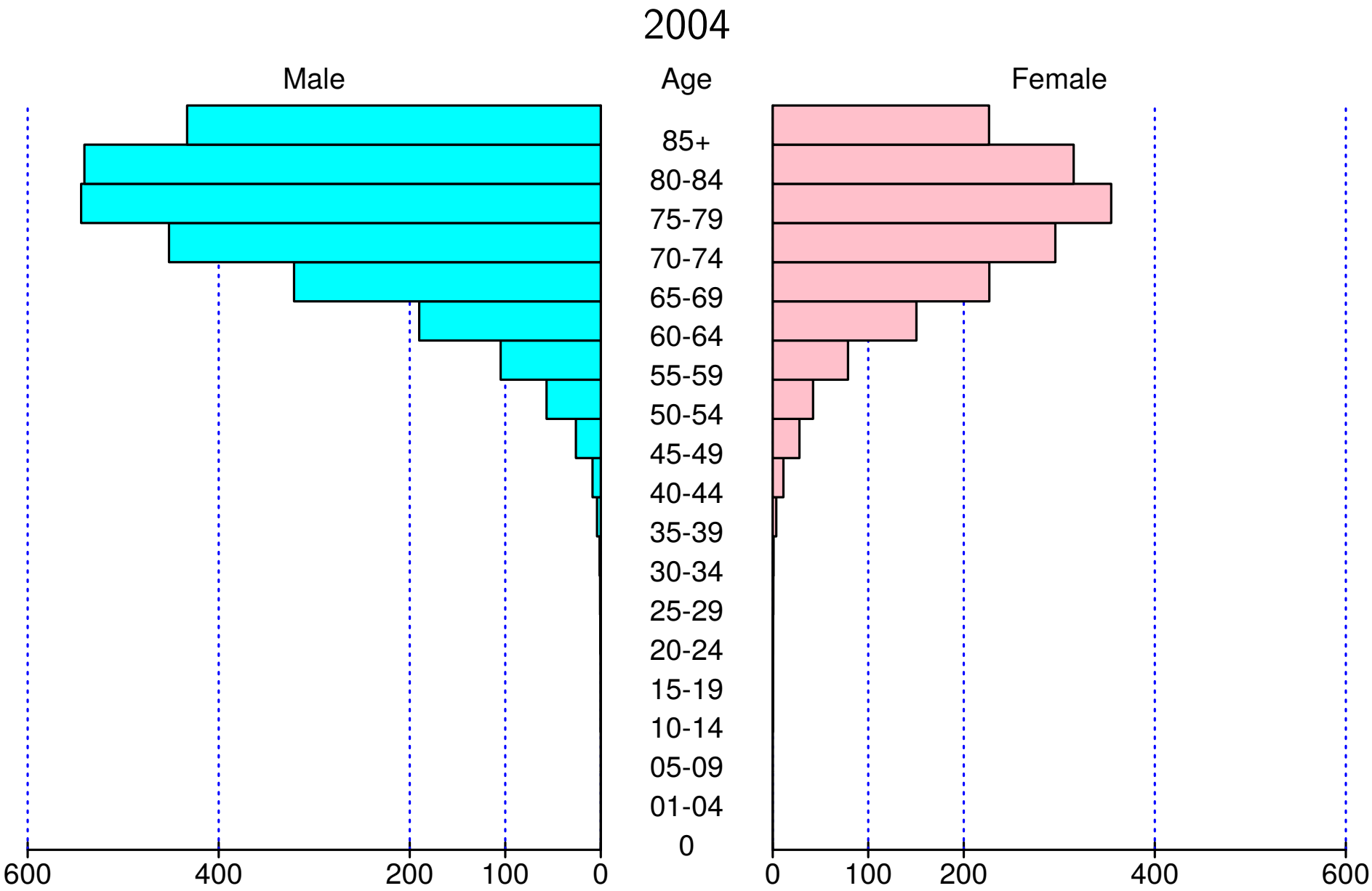

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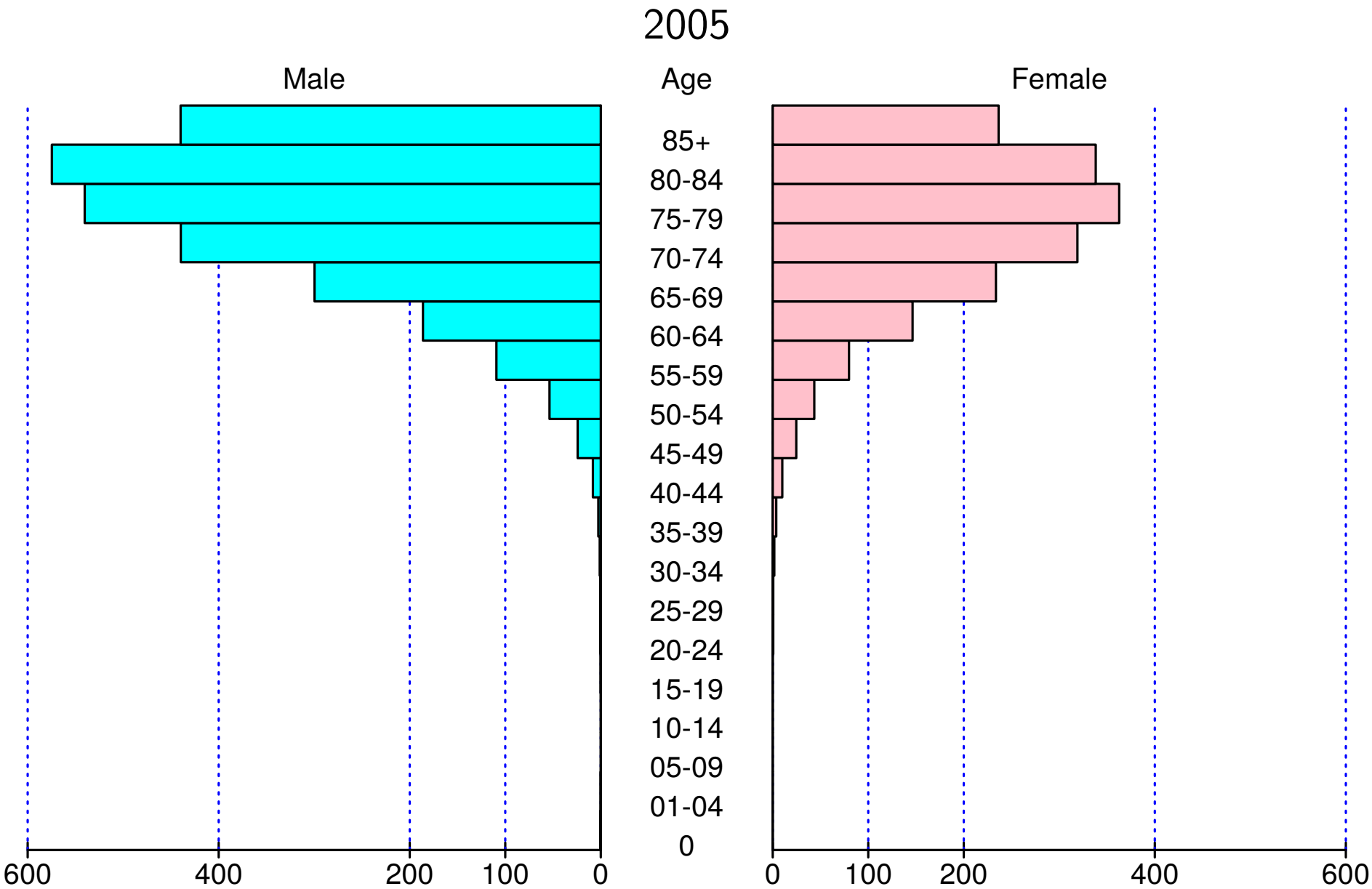

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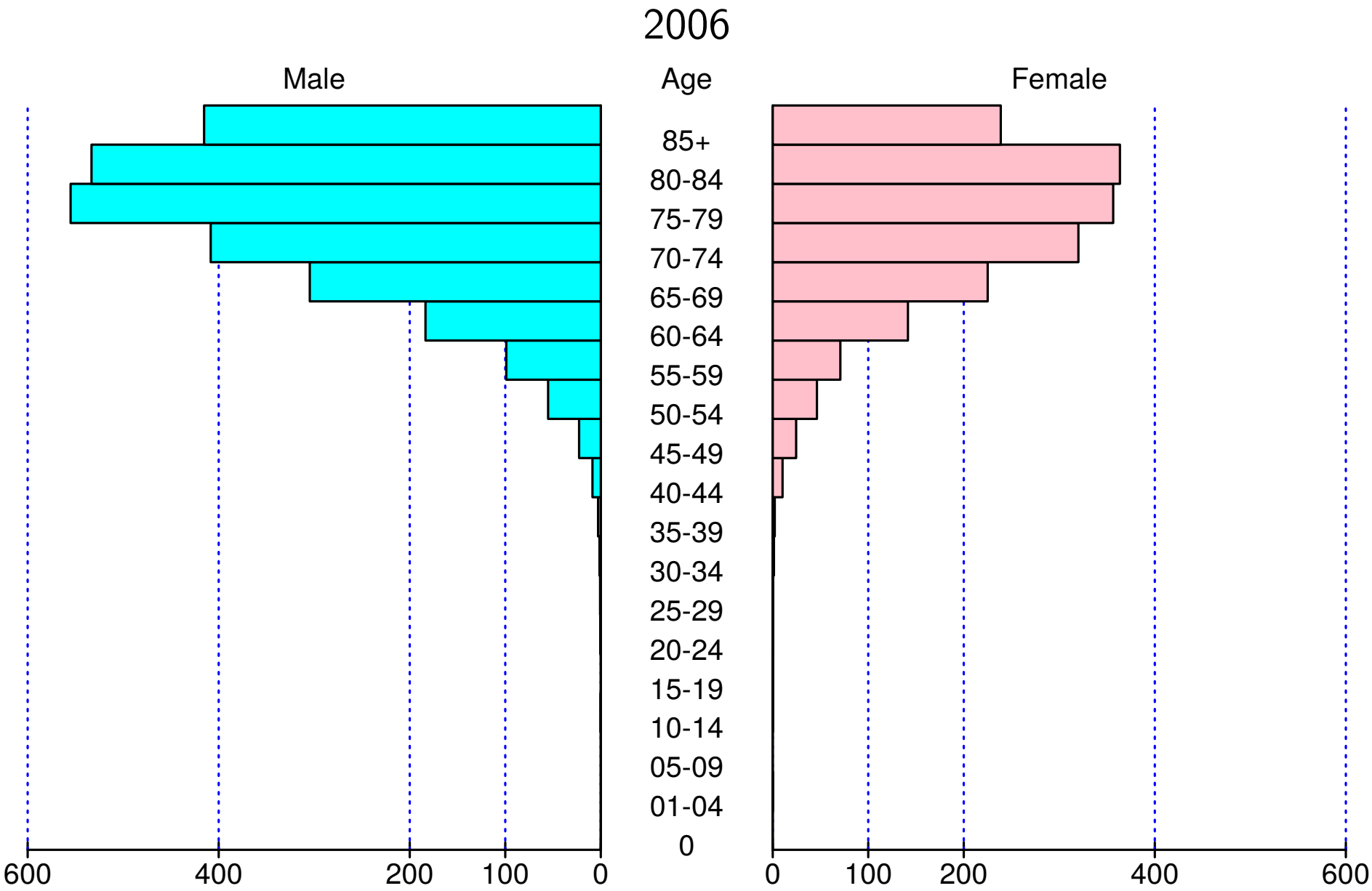

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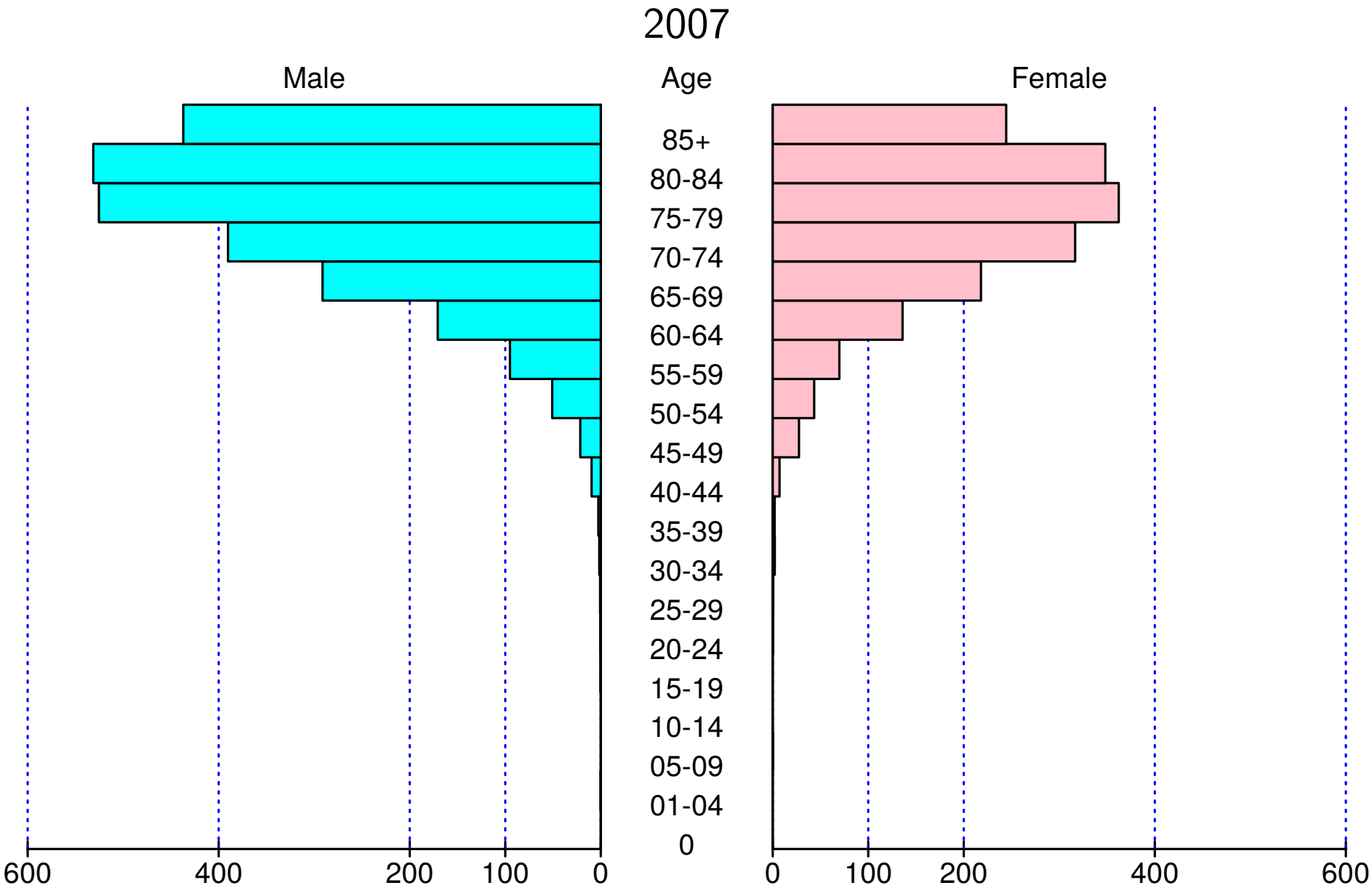

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The **incidence rate** (IR) the number of new cases of disease that occur per unit of individual time at risk, over a defined follow-up period:

$$IR = \frac{\text{number of new cases in the period}}{\text{the sum of the individual time at risk}}$$

The **time at risk** is the time spent by the individual without disease, i.e. the time to be in risk of disease. When an animal becomes ill, the rest of the period is not included into the calculation.

E.g. if six healthy sows are studied for a year, and during this period none of them will be affected by the event, then the denominator for the calculation is "6 sow-year".

The incidence rate can be calculated for /animal-week, /animal-year, /100 animal-week, /100 animal-year, etc.

In the first week 20 animals became infected, so for them $20 \times 0.5 = 10$ animal-week at risk, assuming that all became infected at the middle of the week. For the second week it is $15 \times 1.5 = 22.5$ animal-week. For the third $10 \times 2.5 = 25$, fourth $5 \times 3.5 = 17.5$ and fifth $1 \times 4.5 = 4.5$ animal-week at risk.

Week	New cases	Animal-week at risk
1	20	$20 \times 0.5 = 10$
2	15	$15 \times 1.5 = 22.5$
3	10	$10 \times 2.5 = 25$
4	5	$5 \times 3.5 = 17.5$
5	1	$1 \times 4.5 = 4.5$

The 49 remained healthy animals means $49 \times 5 = 245$ animal-week. Summarizing $10 + 22.5 + 25 + 17.5 + 4.5 + 245 = 324.5$ animal-week at risk, so the $IR = 51/324.5 = 0.16$/animal-week.

The incidence rate makes it possible:

- to quantify the disease occurence in open population
- one indifidual may be affected more than one times

Diffictulty is to record preciselly the time at risk for all individuals. If this precise data recording is not applicable, there are some approximantions for the denominator calculation:

- the population at risk at middle of period $\times$ the length of study
- $\left(N_{\text{start}} + \frac{1}{2}N_{\text{new}} - \frac{1}{2}N_{\text{lost}}\right) \times$ the length of study
- $\left(N_{\text{start}} + \frac{1}{2}N_{\text{new}} - \frac{1}{2}N_{\text{lost}} + \frac{1}{2}N_{\text{cases}}\right) \times$ the length of study

Incidence of porcine cysticercosis in Angónia District, Mozambique

A total of 108 pigs from an endemic area in Mozambique were selected and followed for 8 months to estimate the prevalence and incidence of *Taenia solium* cysticercosis as indicators of ongoing transmission of the disease. The pigs were sampled and tested repeatedly for cysticercosis by Ag-ELISA at 4, 9 and 12 months of age. Porcine cysticercosis was diagnosed in 5.6% (95% CI: 2.1–11.7%), 33.3% (95% CI: 23.7–44.1%) and 66.7% (95% CI: 55.5–76.9%) of the animals, for the first, second and third sampling rounds, respectively, and varied by village. The mean incidence rate of the disease increased significantly from **6.2 cases per 100 pig-months** between 4 and 9 months of age, to **21.2 cases per 100 pig-months** between 9 and 12 months of age (incidence rate difference = 15.0; 95% CI: 6.8–23.3). Risk factors for the disease are present in the study area, thus control and educational programmes for the community should be initiated to build awareness of the transmission and impact of *T. solium* infections.

Pondja et al. (2012)

Bank voles show high seropositivity rates in a natural TBEV focus in Hungary

Rodents captured in a known tick-borne encephalitis virus (TBEV) focus were serologically surveyed for 4 years, with 28 visits. The collected sera were analysed by virus neutralization test. Bank vole (*Myodes glareolus*) had a significantly higher **incidence rate** of antibodies to TBEV (20.5%) than *Apodemus flavicollis* (3.7%) and *Apodemus agrarius* (4.6%). In all species, rates were higher in adults (6.8%) than in juveniles (1.7%). A higher **incidence rate** was observed in female *A. flavicollis* individuals (6.7%) than in males (1.5%). Smaller bank vole population coincided with lower (1.2 – 4.8%) seropositivity in all small rodents, while more abundant bank vole population meant higher (17.9%) total seropositivity. The TBEV focus originally had only *Apodemus* mice, bank voles appeared later, reached 20.5% positivity and raised the positivity in small rodents from 4% to 10.2% in 3 years. The results highlight the role of *M. glareolus* and of adult rodents in maintaining the TBEV in nature.

Zöldi et al. (2015)

Inconsistencies between abstracts and manuscripts in published studies about lumbar spine surgery

STUDY DESIGN: Systematic review.

OBJECTIVE: To perform a comparison of randomized controlled trial (RCT) abstracts and manuscripts published in recent spinal literature.

SUMMARY OF BACKGROUND DATA: RCTs represent the "gold standard" upon which evidence-based treatment decisions are made. Inconsistencies between an abstract and manuscript can mislead readers' interpretation of findings and conclusions. Abstract findings are often cited without reference to the manuscript itself. In other fields of medicine, studies have shown discrepancies between RCT abstracts and manuscripts.

METHODS: A literature search of RCTs published in Spine, The Spine Journal, and Journal of Spinal Disorders and Techniques during a 10-year period (2001-2010) was performed. All manuscripts described as randomized trials concerning lumbar spinal surgery were selected. Manuscripts were analyzed using a standardized 21-item questionnaire to collect data regarding inconsistencies or bias in the abstract compared with the manuscript. Abstracts were considered deficient if they contained data that were either inconsistent with the manuscript or if they failed to include important findings from the manuscript. Four reviewers reported on the 40 manuscripts that met the inclusion criteria. Each manuscript was reviewed by 2 reviewers. In the event of conflicts in analysis, resolution was achieved through discussion between the reviewers.

RESULTS: **At least 1 inconsistency was found in 75% of studies.** Despite the word "randomized" appearing in 75% of titles and 92.5% of abstracts, the method of randomization was not described in 37.5% of manuscripts and (if described) was considered unacceptable in 28%. The primary outcome of the study was clearly stated in only 22.5% of abstracts and 47.5% of manuscripts. Pertinent negatives were not reported in 40% of the abstracts. Relevant statistically significant results were reported in only 60% of abstracts.

CONCLUSION: **Abstracts are discrepant with full manuscripts in a surprisingly high proportion of manuscripts**. Authors, editors, and peer reviewers should strive to ensure that abstracts accurately represent the data in RCT manuscripts.

Lehmen et al. (2014)

Cumulative mortality, CM is estimated as cumulative incidence:

$$CM = \frac{\text{number of died animals in the period}}{\text{size of the population at risk at the begining of period}}$$

Mortality rate, M is calculated as the incidence rate:

$$M = \frac{\text{number of died animals in the period}}{\text{the sum of the individual time at risk of death}}$$

Fatality rate:

$$CF = \frac{\text{the number of fatal cases of a disease}}{\text{all individuals who contract the disease}}$$

Survival analysis has emerged as a special area related to the incidence of deaths in a population. It is important to note that in survival studies, the observed outcome is not necessarily the death.

In survival studies the time spent until a certain outcome from a starting point* is the base of health realted event quantification. As outcome different events might be considered (e.g. recurrence, progression).

In the studies the precise survival time is known just for subjects having the **end point** event occurence.

*time to event, survival time

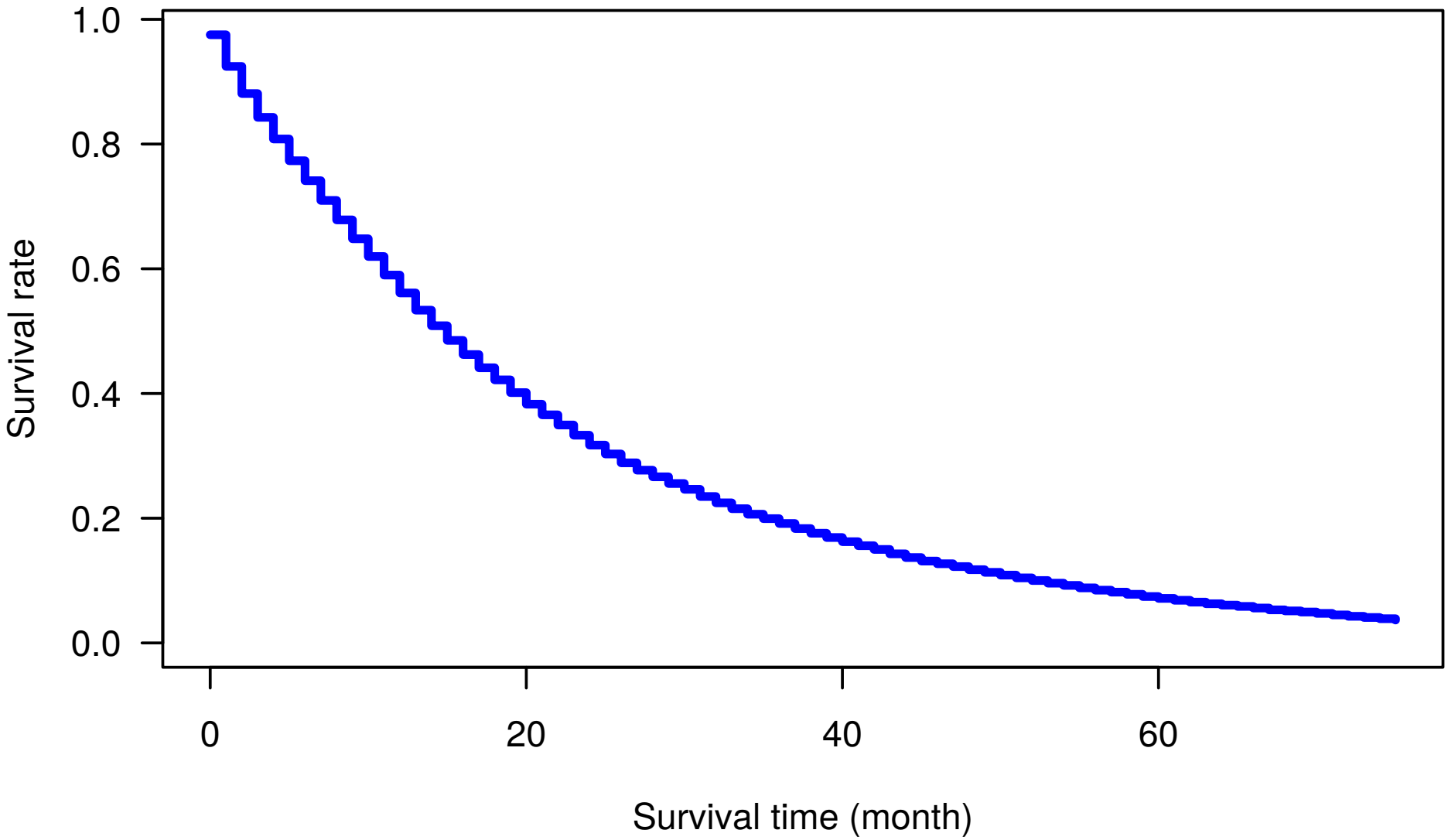
In the simplest case:

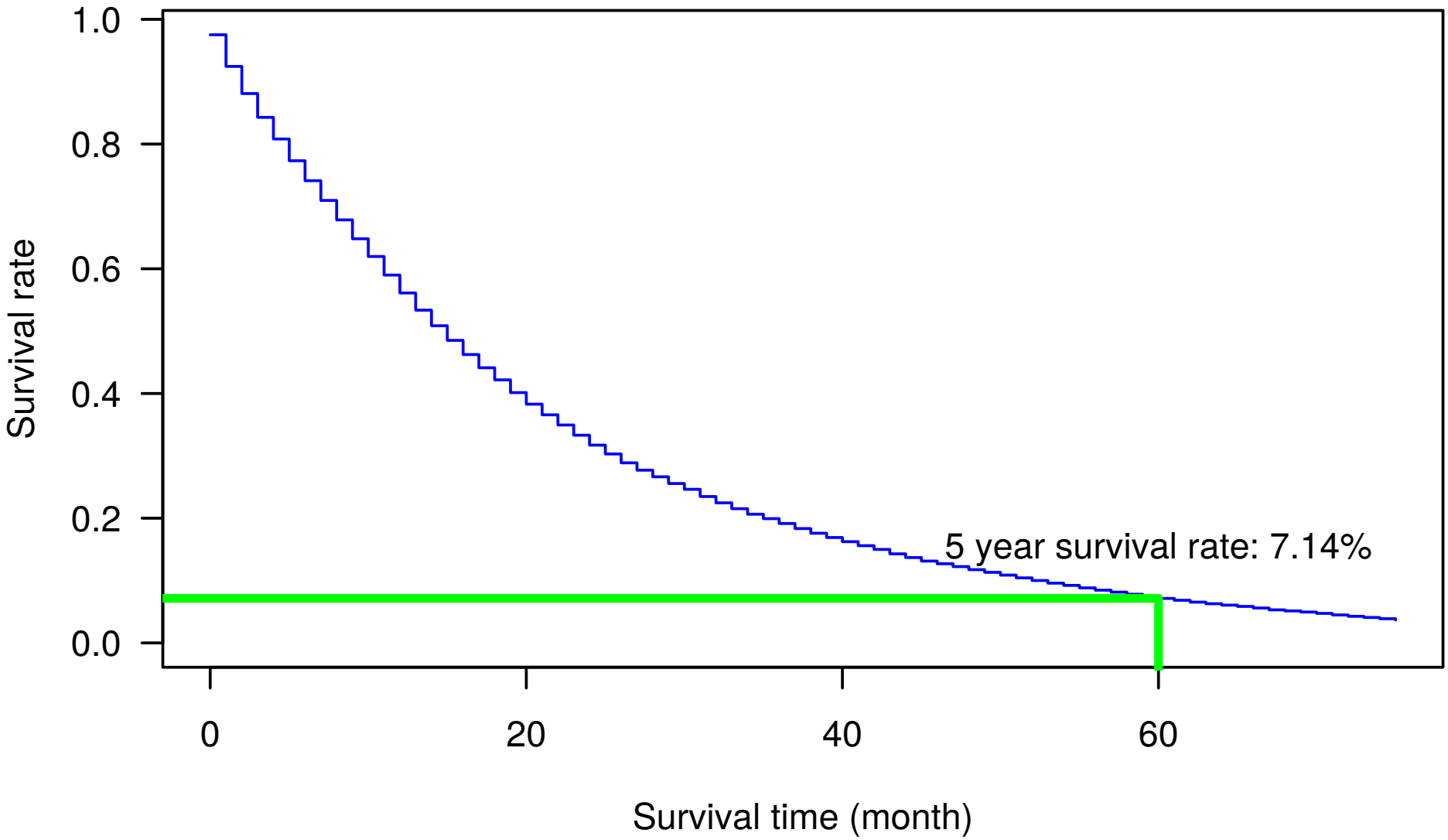
$$\text{survival rate}(t) = \frac{\text{No. of subject having survical time} \geq t}{n}$$

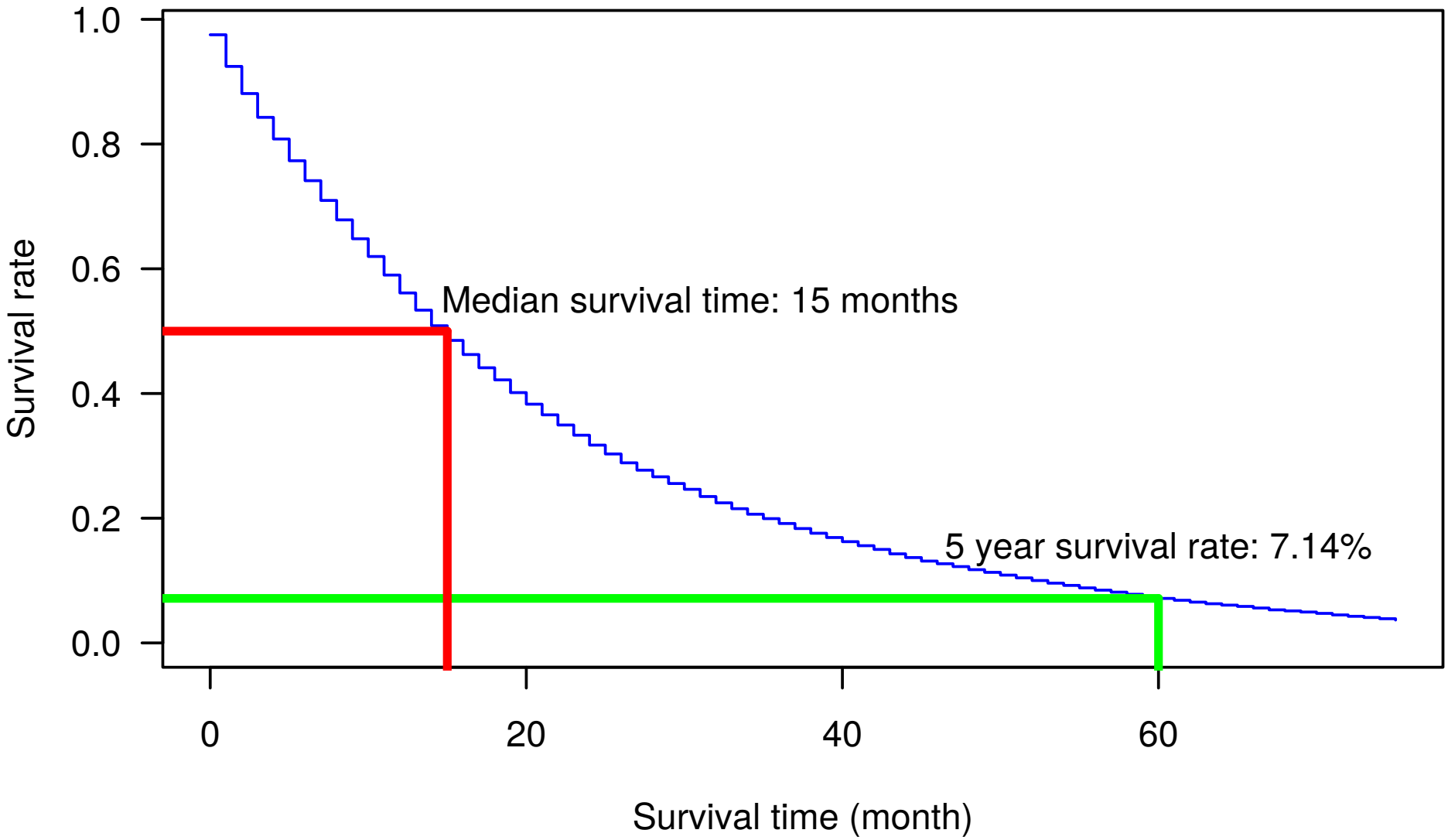
The number of the observed subjects at the start of the study[†]: 23870

1. First month
   - The number of death until the end of period: 591
   - The rate of the survivors of this period: $\frac{23870 - 591}{23870} = 0.975$
   - Survival rate: 97.5%
2. Second month
   - The number of death until the end of period: $591 + 1211$
   - The rate of the survivors of this period: $\frac{23870 - (591 + 1211)}{23870} = 0.925$
   - Survival rate: 92.5%
3. ...

[†]SEER-database, lung cancer


1.0
0.8
0.6
0.4
0.2
0.0
Survival rate
0
20
40
60
Survival time (month)


1.0
0.8
0.6
0.4
0.2
0.0
Survival rate
0
20
40
60
Survival time (month)
5 year survival rate: 7.14%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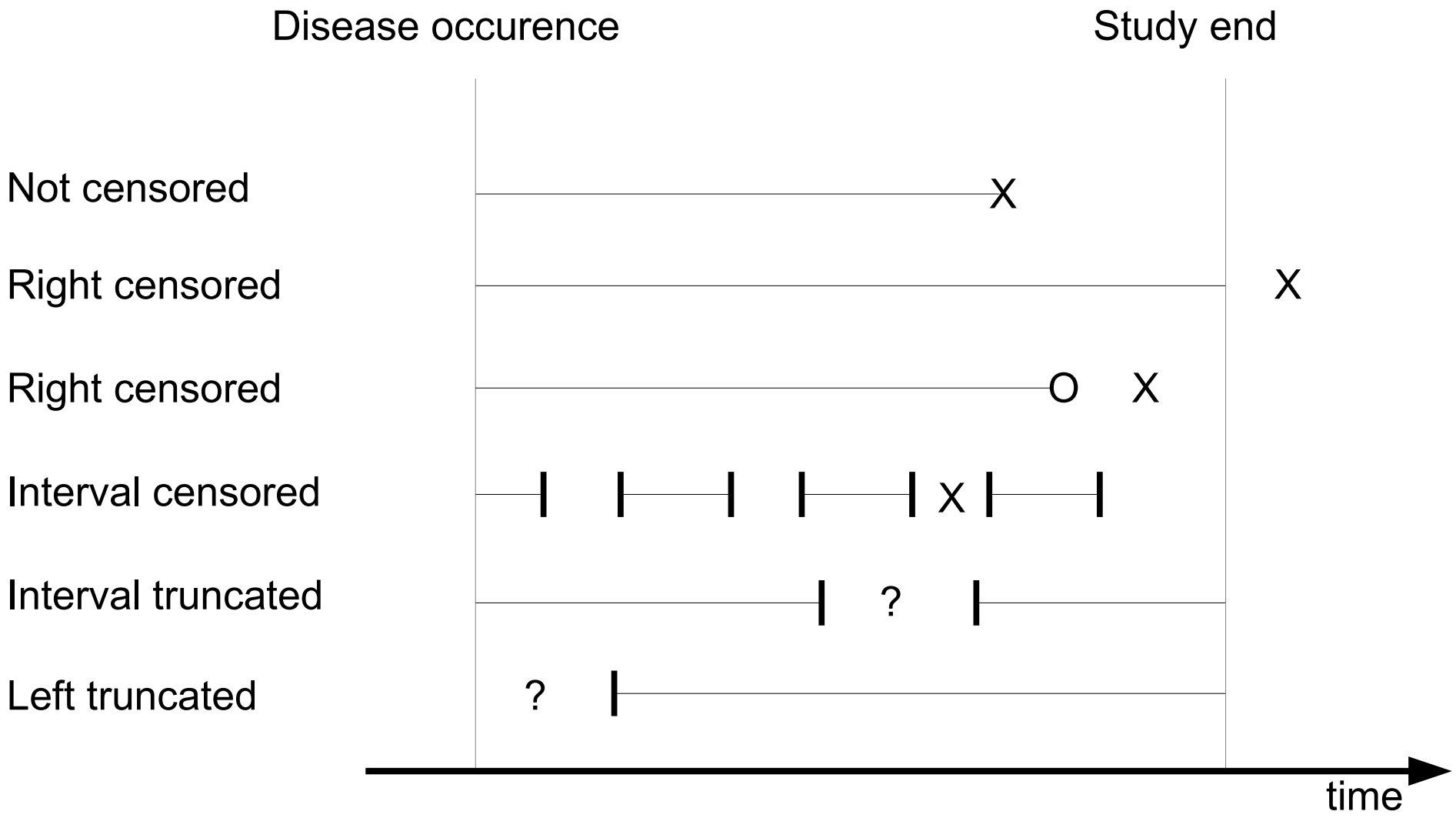
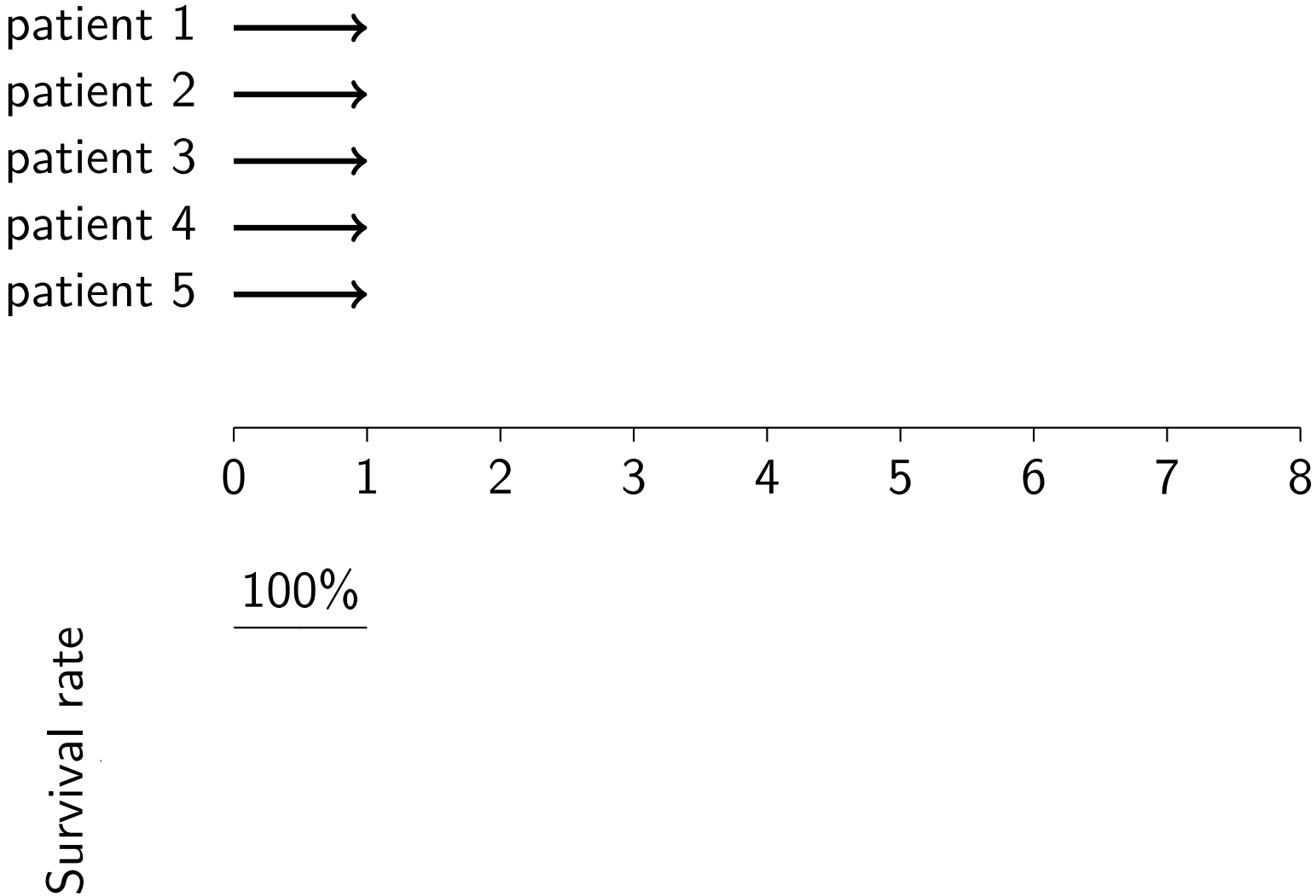
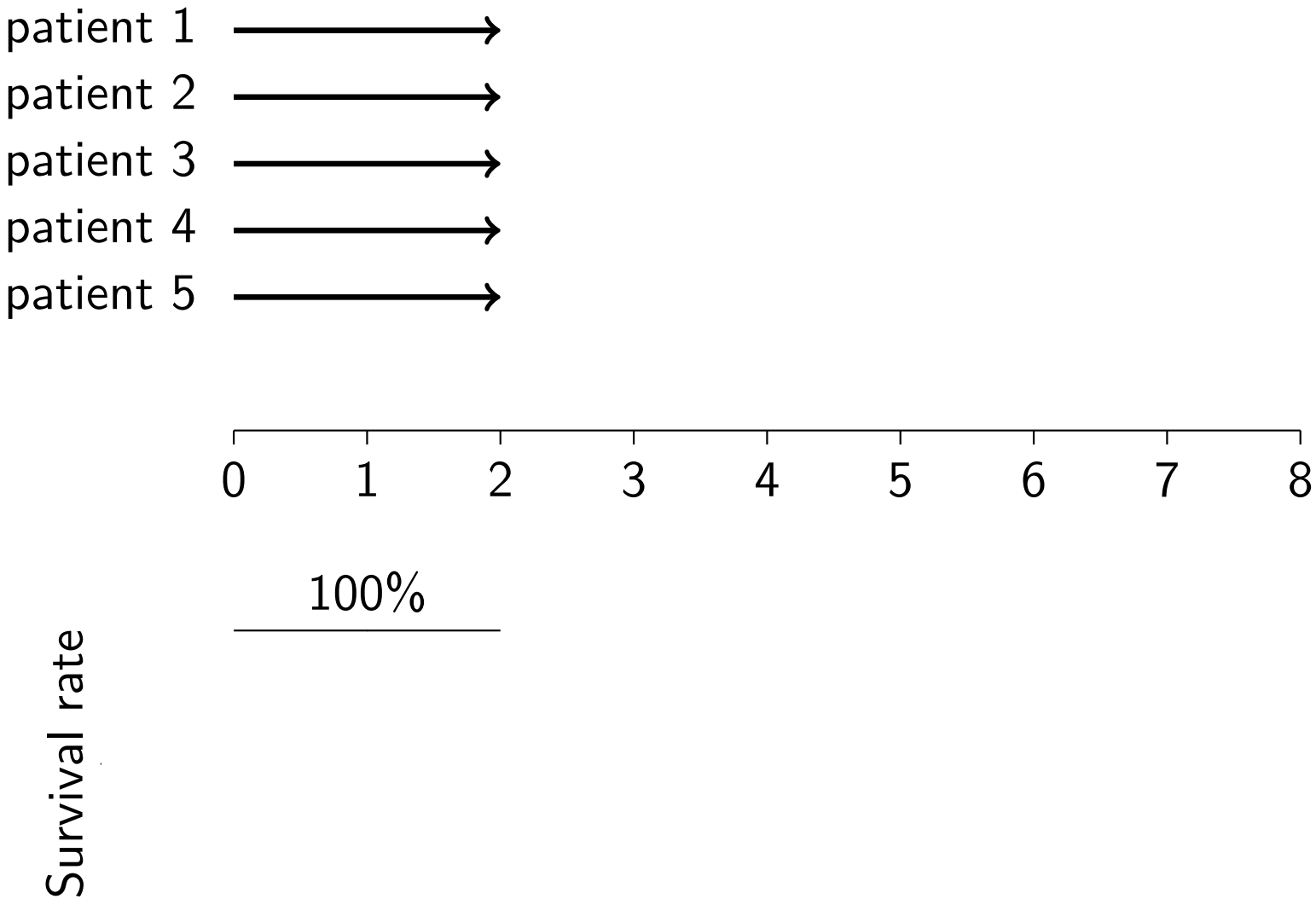
0.8
0.6
0.4
0.2
0.0
Survival rate
Median survival time: 15 months
5 year survival rate: 7.14%
0
20
40
60
Survival time (month)

Censored

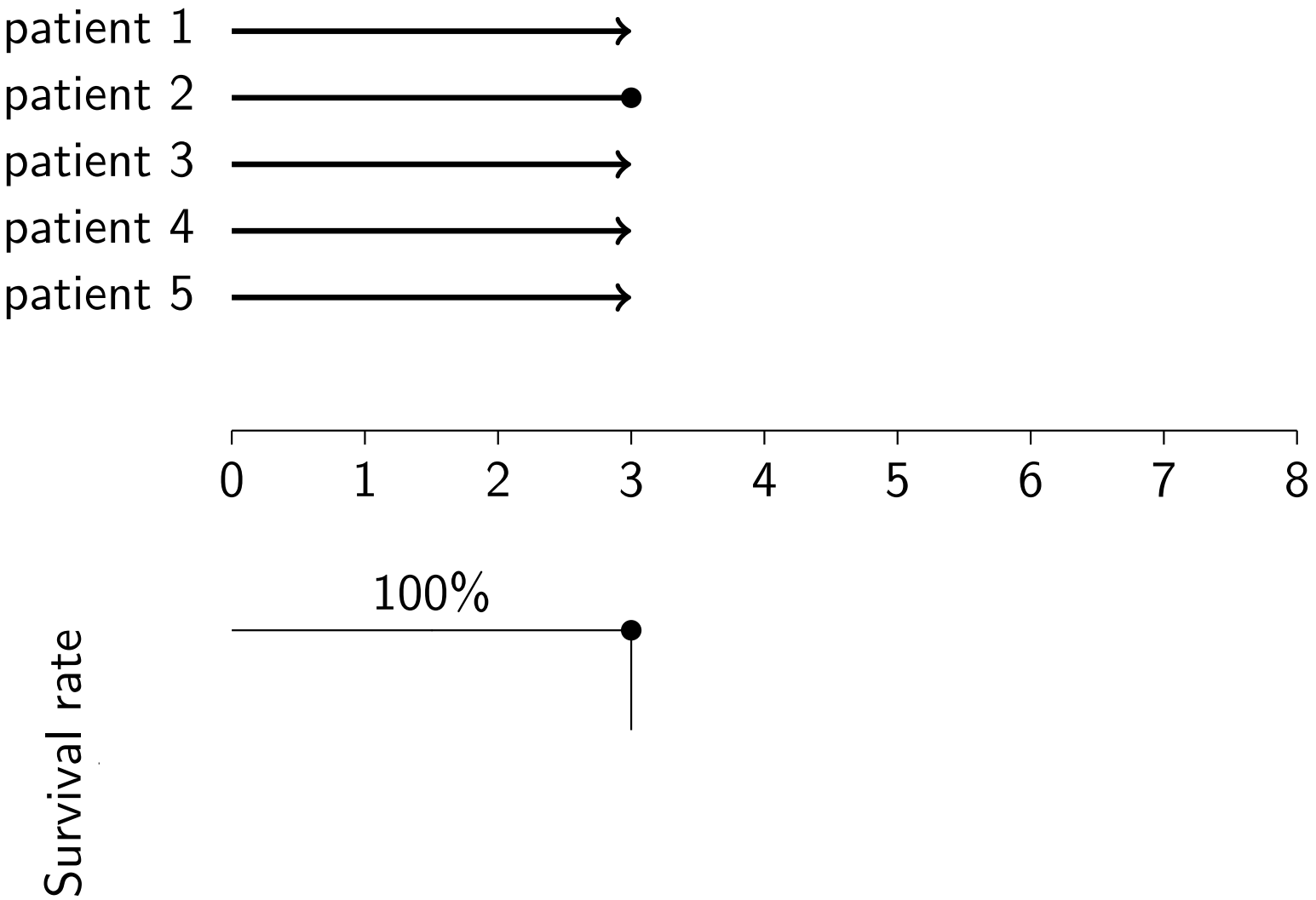

Disease occurence
Study end
Not censored
Right censored
Right censored
Interval censored
Interval truncated
Left truncated
X
X
O
X
X
?
?
time



$$S(t_i) = \frac{alive_i - dead_i}{alive_i} \times S(t_{i-1})$$



$$S(t_i) = \frac{alive_i - dead_i}{alive_i} \times S(t_{i-1})$$



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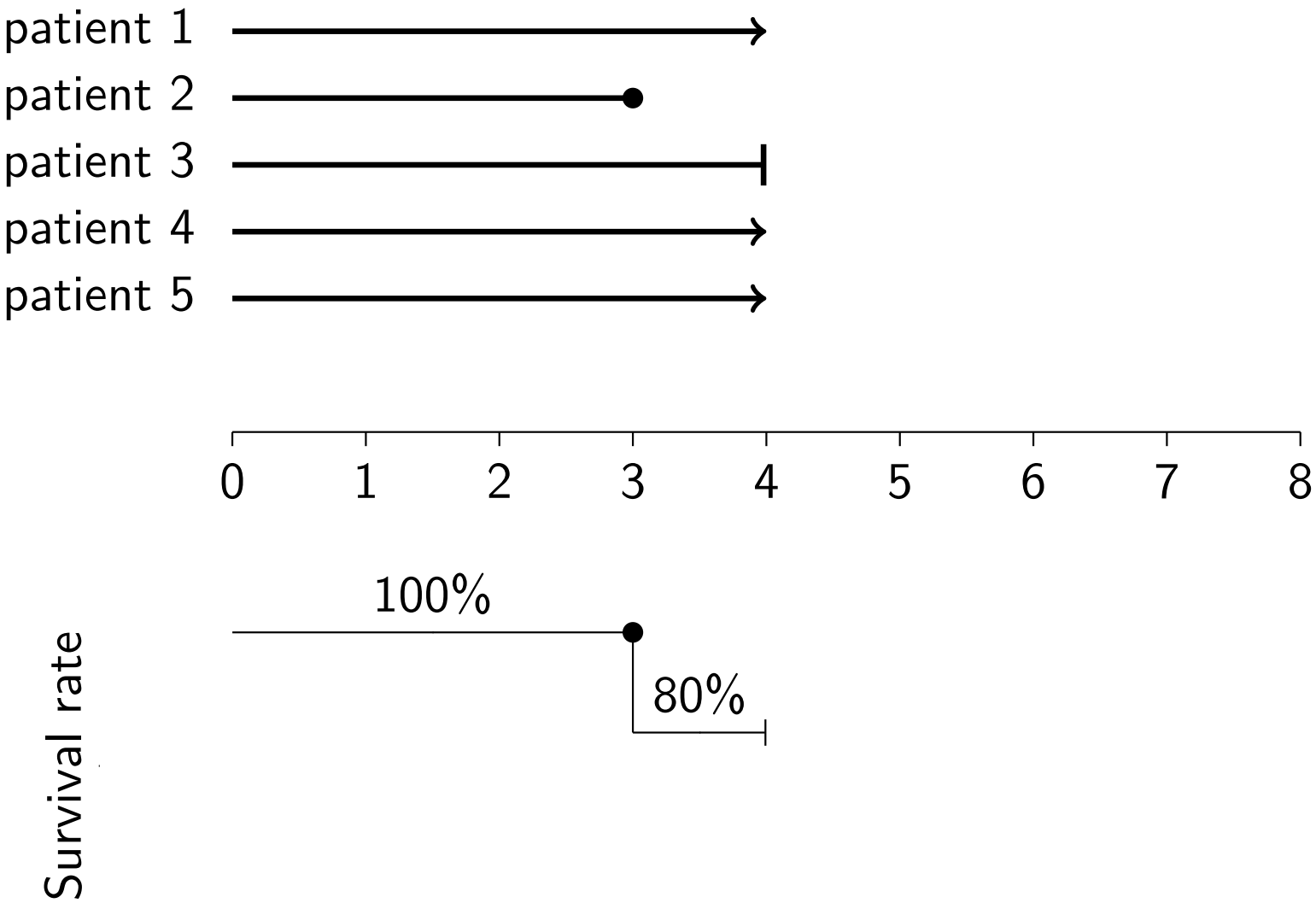
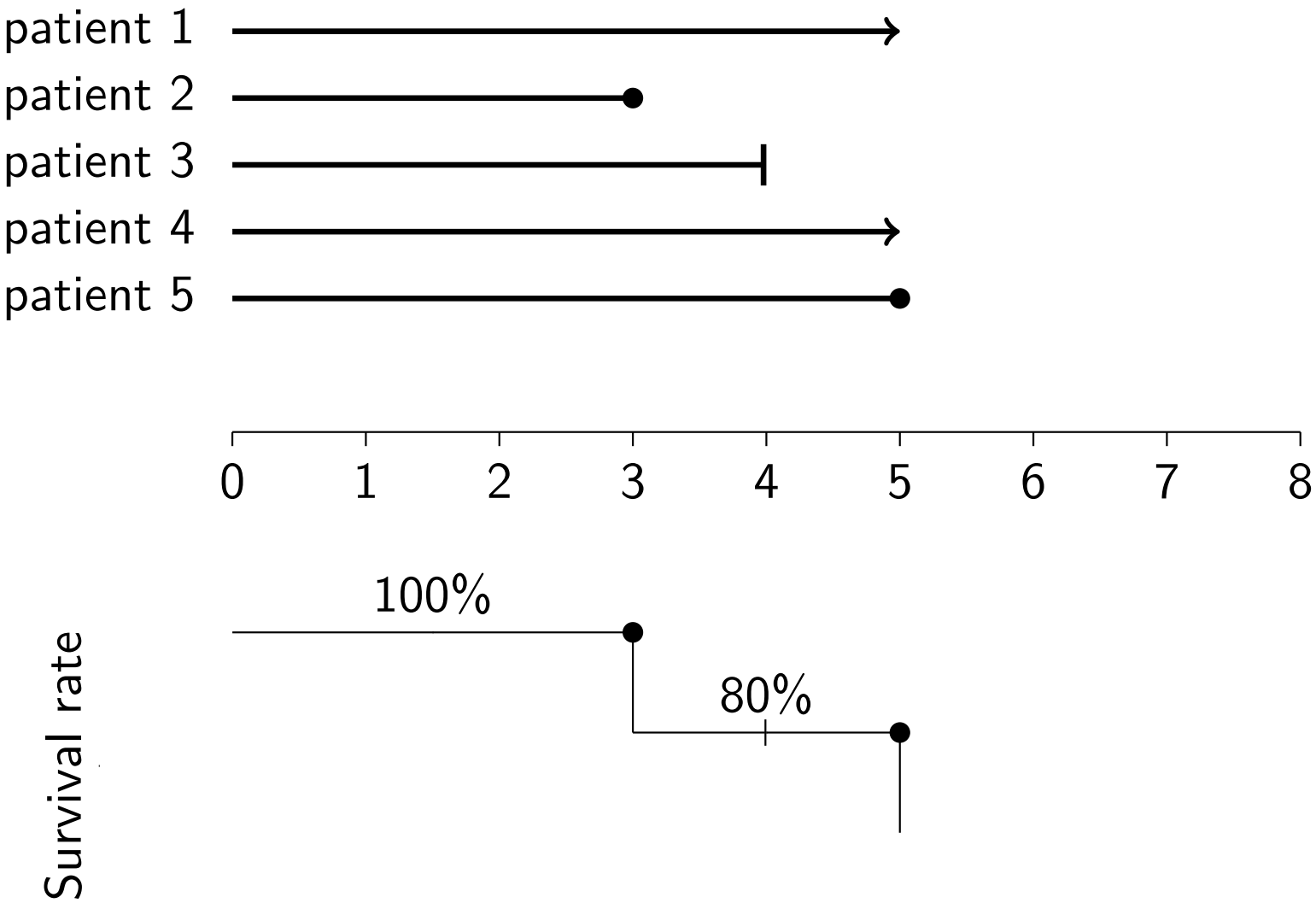
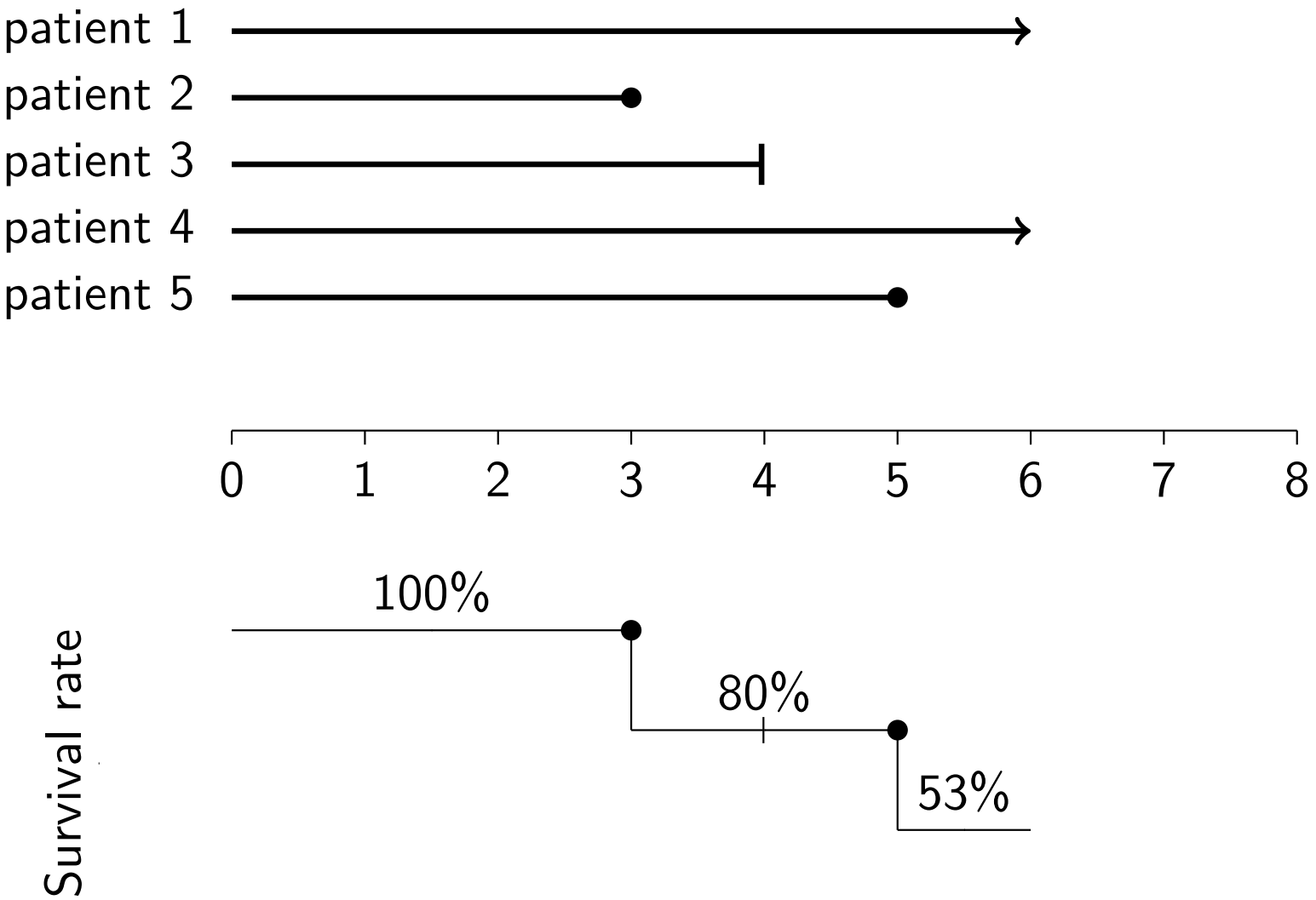


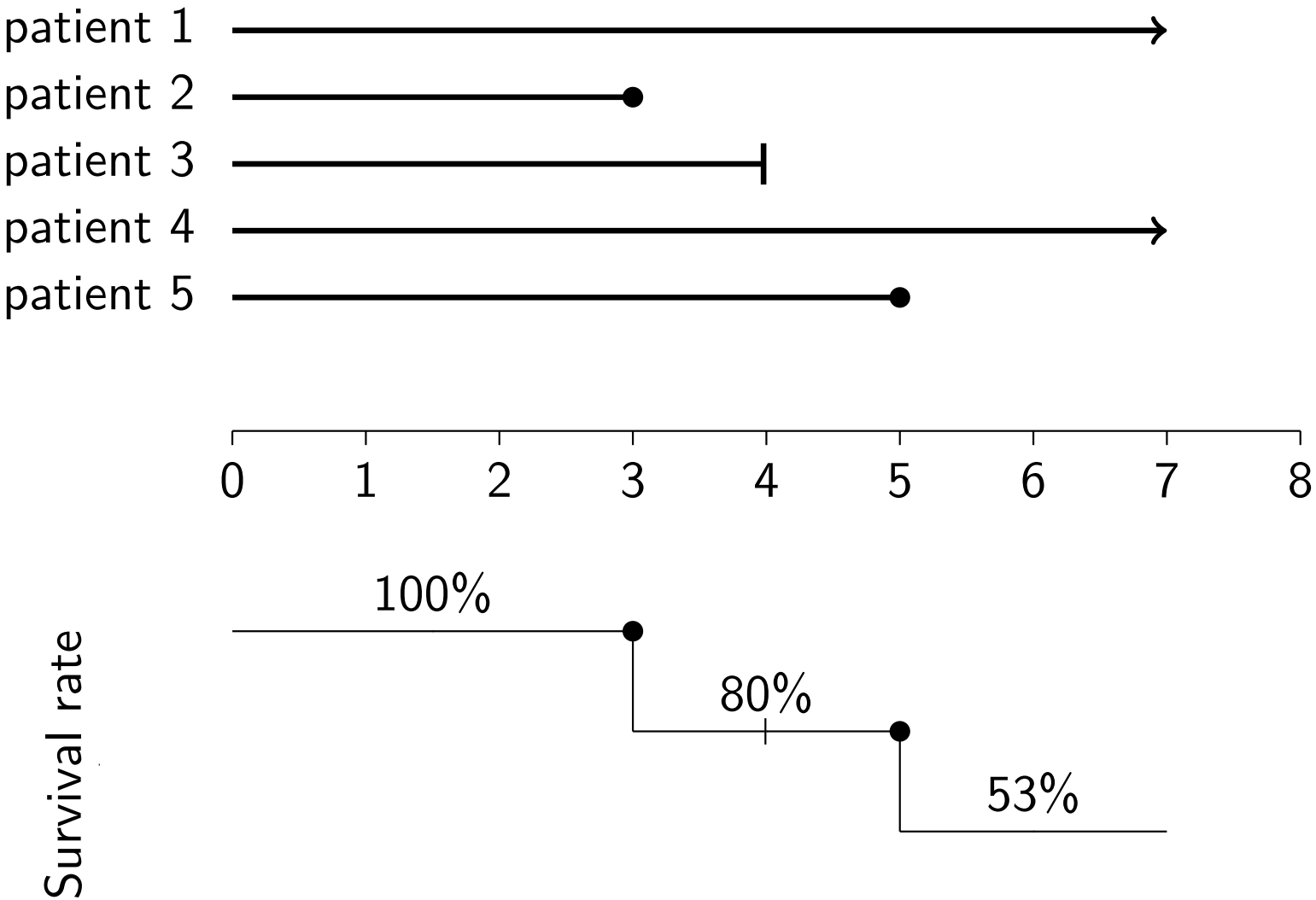
$$S(t_i) = \frac{alive_i - dead_i}{alive_i} \times S(t_{i-1})$$



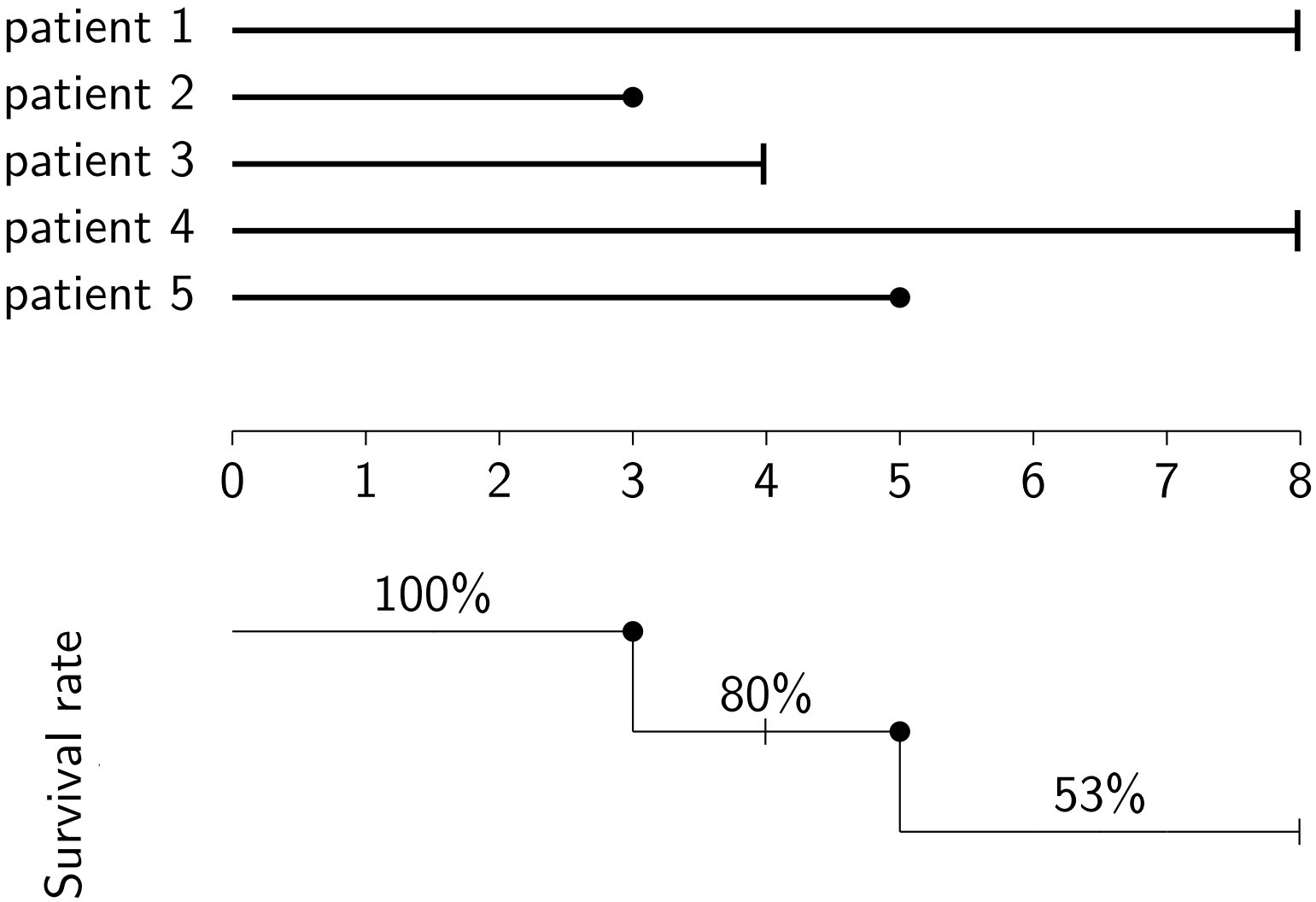
$$S(t_i) = \frac{alive_i - dead_i}{alive_i} \times S(t_{i-1})$$



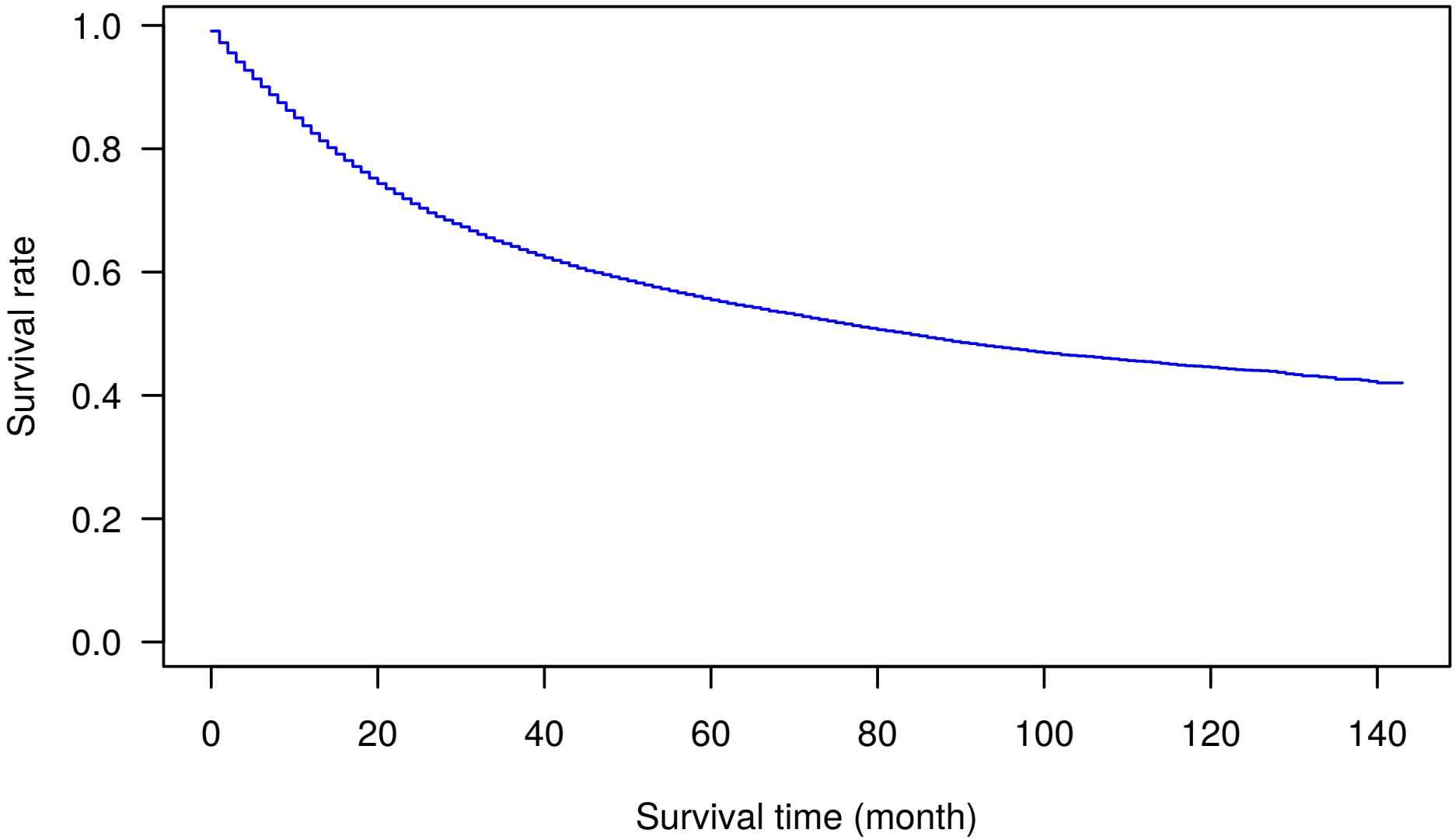
$$S(t_i) = \frac{alive_i - dead_i}{alive_i} \times S(t_{i-1})$$

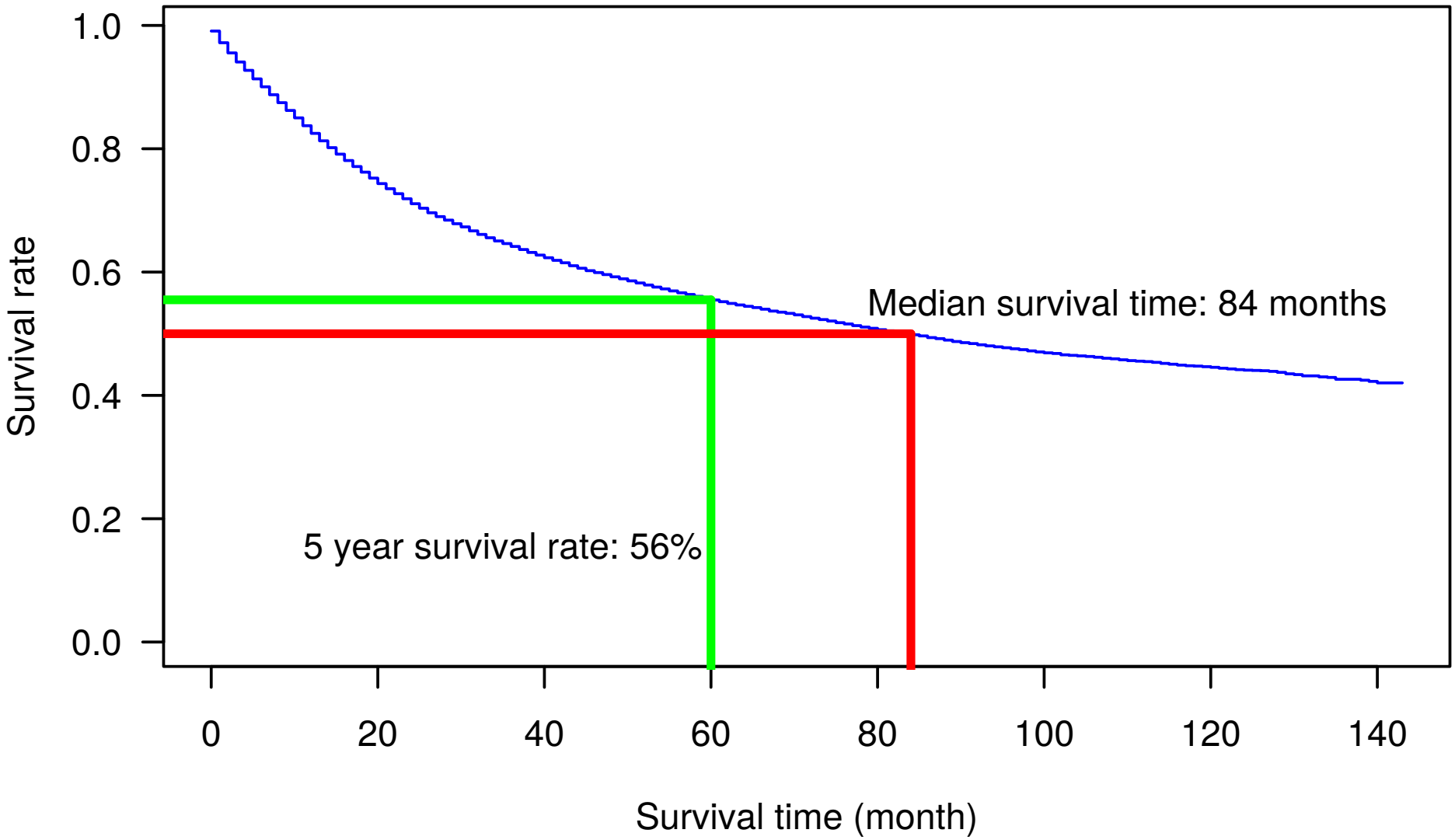


$$S(t_i) = \frac{alive_i - dead_i}{alive_i} \times S(t_{i-1})$$

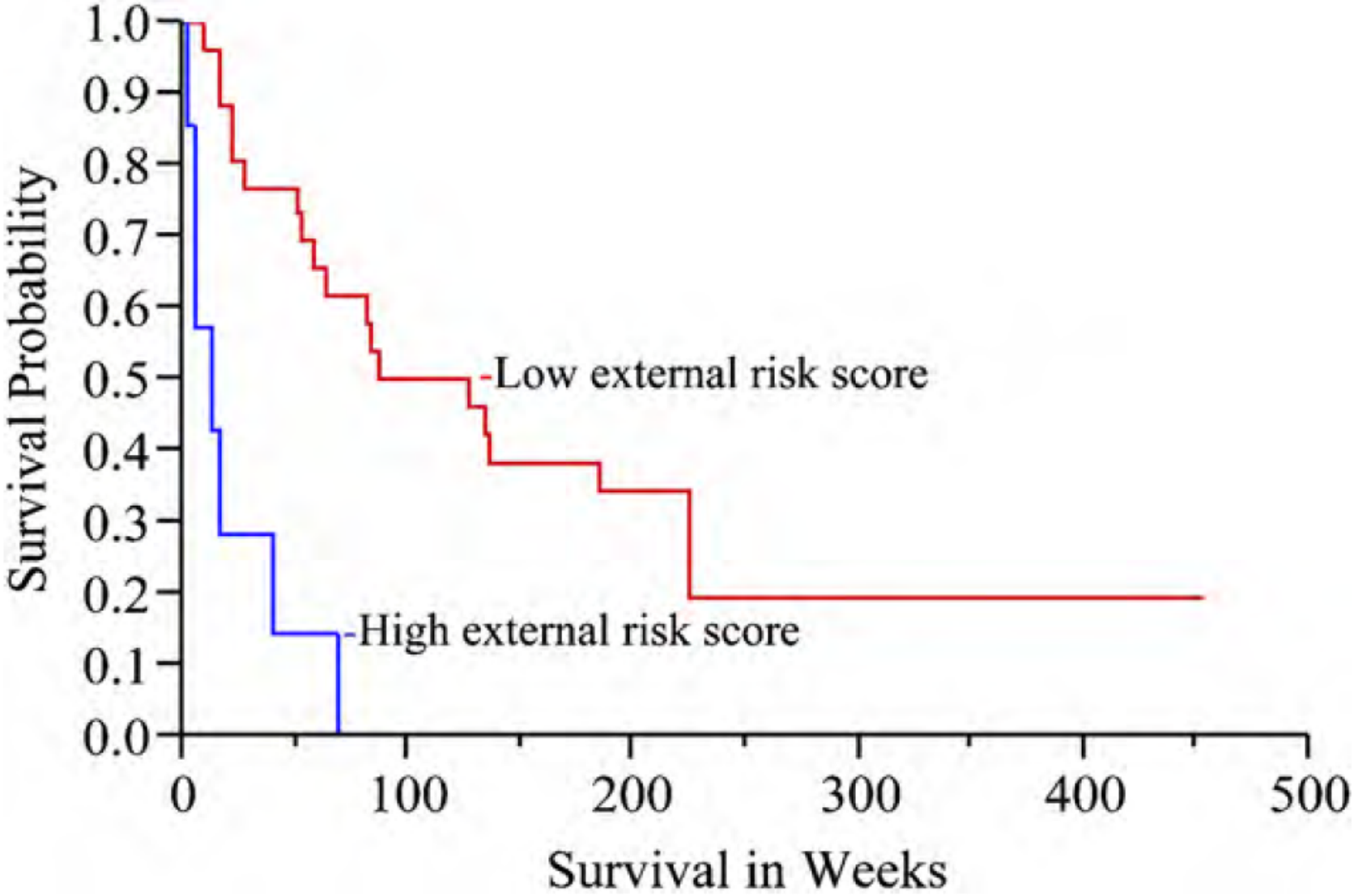


$$S(t_i) = \frac{alive_i - dead_i}{alive_i} \times S(t_{i-1})$$


1.0
0.8
0.6
0.4
0.2
0.0
Survival rate
0
20
40
60
80
100
120
140
Survival time (month)

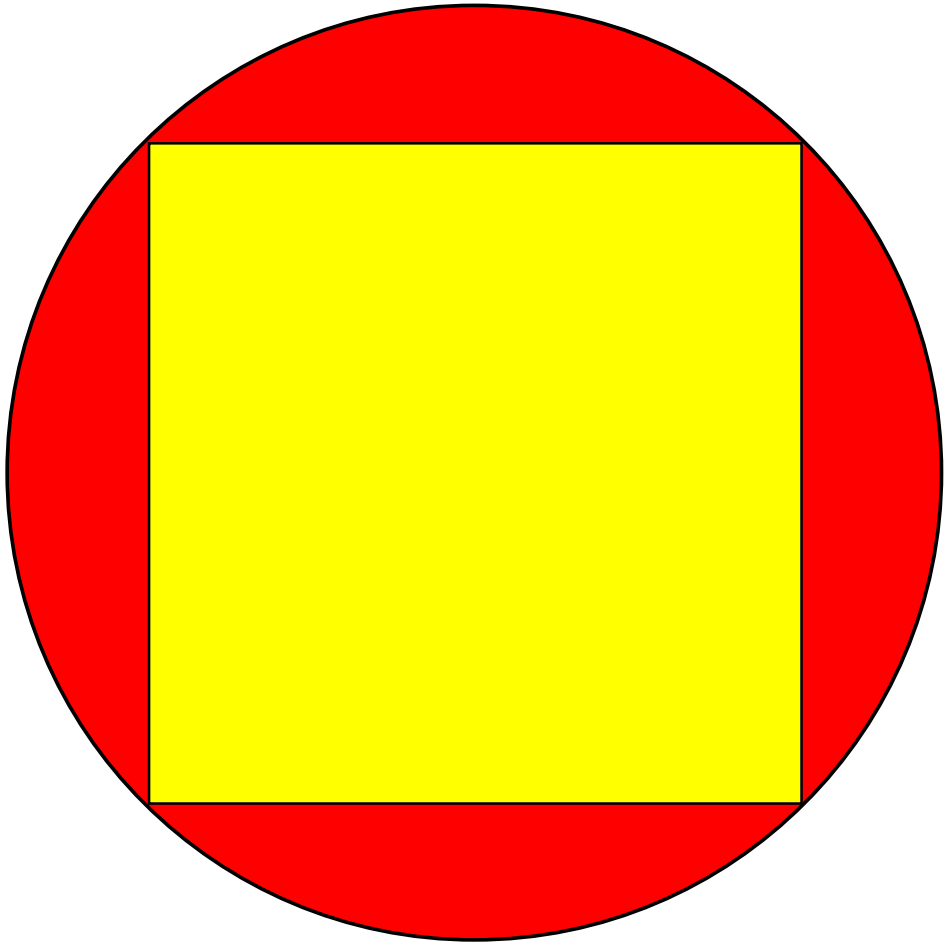

1.0
0.8
0.6
0.4
0.2
0.0
Survival rate
Median survival time: 84 months
5 year survival rate: 56%
0
20
40
60
80
100
120
140
Survival time (month)

A prospective study evaluating duration of swine breeding herd PRRS virus-free status and its relationship with measured risk

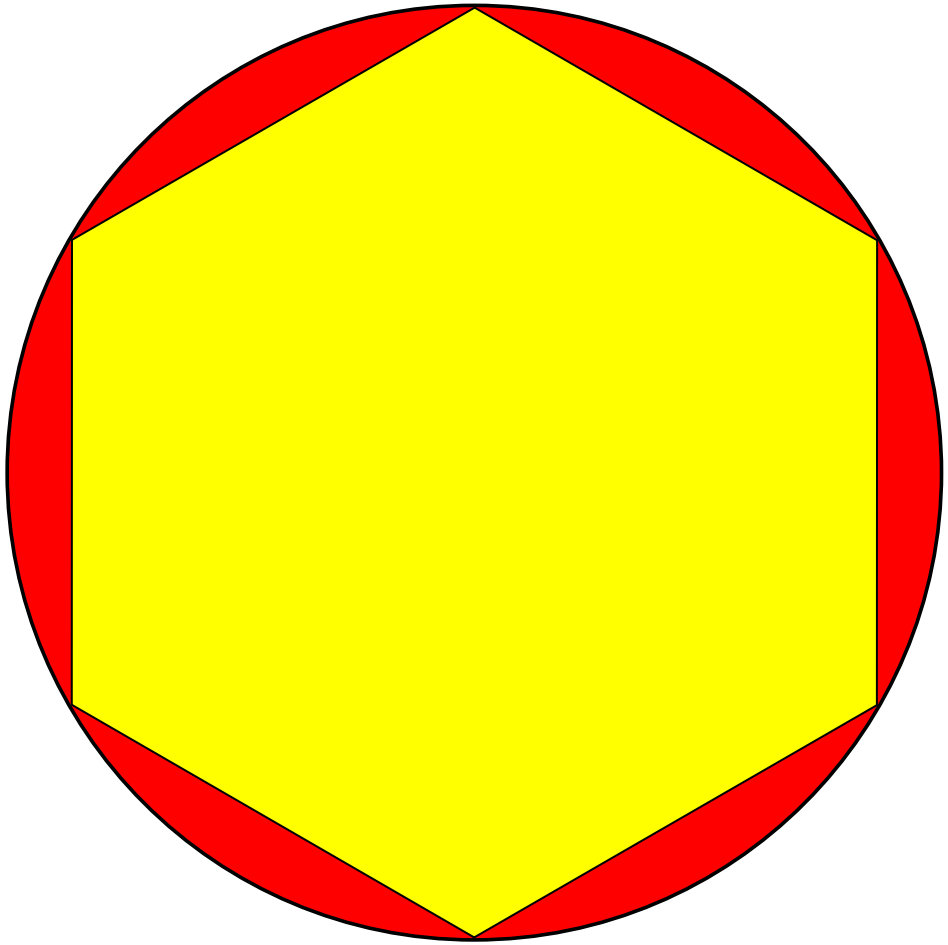


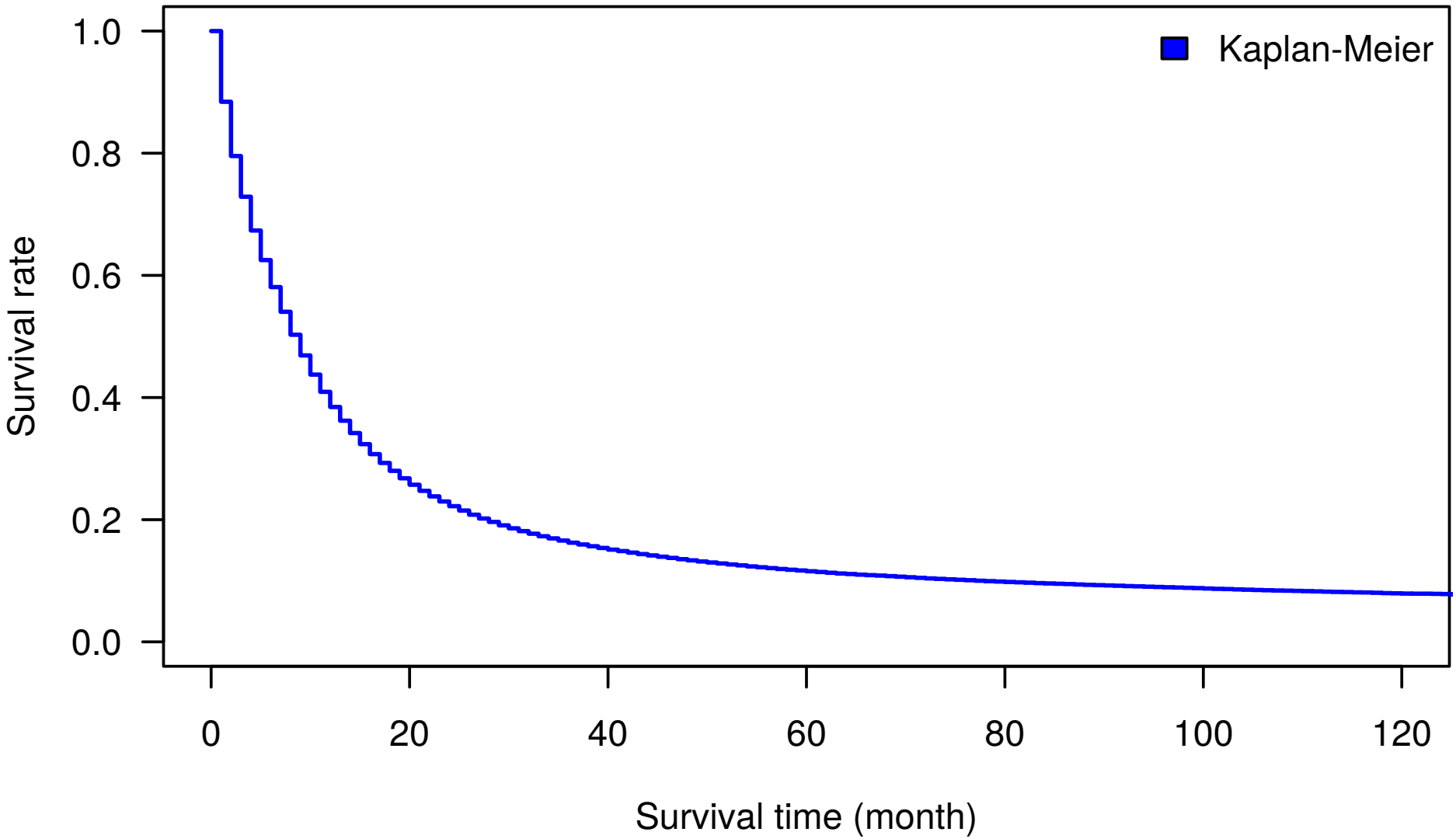
[†]Holtkamp et al. (2010)

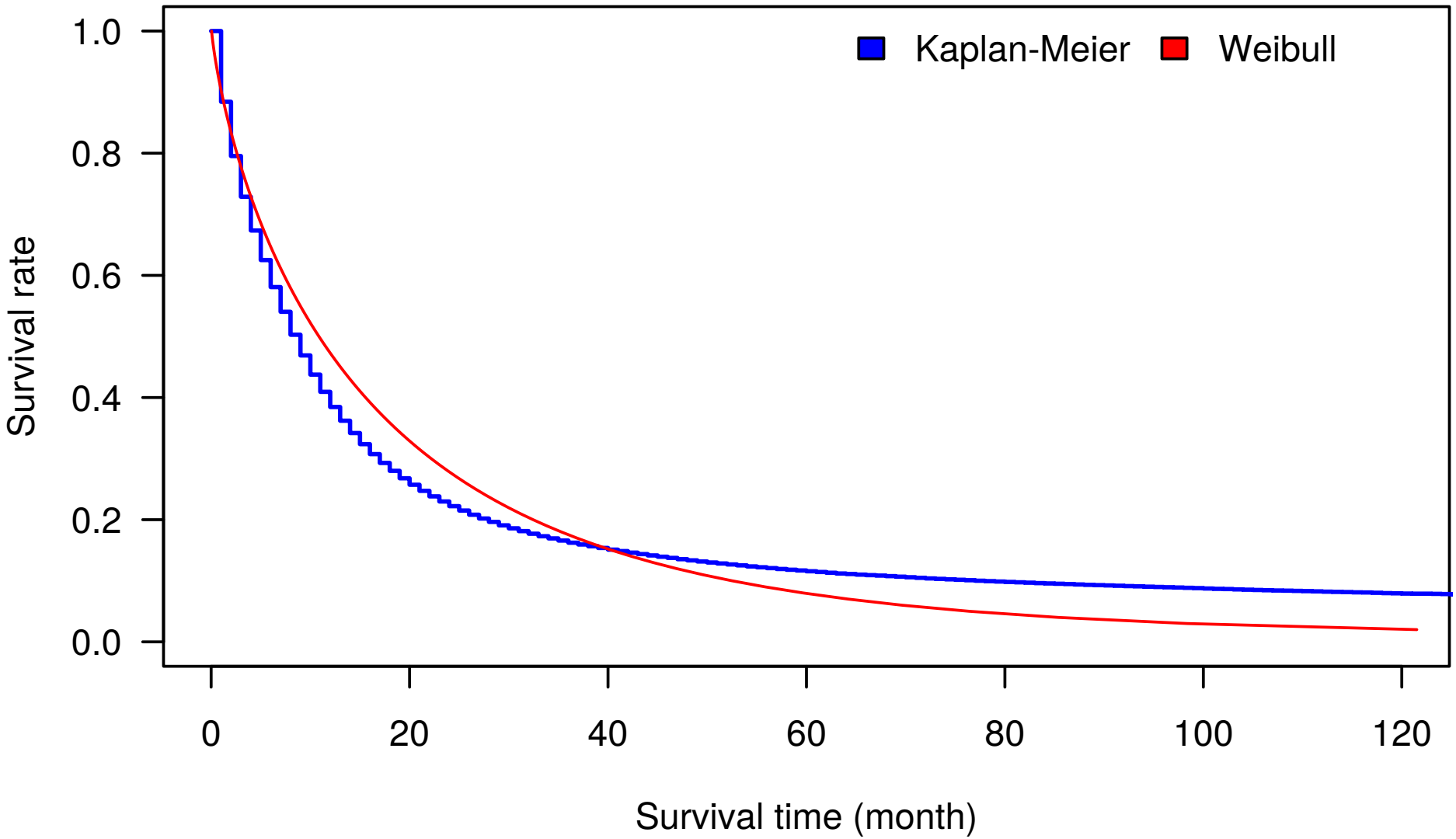
Nicolaus Cusanus
1401–1464

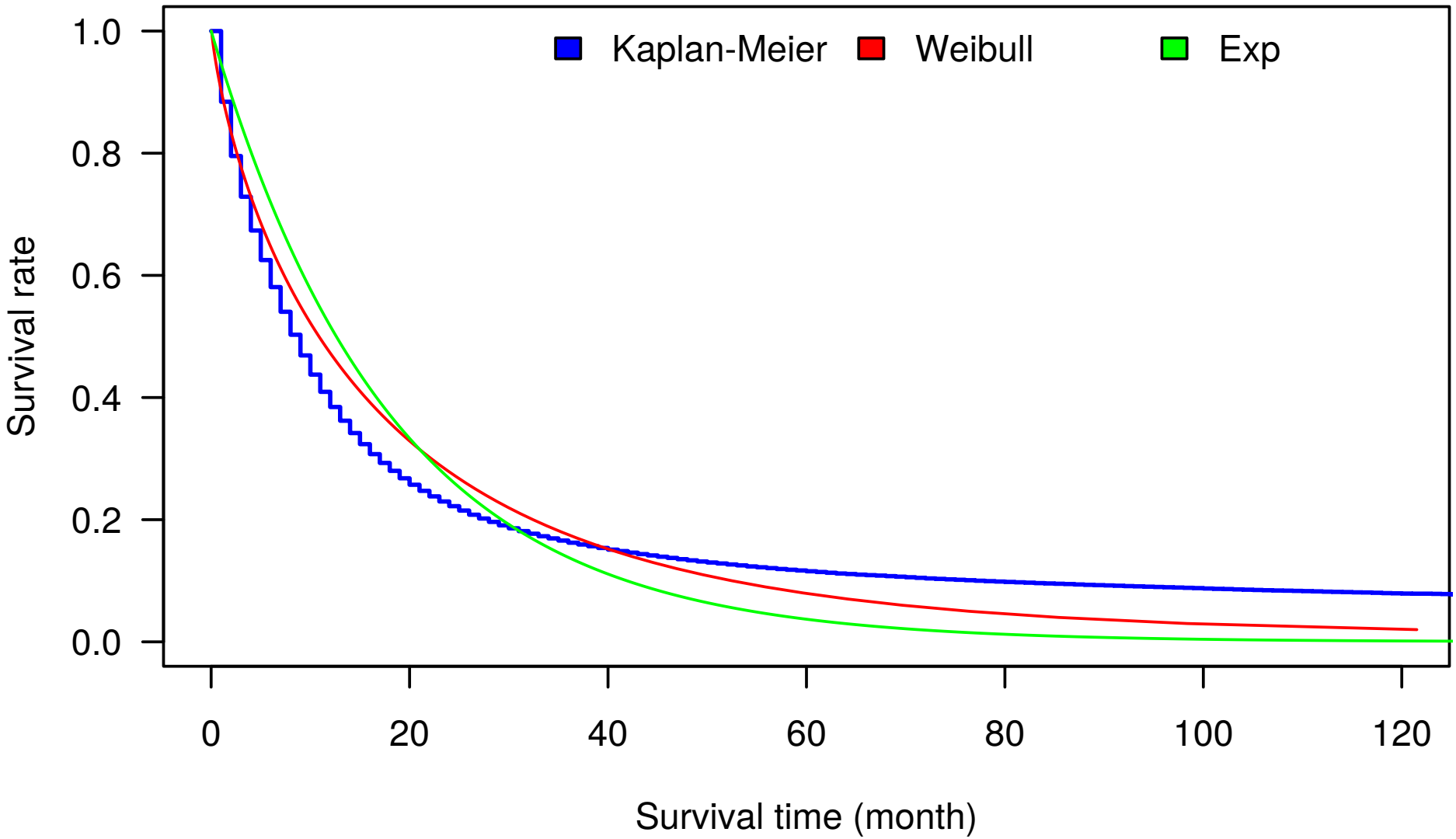


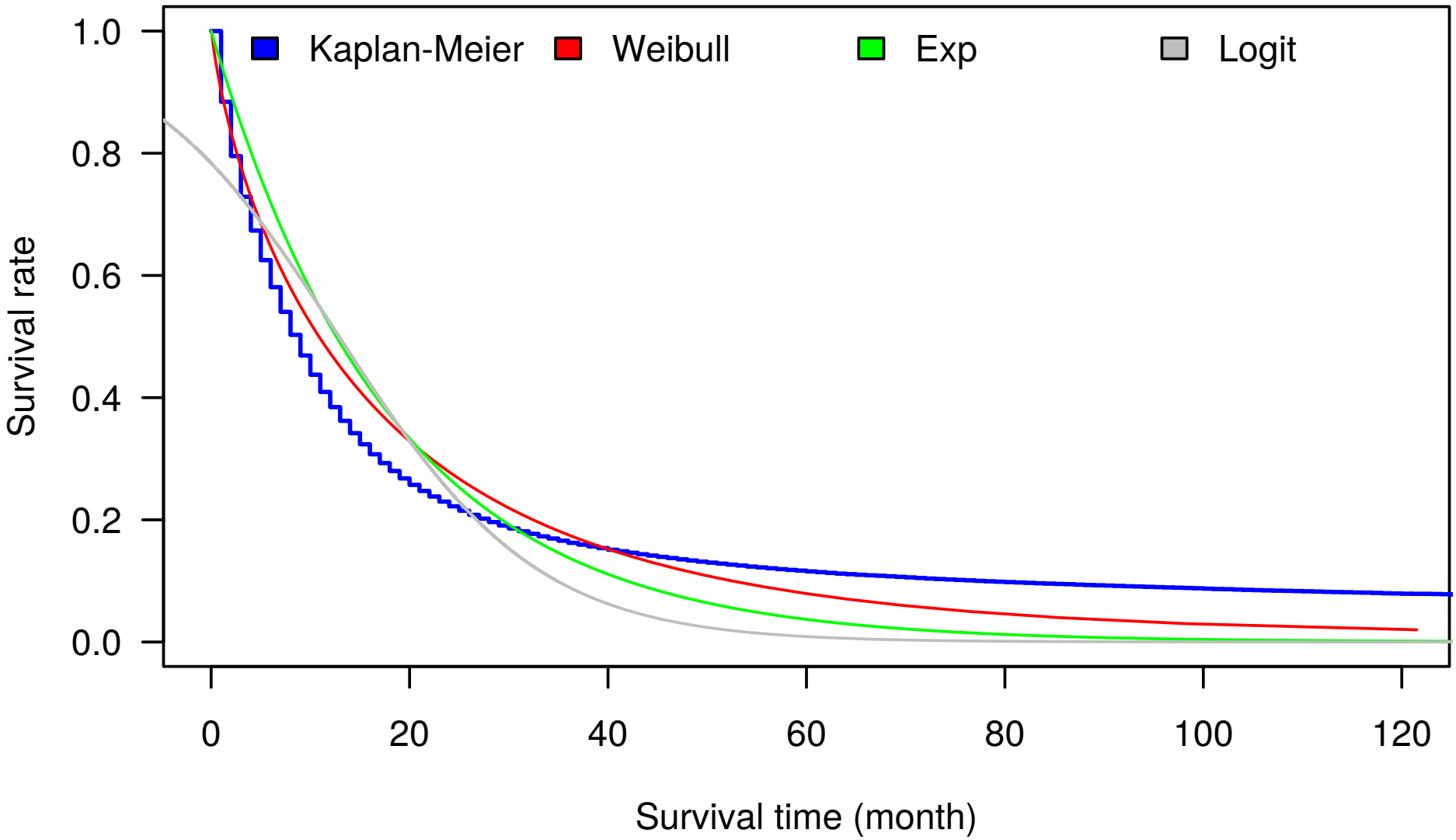
Nicolaus Cusanus
1401–1464

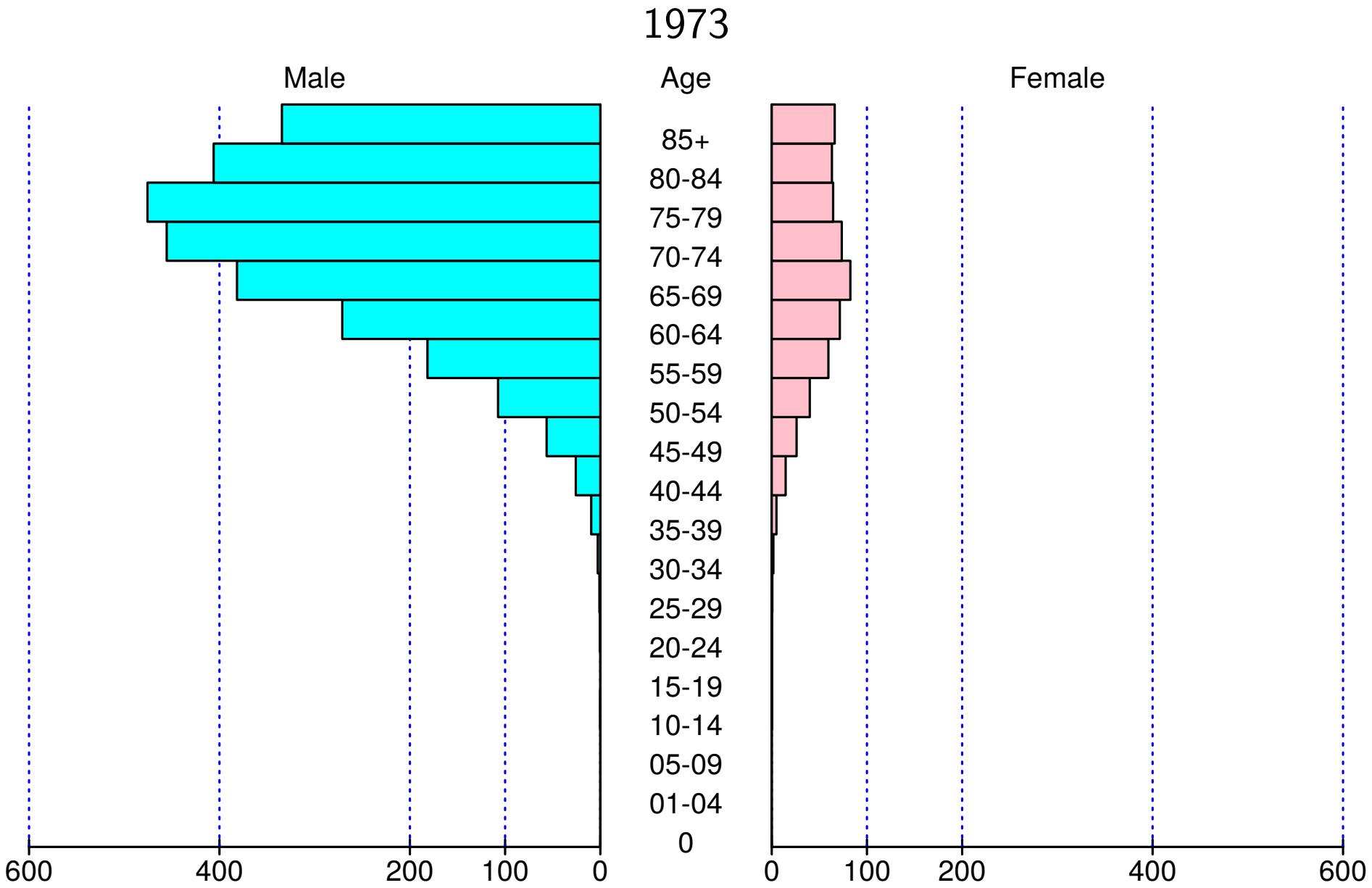



Kaplan-Meier
Survival rate
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
120
Survival time (month)


Kaplan-Meier
Weibull
Survival rate
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
120
Survival time (month)


Kaplan-Meier
Weibull
Exp
Survival rate
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
120
Survival time (month)


Kaplan-Meier
Weibull
Exp
Logit
Survival rate
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
120
Survival time (month)


1973
Male
Age
Female
85+
80-84
75-79
70-74
65-69
60-64
55-59
50-54
45-49
40-44
35-39
30-34
25-29
20-24
15-19
10-14
05-09
01-04
0
600
400
200
100
0
0
100
200
400
600

	No. of dogs with positive titres	sampled	Seroprevalence
Edinburgh	61	260	0.24
Glasgow	69	251	0.27
$\sum$	130	511	

	No. of dogs with positive titres	sampled	Seroprevalence
Edinburgh	61	260	0.24
Glasgow	69	251	0.27
$\sum$	130	511	

	No. of dogs with positive titres			sampled			Seroprevalence	
	♂	♀	$\sum$	♂	♀	$\sum$	♂	♀
Edinburgh	15	46	61	48	212	260	0.31	0.22
Glasgow	53	16	69	180	71	251	0.29	0.23
$\sum$	68	60	130	228	283	511		

	No. of dogs with positive titres			sampled			Seroprevalence	
	♂	♀	$\sum$	♂	♀	$\sum$	♂	♀
Edinburgh	15	46	61	48	212	260	0.31	0.22
Glasgow	53	16	69	180	71	251	0.29	0.23
$\sum$	68	60	130	228	283	511		

$$\text{direct adjusted value} = P_{male} \times \frac{S_{male}}{N} + P_{female} \times \frac{S_{female}}{N}$$

$$N = S_{male} + S_{female}$$

$$\text{Edinburgh} = 0.31 \times \frac{228}{511} + 0.22 \times \frac{283}{511} = 0.26$$

$$\text{Glasgow} = 0.29 \times \frac{228}{511} + 0.23 \times \frac{283}{511} = 0.26$$

	No. of dogs with positive titres	sampled	Seroprevalence
Edinburgh	61	260	0.24
Glasgow	69	251	0.27
$\sum$	130	511	

	No. of dogs with positive titres	sampled	Seroprevalence
Edinburgh	61	260	0.24
Glasgow	69	251	0.27
$\sum$	130	511	

$$\text{overall seroprevalence} = \frac{130}{511} = 0.25$$

	No. of dogs with positive titres	sampled	Seroprevalence
Edinburgh	61	260	0.24
Glasgow	69	251	0.27
$\sum$	130	511	

$$\text{overall seroprevalence} = \frac{130}{511} = 0.25$$

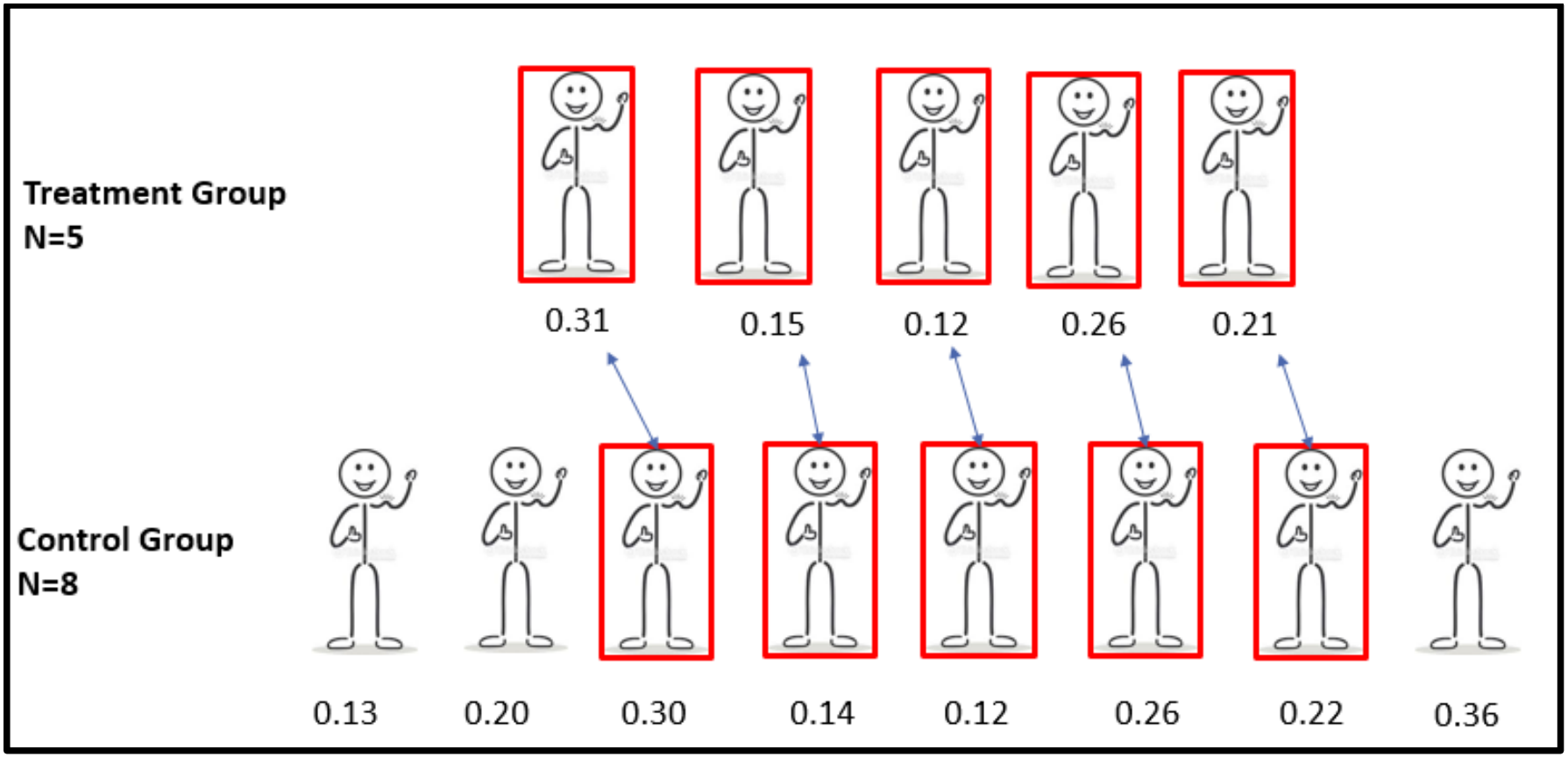
	Observed	Population	Expected
Edinburgh	61	260	$260 \times 0.25 = 65$
Glasgow	69	251	$251 \times 0.25 = 62.75$

	No. of dogs with positive titres	sampled	Seroprevalence
Edinburgh	61	260	0.24
Glasgow	69	251	0.27
$\sum$	130	511	

$$\text{overall seroprevalence} = \frac{130}{511} = 0.25$$

	Observed	Population	Expected	SMR
Edinburgh	61	260	65	$61/65 = 0.94$
Glasgow	69	251	62.75	$69/62.75 = 1.10$

- Propensity score based paires



https://support.sas.com/resources/papers/proceedings17/0689-2017.pdf

Alves, E. B., F. B. Figueiredo, M. F. Rocha, M. C. Castro, and G. L. Werneck (2020). Effectiveness of insecticide-impregnated collars for the control of canine visceral leishmaniasis. *Preventive Veterinary Medicine 182*, 105104.

Dinya, E. and N. Solymosi (2016). *Biometria a klinikumban 2. Feladatok megoldása R-környezetben*. Budapest: Medicina.

Dohoo, I., W. Martin, and H. Stryhn (2002). *Veterinary Epidemiologic Research* (2nd ed.). Charlottetown, Prince Edward Island, Canada: VER Inc.

Holtkamp, D. J., P. E. Yeske, D. D. Polson, J. L. Melody, and R. C. Philips (2010). A prospective study evaluating duration of swine breeding herd prrs virus-free status and its relationship with measured risk. *Preventive veterinary medicine 96*(3-4), 186–193.

Lehmen, J. A., R. M. Deering, A. K. Simpson, C. S. Carrier, and C. M. Bono (2014). Inconsistencies between abstracts and manuscripts in published studies about lumbar spine surgery. *Spine 39*(10), 841–845.

Noordhuizen, J. P. T. M., K. Frankena, M. Thrusfield, and E. A. M. Graat (2001). *Application of Quantitative Methods in Veterinary Epidemiology*. Wageningen, The Netherland: Wageningen Pers.

Pfeiffer, D. (2002). Veterinary epidemiology: An introduction. `ww3.panaftosa.org.br/Comp/MAPA/431857.pdf`.

Pfeiffer, D. (2010). *Veterinary Epidemiology: An Introduction*. Oxford, UK: Wiley.

Pondja, A., L. Neves, J. Mlangwa, S. Afonso, J. Fafetine, A. L. Willingham III, S. M. Thamsborg, and M. V. Johansen (2012). Use of oxfendazole to control porcine cysticercosis in a high-endemic area of mozambique. *PLoS neglected tropical diseases 6*(5), e1651.

Smith, R. D. (2005). *Veterinary Clinical Epidemiology: From Patient to Population* (3rd ed.). Boca Raton, Florida, USA: CRC Press.

Thrusfield, M., R. Christley, H. Brown, P. J. Diggle, N. French, K. Howe, L. Kelly, A. O'Connor, J. Sargeant, and H. Wood (2018). *Veterinary Epidemiology* (4th ed.). Oxford, UK: Wiley.

Zöldi, V., T. Papp, J. Reiczigel, and L. Egyed (2015). Bank voles show high seropositivity rates in a natural TBEV focus in Hungary. *Infectious Diseases 47*(3), 178–181.