

CST 310 / SER 417: Population, Space & Environment

# Spatial Approaches in Population Studies: Analytical Methods and Representation Techniques

## Basic Concepts and Measures in Demography Mortality & Life Expectancy

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# Mortality



## Gross Mortality Rate (TBM)

- What is the death risk of a person in a certain year?
  - Relation : total deaths/ total population in a year (j)
  - TBM:

$$TBM = \frac{O_j}{P_j}$$

$P_j$  = Population time j

$O_j$  = n deaths time j

- Which population ?
  - **JAN**: would exclude new births, the weights for survivals can not be the same as the ones that will die;
  - **DEZ**: would exclude people that died along the year; the ones born along the year did not have the same death risk.
  - **IDEAL**: “*person-year*”
    - People presented from the beginning till the end of the year → integral
    - The born/dead along the year → fraction of the year alive

# Mortality



## Gross Mortality Rate (TBM)

Instead of the ideal (person-Year)

- Mid-year Total Population → considering uniformity of births and deaths  
(or any 12 consecutive months)

- n deaths/1000 inhabitants

$$TBM = \frac{O_j}{P_j}$$

- Depends on:
  - Intensity of deaths at each age range
  - different probability / age range → **Population Age Distribution**

# Mortality



## Specific Death Rate (TEM)

- Death risk / age range
- Rate: 
$$\frac{\text{Total of deaths for an specific age range}}{\text{Total population for the specific age rage}}$$

$${}_nTEM_{x,j} = \frac{{}_nO_{x,j}}{{}_nQ_{x,j}}$$

$x$  = lower age limit of the age range;

$n$  = amplitude of the are range;

$j$  = reference year

$Q_{x,j}$  = Population at age range  $x$ , at time  $j$

- TBM & TEM ?  
(Gross and Specific Mortality?)

# Mortality



## Specific Death Rate (TEM)

- Death risk / age range
- Rate: 
$$\frac{\text{Total of deaths for an specific age range}}{\text{Total population for the specific age range}}$$

$${}_nTEM_{x,j} = \frac{{}_nO_{x,j}}{{}_nQ_{x,j}}$$

$x$  = lower age limit of the age range;

$n$  = amplitude of the are range;

$j$  = reference year

$Q_{x,j}$  = Population at age range  $x$ , at time  $j$

- TBM & TEM relation:

$$TBM_j = \sum_x {}_nTEM_{x,j} \frac{{}_nQ_{x,j}}{\sum_x {}_nQ_{x,j}}$$



# Mortality

- Total of Deaths in a year:  $O_j = \sum_x {}_n TEM_{x,j} \cdot {}_n Q_{x,j}$

- TBM:  $TBM_j = \frac{\sum_x {}_n TEM_{x,j} \cdot {}_n Q_{x,j}}{\sum_x {}_n Q_{x,j}}$

- Weighted average of specific mortality / age rates, or:

$$TBM_j = \sum_x {}_n TEM_{x,j} \frac{{}_n Q_{x,j}}{\sum_x {}_n Q_{x,j}}$$

- TBM - depend on the intensity ( ${}_n TEM_{x,j}$ ) and proportional age distribution  
 $({}_n Q_{x,j} / \sum_x {}_n Q_{x,j})$ .

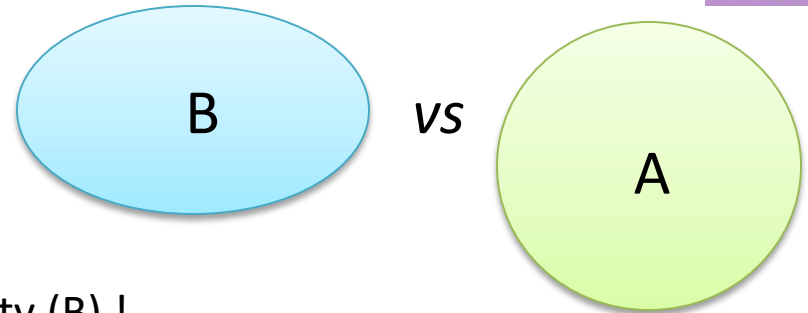
→ Population with similar TEMs can have distinct TBMs, right?



# Mortality



Considering Pop A and Pop B :



If :  $TEM(A) > TEM(B)$  for every age:  
→ then: mortality (A) > mortality (B) !

**HOWEVER....**

depending on proportional population age distributions...  
 $TBM(A)$  can be smaller than  $TBM(B)$  !!!

**CONCLUDING:**

**TBM** - is not a good indicator for analyzing mortality levels among different populations  
(unless age structures are similar)

**Specif Rates** are more adequate for comparisons.

And can be extended to other variables that influence the risk of dying:  
*sex, marital status, causes of death, socioeconomic groups, etc.*

# Mortality



## Infant Mortality Rate (TMI)

- Corresponds to the **risk** of a live-born die before reaching **one year** of age.  
(Includes the idea of a Probability )

Children born in an year (***j***), will only complete one year of age in the following year, (***j + 1***)

$$TMI^{(nj)} = \frac{{}_1O_{o,j}^{(nj)} + {}_1O_{o,j+1}^{(nj)}}{N_j}$$

N = n of live-born;

${}_1O_o^{(nj)}$  = deaths of children younger than 1 year, born in time *j*;

*j* , *j + 1* = observation years

→ Infant mortality (in a calendar year) will occur along two consecutive years, ***j*** and ***j + 1***.

→ It would take 2 years to calculate the TMI of the live births of ***j*** !!!!



# Mortality



## Infant Mortality Rate (TMI)

- Corresponds to the **risk** of a live-born die before reaching **one year** of age.
- Subject to **underregistration**, depending on the quality of the vital statistics system in the region in question, → corrections may be required to have a more reliable indicator
- It can be taken as a measure of probability.

$$\text{TMI} \Leftrightarrow {}_0\text{TEM}.$$

- Differences in Denominator:
  - TMI = live-born along one year
  - ${}_0\text{TEM}$  = Population younger than 1 year old, in mid-year

# Mortality



## Infant Mortality Rate (TMI)

Numerator = children < 1y

- unequal distribution of deaths in this interval:

### Situations:

Pop with low infant mortality & deaths **concentrated** in the first weeks of life

- due to genetic causes and / or related to childbirth

Pop with high infant mortality & deaths **less** concentrated in the first weeks of life

- linked to environmental conditions such as sanitation, nutrition, etc.



To Differentiate them.....

# Mortality



## Infant Mortality Rate (TMI)

## Neonatal Mortality Rate (TMN)

Ratio between:

deaths occurring within the first 4 weeks of life  
(less than 28 days of age)

number of births



## Postnatal Mortality Rate (TMPN)

Ratio between:

deaths of children from 28 days to one year of life  
number of births



# Mortality

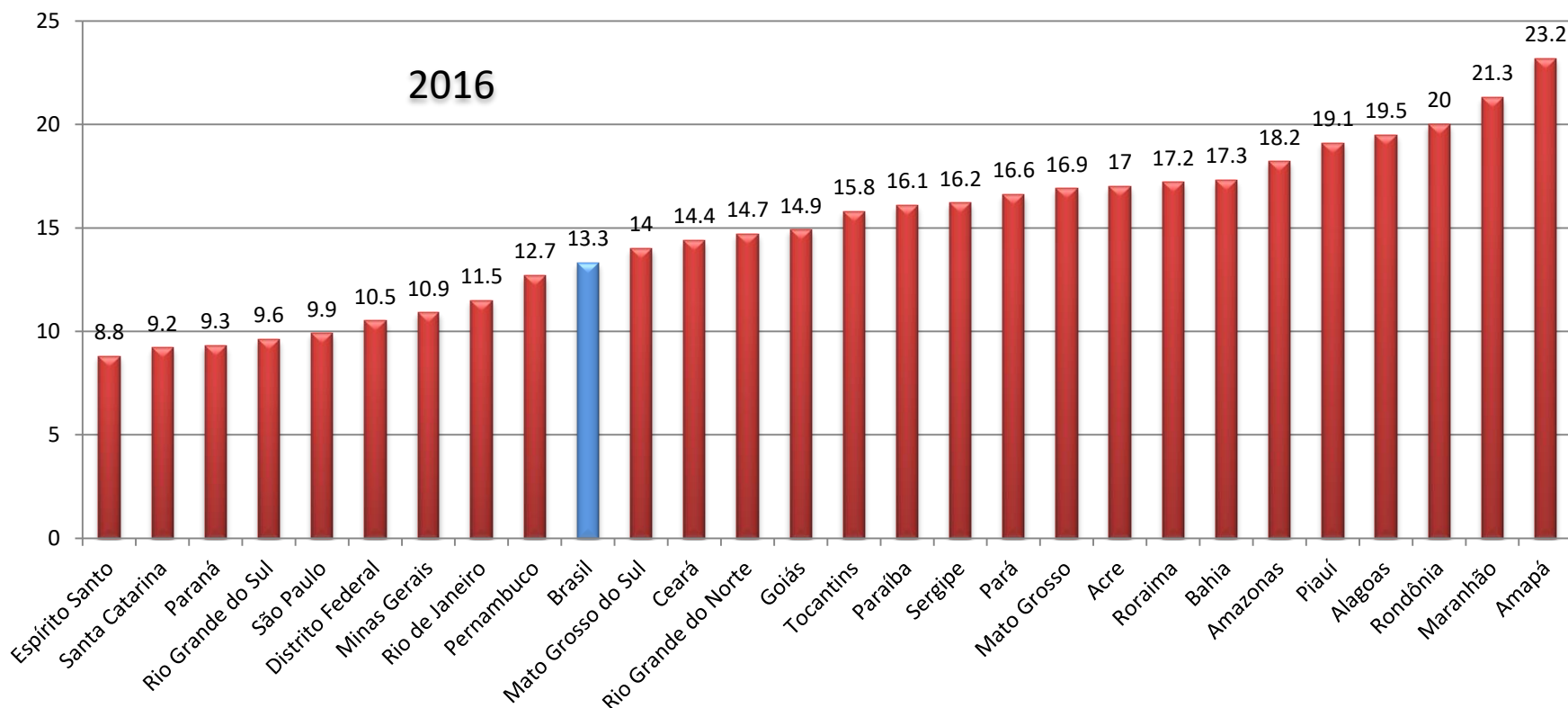
## Infant Mortality Rate (TMI)

Infant Mortality in Brazil - 2000 - 29.0 deaths/1000 live births

2013 - 15.0 deaths/1000 live births, (-48.2%)

2016 - 13.3

(2013) Regional inequalities: NE (19.4), N (19.2) and CO (15.6); SE(11.6) and S (10.4);  
extreme values: Maranhão (24.7) and Santa Catarina (10.1)



# Mortality



## Life expectancy at a given age(x) -> $e^0_x$

Indicator that is a summary measure

It is not affected by the age structure of the population (TBM x TEM remember ??)

- average number of years that an individual will live from that age;
- considering the *level* and *structure* of mortality *by age* observed in that population.

$e^0_x = 50 \rightarrow$  You will survive 50y, in average !?  
(if mortality / age range were maintained)

Calculates from a life-table survival

(tabela de sobrevivência; tábua de mortalidade; tábua de vida)

( )

Coorte = a group of people who have in common an event that occurred in the same period.

Ex: cohort of people born in the 2002 World Cup, cohort of people who entered the first series in 2001, cohort of married people who entered at PGINPE in 2018.

Stationary Population = population in each unit of time, n of births = n of deaths

# Mortality



Life expectancy at a given age(x)  $\rightarrow e^0_x$

- To get  $e^0_x$ 
  - Take a **coorte** of birth in a specific **year**;
  - **Follow** it till the extinguishment, taking note of the **time living** for each person;
  - Calculate the **average life time** of individuals in the coorte

This is a survival table of a cohort or actual generation  $\rightarrow$  need long series of good quality death statistics (European populations).

Usual:

- to submit hypothetical cohort of newborns to the experience of mortality;
- (TEMs) from a real pop of the year and follow it until the death of the last individual.

Or

consider a stationary population

# Mortality



Life expectancy at a given age(x)  $\rightarrow e^0_x$

- To get  $e^0_x$   
submit hypothetical cohort of newborns to experience mortality OR  
consider a stationary population.

From Survival Tables, or LIFE Table:

life expectancies are obtained, which allow **comparisons of mortality** levels among different populations.

Life expectancy at  $e^0_x$  (unlike TBM):

**do not depend on the age structure** of the actual populations under study, but only on their mortality.



# Mortality

TABELA DE SOBREVIVÊNCIA FEMININA  
DA REGIÃO METROPOLITANA DE BELO HORIZONTE, 1983

## Life Table

**n** = amplitude of the class interval

**$nq_x$**  = Death's Probability of **l** of age **x** die before completing **x + n**

Probability of death of the **l** of age **x** die before completing **x + n**

What is the probability that a 10-year-old woman die before she is 15?

R: 0.00195

Idade	n	$nq_x$	$l_x$	$d_x$	$nL_x$	$T_x$	$e_x^o$	$nP_{x:x+n}$
0	1	0,04582	100000	4582	96304	7111154	71,11	0,98746
1	4	0,00673	95418	642	380388	7014850	73,54	0,98746
5	5	0,00285	94776	270	473205	6634815	70,01	0,99520
10	5	0,00195	94506	184	472070	6161610	65,20	0,99740
15	5	0,00324	94322	306	470845	5689540	60,32	0,99621
20	5	0,00434	94016	408	469060	5218695	55,51	0,99494
25	5	0,00578	93608	541	466688	4749635	50,74	0,99207
30	5	0,01010	93067	940	462985	4282947	46,02	0,98936
35	5	0,01119	92127	1031	458058	3819962	41,46	0,98521
40	5	0,01843	91096	1679	451283	3361904	36,91	0,97745
45	5	0,02674	89417	2391	441108	2910621	32,55	0,97017
50	5	0,03300	87026	2872	427950	2469513	28,38	0,95992
55	5	0,04740	84154	3989	410798	2041563	24,26	0,93752
60	5	0,07831	80165	6278	385130	1630765	20,34	0,89555
65	5	0,13280	73887	9812	344905	1245635	16,86	0,86432
70	5	0,13901	64075	8907	298107	900730	14,06	0,84248
75	5	0,17901	55168	9876	251150	6026237	10,92	-
80	$\omega$	1,00000	45292	45292	351473	351473	0,76	-

$${}_5P_{75,75+\omega} = 0,39021$$

$$qx = dx / lx$$

N deaths x/pop age x

Fonte: RODRIGUES, R. N. "Vida Severina", healthy family?: morbidity and mortality in two metropolitan regions of Brazil. Camberra, 1989. Tese (Doutorado) Austrian National University.  
Nota:  $\omega$  significa que se trata de intervalo aberto.

# Mortality

## Life Table

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# Mortality

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DA REGIÃO METROPOLITANA DE BELO HORIZONTE, 1983

## Life Table

$l_x$  = survivals

$l_x$  = Hypothetical Cohort

Number of survivors at the age  $x$ ,  
from an initial cohort (10 =  
100,000 births), depending on  
 $nq_x$  of the table.

How many women from the initial  
cohort (of 100,000 women)  
will survive (with this life table)  
at the age of 10 years ?

R: 94,506

$l_x$  = Stationary Population:

N of people reaching age  $x$  every  
year

How many women complete 50y  
each year ?

R: 87,026

Idade	n	$nq_x$	$l_x$	$d_x$	$nL_x$	$T_x$	$e_x^o$	$nP_{x \rightarrow x+n}$
0	1	0,04582	100000	4582	96304	7111154	71,11	0,98746
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# Mortality

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DA REGIÃO METROPOLITANA DE BELO HORIZONTE, 1983

## Life Table

$d = n$  deaths

${}_n d_x =$  Hypothetical Cohort

Number of deaths between the ages  $x$  and  $x + n$  of survivors of the cohort of age  $x$ .

How many surviving women of the age of 15 will die before their 20th birthday

R: 306

${}_n d_x =$  Stationary Population:

N of deaths that occurs every year from people between age  $x$  and  $x + n$ .

How many women between the ages of 40 and 45 die each year ?

R: 1,679

Idade	$n$	${}_n q_x$	$l_x$	$d_x$	${}_n L_x$	$T_x$	$e_x^o$	${}_n P_{x:x+n}$
0	1	0,04582	100000	4582	96304	7111154	71,11	0,98746
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# Mortality

TABELA DE SOBREVIVÊNCIA FEMININA  
DA REGIÃO METROPOLITANA DE BELO HORIZONTE, 1983

## Life Table

$L$  = "age-time"

${}_nL_x$  = Hypothetical Cohort

Time to be lived by the cohort survivors at age  $x$ , between this age and the beginning of the next age group. It is the number of **person-years** between the ages  $x$  and  $x + n$

Survivors aged 15 years together will live 470,845 years in the next 5 years

${}_nL_x$  = Stationary Population :

N of persons with age  $x$  to  $x + n$  or the population of the age group at which time

At any time, the number of women aged 40 to 45 years is 451,283

Idade	n	${}_nq_x$	$l_x$	$d_x$	${}_nL_x$	$T_x$	$e_x^o$	${}_nP_{x \times x+n}$
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Nota:  $\omega$  significa que se trata de intervalo aberto.



# Mortality

TABELA DE SOBREVIVÊNCIA FEMININA  
DA REGIÃO METROPOLITANA DE BELO HORIZONTE, 1983

## Life Table

$L$  = "age-time"

$${}_nL_x = n(l_{x+n} + {}_na_x * {}_nd_x)$$

In this case:  ${}_na_x = 0.5$  for  $x \geq 4 \dots$

$${}_5L_{15} = 5 (94016 + 0.5 * 306)$$

$${}_nL_x = n(l_{x+n} + {}_na_x * {}_nd_x)$$

For  $x < 5$ ,  ${}_na_x$  varies according to the level of mortality.

- ${}_1a_0$  in populations with low mortality, as in the example, is estimated as 0.10. In underdeveloped populations  ${}_1a_0$  can increase up to 0.3;
- ${}_4a_1$ , generally estimated = 0.40.
- For Brazilian data from the 1990s, it is reasonable to use  ${}_1a_0 = 0.2$
- In this example:  ${}_1a_0 = 0.19336$

Idade	n	${}_nq_x$	$l_x$	$d_x$	${}_nL_x$	$T_x$	$e_x^o$	${}_nP_{x \geq x+n}$
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Nota:  $\omega$  significa que se trata de intervalo aberto.

# Mortality

## Life Table

T = "age-time to the end"

$$T_x = \sum_{a=x}^{w-1} L_a$$

$$T_x = T_{x+n} + {}_nL_x$$

$T_x$  = Hypothetical Cohort

Time to be lived from the age cohort x until this cohort is extinguished.

Survivors of the age of 15 years together will live 5,689,540 years until the last one has died

$I_x$  = Stationary Population :

N of people of age x or more.

At any time, the number of women over 40 is 3,361,904

TABELA DE SOBREVIVÊNCIA FEMININA  
DA REGIÃO METROPOLITANA DE BELO HORIZONTE, 1983

Idade	n	${}_nq_x$	$l_x$	$d_x$	${}_nL_x$	$T_x$	$e_x^o$	${}_nP_{x \times x+n}$
0	1	0,04582	100000	4582	96304	7111154	71,11	0,98746
1	4	0,00673	95418	642	380388	7014850	73,54	0,98746
5	5	0,00285	94776	270	473205	6634815	70,01	0,99520
10	5	0,00195	94506	184	472070	6161610	65,20	0,99740
15	5	0,00324	94322	306	470845	5689540	60,32	0,99621
20	5	0,00434	94016	408	469060	5218695	55,51	0,99494
25	5	0,00578	93608	541	466688	4749635	50,74	0,99207
30	5	0,01010	63067	940	462985	4282947	46,02	0,98936
35	5	0,01119	92127	1031	458058	3819962	41,46	0,98521
40	5	0,01843	91096	1679	451283	3361904	36,91	0,97745
45	5	0,02674	89417	2391	441108	2910621	32,55	0,97017
50	5	0,03300	87026	2872	427950	2469513	28,38	0,95992
55	5	0,04740	84154	3989	410798	2041563	24,26	0,93752
60	5	0,07831	80165	6278	385130	1630765	20,34	0,89555
65	5	0,13280	73887	9812	344905	1245635	16,86	0,86432
70	5	0,13901	64075	8907	298107	900730	14,06	0,84248
75	5	0,17901	55168	9876	251150	6026237	10,92	-
80	$\omega$	1,00000	45292	45292	351473	351473	0,76	-

$${}_5P_{75,75+\omega} = 0,39021$$

Fonte: RODRIGUES, R. N. "Vida Severina", healthy family?: morbidity and mortality in two metropolitan regions of Brazil. Camberra, 1989. Tese (Doutorado) Austrian National University.

Nota:  $\omega$  significa que se trata de intervalo aberto.



# Mortality

## Life Table

$e_x^0$  = is the life expectancy.

Average number of years of life expected from age x.

$$e_x^0 = T_x / l_x$$

The life expectancy of 15-year-old women is **60.32 years**

The life expectancy of 40-year-old women is **36.91 years**.

TABELA DE SOBREVIVÊNCIA FEMININA  
DA REGIÃO METROPOLITANA DE BELO HORIZONTE, 1983

Idade	n	$nq_x$	$l_x$	$d_x$	$nL_x$	$T_x$	$e_x^0$	${}_nP_{x \rightarrow x+n}$
0	1	0,04582	100000	4582	96304	7111154	71,11	0,98746
1	4	0,00673	95418	642	380388	7014850	73,54	0,98746
5	5	0,00285	94776	270	473205	6634815	70,01	0,99520
10	5	0,00195	94506	184	472070	6161610	65,20	0,99740
15	5	0,00324	94322	306	470845	5689540	60,32	0,99621
20	5	0,00434	94016	408	469060	5218695	55,51	0,99494
25	5	0,00578	93608	541	466688	4749635	50,74	0,99207
30	5	0,01010	93067	940	462985	4282947	46,02	0,98936
35	5	0,01119	92127	1031	458058	3819962	41,46	0,98521
40	5	0,01843	91096	1679	451283	3361904	36,91	0,97745
45	5	0,02674	89417	2391	441108	2910621	32,55	0,97017
50	5	0,03300	87026	2872	427950	2469513	28,38	0,95992
55	5	0,04740	84154	3989	410798	2041563	24,26	0,93752
60	5	0,07831	80165	6278	385130	1630765	20,34	0,89555
65	5	0,13280	73887	9812	344905	1245635	16,86	0,86432
70	5	0,13901	64075	8907	298107	900730	14,06	0,84248
75	5	0,17901	55168	9876	251150	6026237	10,92	-
80	$\omega$	1,00000	45292	45292	351473	351473	0,76	-

$${}_5P_{75,75+\omega} = 0,39021$$

Fonte: RODRIGUES, R. N. "Vida Severina", healthy family?: morbidity and mortality in two metropolitan regions of Brazil. Camberra, 1989. Tese (Doutorado) Austrian National University.  
Nota:  $\omega$  significa que se trata de intervalo aberto.

# Mortality

## Life Table

${}_n\mathbf{P}_{x+n}$  = Proportion of a certain age group that will survive n years (Survival Rate)

$${}_n\mathbf{P}_{x+n} = {}_n\mathbf{L}_{x+n} / {}_n\mathbf{L}_x$$

Or

Average probability of people in group x to x + n surviving for n more years

The average Prob of a woman between 15 and 20 years to survive from 1985 to 1988 is 0.99621

The average P of a woman between 40 and 45 years surviving from 1985 to 1988 is 0.97745

**(Based on mortality level in BH – 1983)**

TABELA DE SOBREVIVÊNCIA FEMININA  
DA REGIÃO METROPOLITANA DE BELO HORIZONTE, 1983

Idade	n	${}_nq_x$	$l_x$	$d_x$	${}_nL_x$	$T_x$	$e_x^o$	${}_n\mathbf{P}_{x+x+n}$
0	1	0,04582	100000	4582	96304	7111154	71,11	0,98746
1	4	0,00673	95418	642	380388	7014850	73,54	0,98746
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20	5	0,00434	94016	408	469060	5218695	55,51	0,99494
25	5	0,00578	93608	541	466688	4749635	50,74	0,99207
30	5	0,01010	63067	940	462985	4282947	46,02	0,98936
35	5	0,01119	92127	1031	458058	3819962	41,46	0,98521
40	5	0,01843	91096	1679	451283	3361904	36,91	0,97745
45	5	0,02674	89417	2391	441108	2910621	32,55	0,97017
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55	5	0,04740	84154	3989	410798	2041563	24,26	0,93752
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70	5	0,13901	64075	8907	298107	900730	14,06	0,84248
75	5	0,17901	55168	9876	251150	6026237	10,92	-
80	$\omega$	1,00000	45292	45292	351473	351473	0,76	-

$${}_5\mathbf{P}_{75,75+\omega} = 0,39021$$

Fonte: RODRIGUES, R. N. "Vida Severina", healthy family?: morbidity and mortality in two metropolitan regions of Brazil. Camberra, 1989. Tese (Doutorado) Austrian National University.  
Nota:  $\omega$  significa que se trata de intervalo aberto.

# Mortality Table projected for 2016


**Mortality Table projected for 2016 – reference July 1, 2015** comes from a projection of mortality from the mortality table built for the year 2010, + data population of the Demographic Census 2010, estimates based on the same census survey and notifications and official records of deaths by sex and age.

## Results:

Life expectancy of **75.8** years for the total population by 2016

- increase of 3 months and 11 days to the estimated for 2015 (75.5 years).

 Male population = 72.2 years  
increase of 3 months and 18 days to the estimated for 2015 (71.9 years).

 Female population = 79.4 years  
increase of 3 months and 7 days to the estimated for 2015 (79.1 years).

## BRASIL: Tábua Completa de Mortalidade - Mulheres - 2016

Idades Exatas (X)	Probabilidades de Morte entre Duas Idades Exatas Q (X, N) (Por Mil)	Óbitos D (X, N)	l ( X )	L (X, N)	T(X)	(Continua)	
						Expectativa de Vida à Idade X E(X)	
0	12.183	1218	100000	98887	7936893	79.4	
1	0.792	78	98782	98743	7838006	79.3	
2	0.496	49	98703	98679	7739263	78.4	
3	0.371	37	98655	98636	7640584	77.4	
4	0.300	30	98618	98603	7541948	76.5	
5	0.254	25	98588	98576	7443345	75.5	
6	0.223	22	98563	98552	7344769	74.5	
7	0.202	20	98541	98531	7246217	73.5	
8	0.188	19	98521	98512	7147686	72.5	
9	0.182	18	98503	98494	7049174	71.6	
10	0.183	18	98485	98476	6950680	70.6	
11	0.195	19	98467	98457	6852204	69.6	
12	0.230	23	98448	98436	6753747	68.6	
13	0.274	27	98425	98412	6655310	67.6	
14	0.318	31	98398	98382	6556899	66.6	
15	0.362	36	98367	98349	6458516	65.7	
16	0.413	41	98331	98311	6360167	64.7	
17	0.454	45	98291	98268	6261857	63.7	
18	0.479	47	98246	98222	6163588	62.7	
19	0.491	48	98199	98175	6065366	61.8	
20	0.503	49	98151	98126	5967191	60.8	
21	0.518	51	98101	98076	5869065	59.8	
22	0.536	53	98050	98024	5770989	58.9	
23	0.558	55	97998	97970	5672965	57.9	
24	0.584	57	97943	97915	5574995	56.9	
25	0.611	60	97886	97856	5477080	56.0	
26	0.640	63	97826	97795	5379224	55.0	
27	0.674	66	97763	97730	5281430	54.0	
28	0.714	70	97698	97663	5183699	53.1	
29	0.759	74	97628	97591	5086036	52.1	
30	0.810	79	97554	97514	4988446	51.1	
31	0.865	84	97475	97433	4890931	50.2	
32	0.920	90	97390	97346	4793499	49.2	
33	0.974	95	97301	97253	4696153	48.3	
34	1.029	100	97206	97156	4598900	47.3	
35	1.091	106	97106	97053	4501744	46.4	
36	1.164	113	97000	96944	4404691	45.4	
37	1.247	121	96887	96827	4307747	44.5	
38	1.343	130	96766	96701	4210921	43.5	

47	2.910	277	95105	94966	3346566	35.2
48	3.150	299	94828	94678	3251600	34.3
49	3.398	321	94529	94368	3156921	33.4
50	3.667	345	94208	94035	3062553	32.5
51	3.959	372	93862	93677	2968518	31.6
52	4.270	399	93491	93291	2874841	30.8
53	4.601	428	93091	92877	2781550	29.9
54	4.956	459	92663	92433	2688673	29.0
55	5.347	493	92204	91957	2596240	28.2
56	5.774	530	91711	91446	2504282	27.3
57	6.234	568	91181	90897	2412836	26.5
58	6.729	610	90613	90308	2321939	25.6
59	7.268	654	90003	89676	2231631	24.8
60	7.860	702	89349	88998	2141955	24.0
61	8.518	755	88647	88269	2052957	23.2
62	9.256	814	87892	87485	1964688	22.4
63	10.087	878	87078	86639	1877203	21.6
64	11.015	949	86200	85725	1790565	20.8
65	12.027	1025	85250	84738	1704840	20.0
66	13.139	1107	84225	83672	1620102	19.2
67	14.386	1196	83118	82520	1536431	18.5
68	15.789	1293	81922	81276	1453910	17.7
69	17.349	1399	80629	79930	1372634	17.0
70	19.036	1508	79230	78476	1292705	16.3
71	20.866	1622	77722	76911	1214229	15.6
72	22.900	1743	76100	75229	1137318	14.9
73	25.170	1872	74358	73422	1062089	14.3
74	27.679	2006	72486	71483	988667	13.6
75	30.375	2141	70480	69409	917184	13.0
76	33.280	2274	68339	67202	847775	12.4
77	36.494	2411	66065	64859	780573	11.8
78	40.076	2551	63654	62378	715714	11.2
79	44.031	2690	61103	59757	653336	10.7
80 ou mais	1000.000	58412	58412	593578	593578	10.2

Fonte: IBGE, Diretoria de Pesquisas (DPE), Coordenação de População e Indicadores Sociais (COPIS).

Notas:

N = 1

Q(X, N) = Probabilidades de morte entre as idades exatas X e X+N.

l(X) = Número de sobreviventes à idade exata X.

D(X, N) = Número de óbitos ocorridos entre as idades X e X+N.

L(X, N) = Número de pessoas-anos vividos entre as idades X e X+N.

T(X) = Número de pessoas-anos vividos a partir da idade X.

E(X) = Expectativa de vida à idade X.

**Tabela 1 - Taxa de mortalidade infantil (por mil), taxa de mortalidade no grupo de 1 a 4 anos de idade (por mil) e taxa de mortalidade na infância (por mil) - Brasil - 1940/2016**

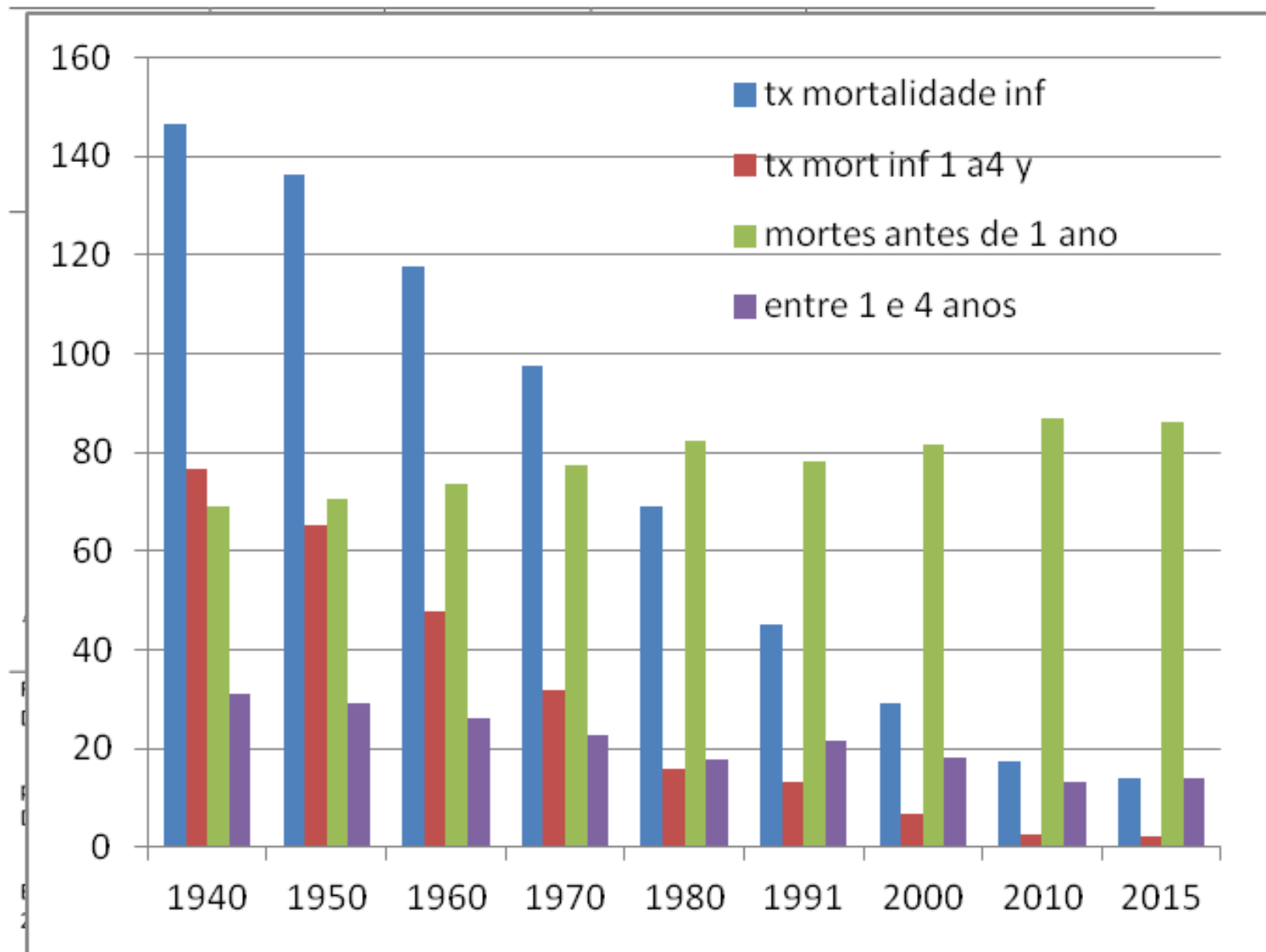
Ano	Taxa de mortalidade infantil (por mil)	Taxa de mortalidade no grupo de 1 a 4 anos de idade (por mil)	Taxa de mortalidade na infância (por mil)	Das crianças que vieram a falecer antes dos 5 anos a chance de falecer (%)	
				Antes de 1 ano	Entre 1 a 4 anos
1940	146,6	76,7	212,1	69,1	30,9
1950	136,2	65,4	192,7	70,7	29,3
1960	117,7	47,6	159,6	73,7	26,3
1970	97,6	31,7	126,2	77,3	22,7
1980	69,1	16,0	84,0	82,3	17,7
1991	45,1	13,1	57,6	78,3	21,7
2000	29,0	6,7	35,5	81,7	18,3
2010	17,2	2,6	19,8	86,9	13,1
2016	13,3	2,2	15,5	85,8	14,2
$\Delta\%$ (1940/2016)	-90,9	-97,1	-92,7		
$\Delta$ (1940/2016)	-133,3	-74,4	-196,6		

Fontes: 1940,1950,1960 e 1970 - Tábuas construídas no âmbito da Gerência de Estudos e Análises da Dinâmica Demográfica.

1980 e 1991 - ALBUQUERQUE, Fernando Roberto P. de C. e SENNA, Janaina R. Xavier "Tábuas de Mortalidade por Sexo e Grupos de Idade - Grandes e Unidades da Federação – 1980, 1991 e 2000. Textos para discussão, Diretoria de Pesquisas, IBGE, Rio de Janeiro, 2005.161p. ISSN 1518-675X ; n. 20

2000 em diante - IBGE/Diretoria de Pesquisas. Coordenação de População e Indicadores Sociais. Gerência de Estudos e Análises da Dinâmica Demográfica. Projeção da população do Brasil por sexo e idade para o período 2000-2060.

Tabela 1 - Taxa de mortalidade infantil (por mil), taxa de mortalidade no grupo de 1 a 4 anos de idade (por mil) e taxa de mortalidade na infância (por mil) - Brasil - 1940/2015





**Tabela 3 - Expectativas de vida em idades exatas, variação em ano do período e tempo médio de vida - Brasil - 1940/2016**

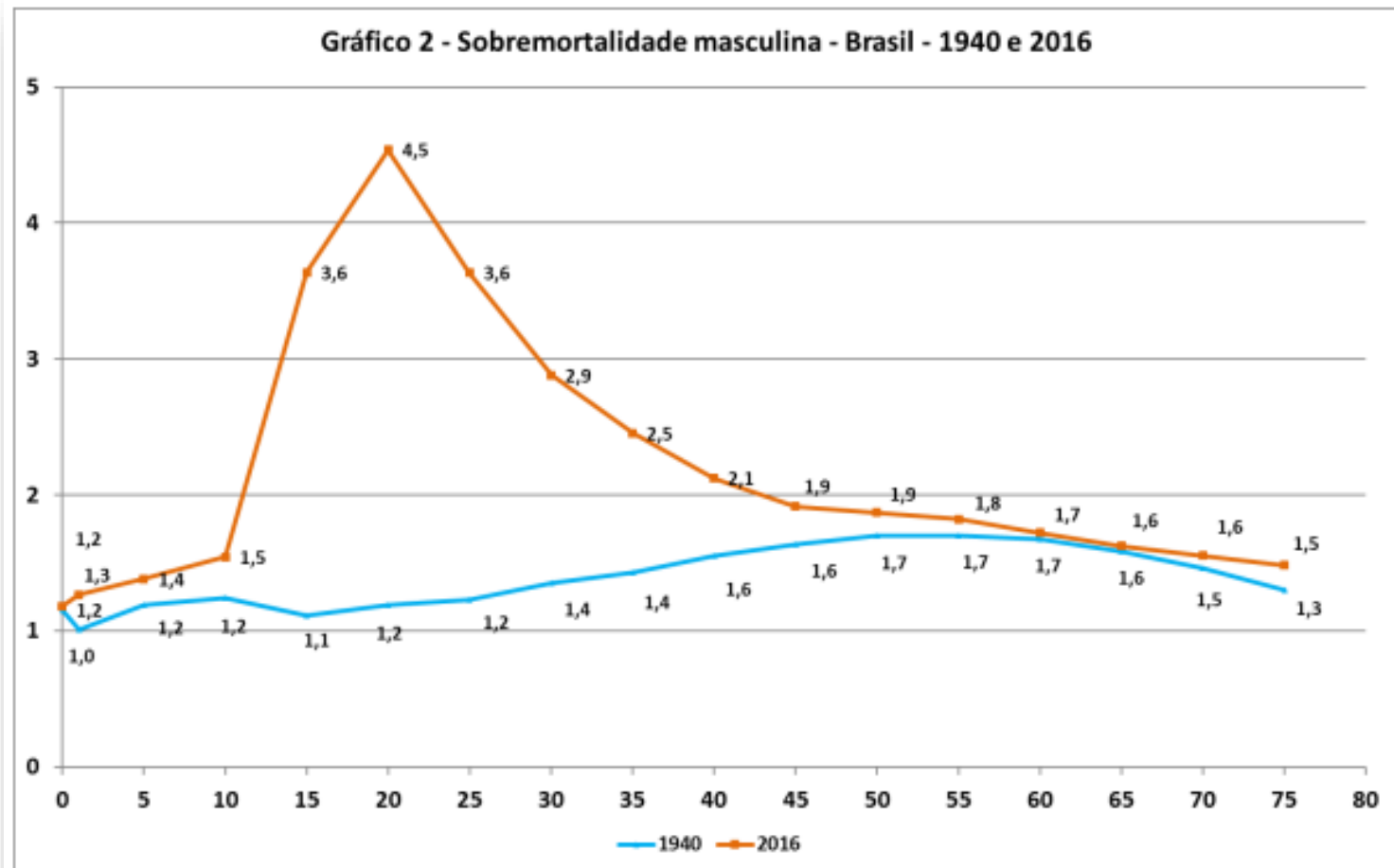
Idade	Expectativas de Vida						Variação (em anos ) 1940/2016			Tempo Médio de Vida - Ambos os Sexos	
	1940			2016			Total	Homem	Mulher	1940	2016
	Total	Homem	Mulher	Total	Homem	Mulher					
0	45,5	42,9	48,3	75,8	72,2	79,4	30,3	29,4	31,1	45,5	75,8
1	52,2	49,7	54,9	75,8	72,3	79,3	23,6	22,6	24,5	53,2	76,8
5	52,5	49,7	55,3	72,0	68,5	75,5	19,5	18,8	20,2	57,5	77,0
10	48,3	45,5	51,1	67,0	63,6	70,6	18,8	18,0	19,5	58,3	77,0
15	43,8	41,1	46,6	62,1	58,7	65,7	18,4	17,6	19,1	58,8	77,1
20	39,6	36,9	42,5	57,5	54,1	60,8	17,8	17,2	18,3	59,6	77,5
25	36,0	33,3	38,8	52,9	49,8	56,0	16,9	16,5	17,2	61,0	77,9
30	32,4	29,7	35,2	48,3	45,3	51,1	15,8	15,6	16,0	62,4	78,3
35	29,0	26,3	31,6	43,7	40,9	46,4	14,7	14,6	14,8	64,0	78,7
40	25,5	23,0	28,0	39,1	36,5	41,6	13,6	13,5	13,6	65,5	79,1
45	22,3	19,9	24,5	34,7	32,2	37,0	12,4	12,3	12,5	67,3	79,7
50	19,1	16,9	21,0	30,3	28,0	32,5	11,3	11,1	11,5	69,1	80,3
55	16,0	14,1	17,7	26,2	24,1	28,2	10,2	9,9	10,5	71,0	81,2
60	13,2	11,6	14,5	22,3	20,3	24,0	9,1	8,7	9,5	73,2	82,3
65	10,6	9,3	11,5	18,5	16,8	20,0	8,0	7,5	8,5	75,6	83,5
70	8,1	7,2	8,7	15,1	13,6	16,3	7,0	6,4	7,6	78,1	85,1
75	6,0	5,4	6,3	12,1	10,8	13,0	6,1	5,4	6,7	81,0	87,1
80 anos ou +	4,3	4,0	4,5	9,5	8,5	10,2	5,2	4,4	5,7		

Fontes: 1940 - Tábuas construídas no âmbito da Gerência de Estudos e Análises da Dinâmica Demográfica.

2016 - IBGE/Diretoria de Pesquisas. Coordenação de População e Indicadores Sociais. Gerência de Estudos e Análises da Dinâmica Demográfica. Projeção da população do Brasil por sexo e idade para o período 2000-2060.



# Male over-mortality

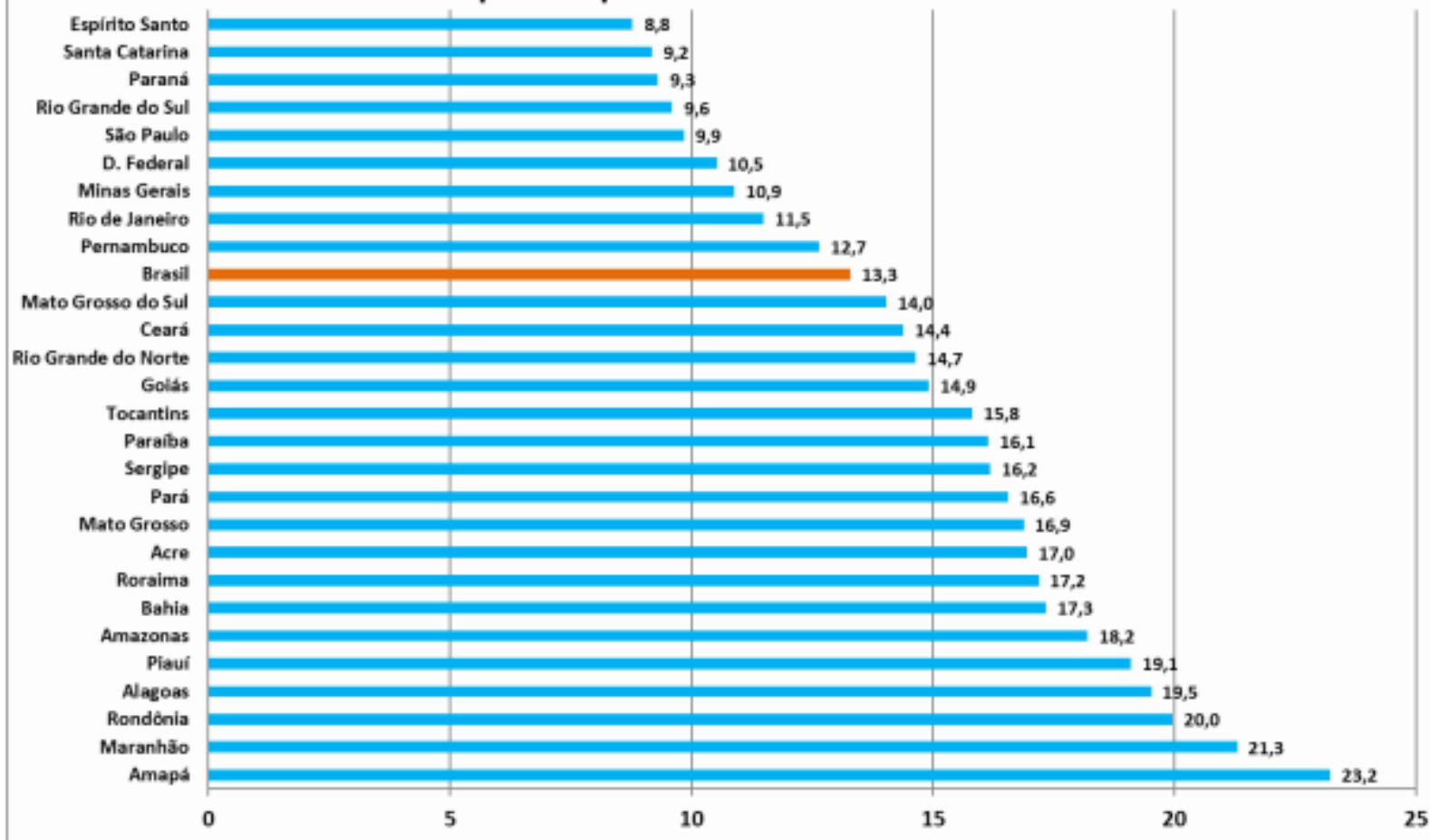


Fonte: Tábua Construída para 1940 e Tábua completa de mortalidade 2016.

**Male over-mortality:** It is the quotient of the central rate of male mortality by the female in each age range ( $x, x + n$ ). Provides the number of times a man of age  $x$  has a **chance of not reaching** the age  $x + n$ , than a woman.

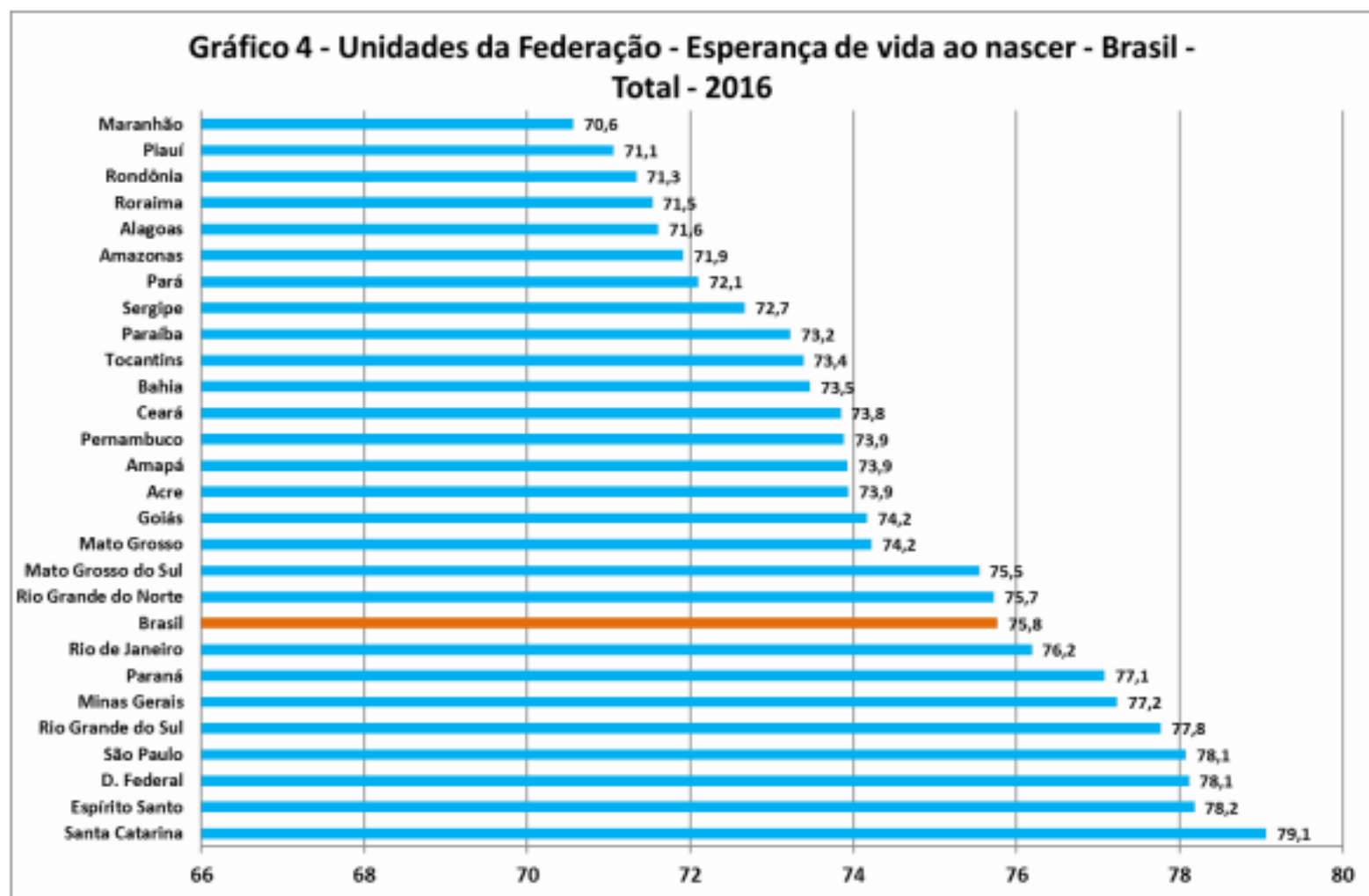
# Infant Mortality (‰) / UF

**Gráfico 3 - Unidades da Federação - Probabilidade (‰) de um recém nascido não completar o primeiro ano de vida - Total - 2016**



Fonte: Projeção da população do Brasil e Unidades da Federação por sexo e idade para o período 2000-2030.

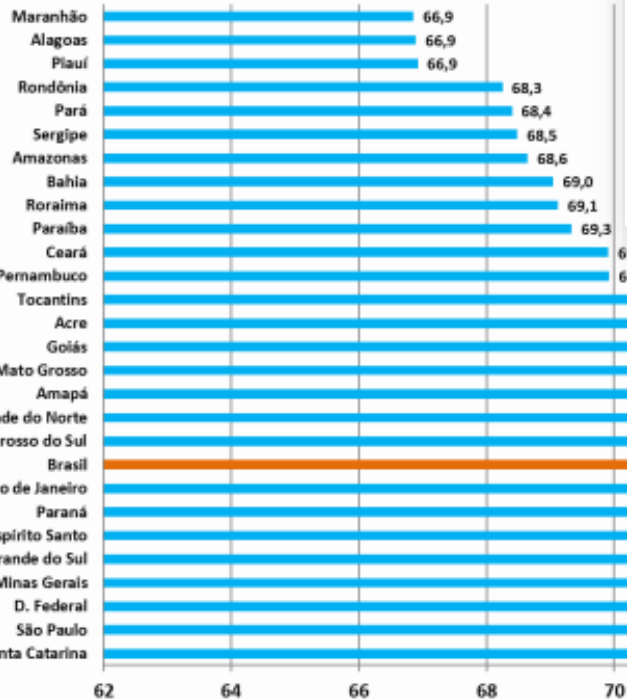
# Life Expectancy / UF



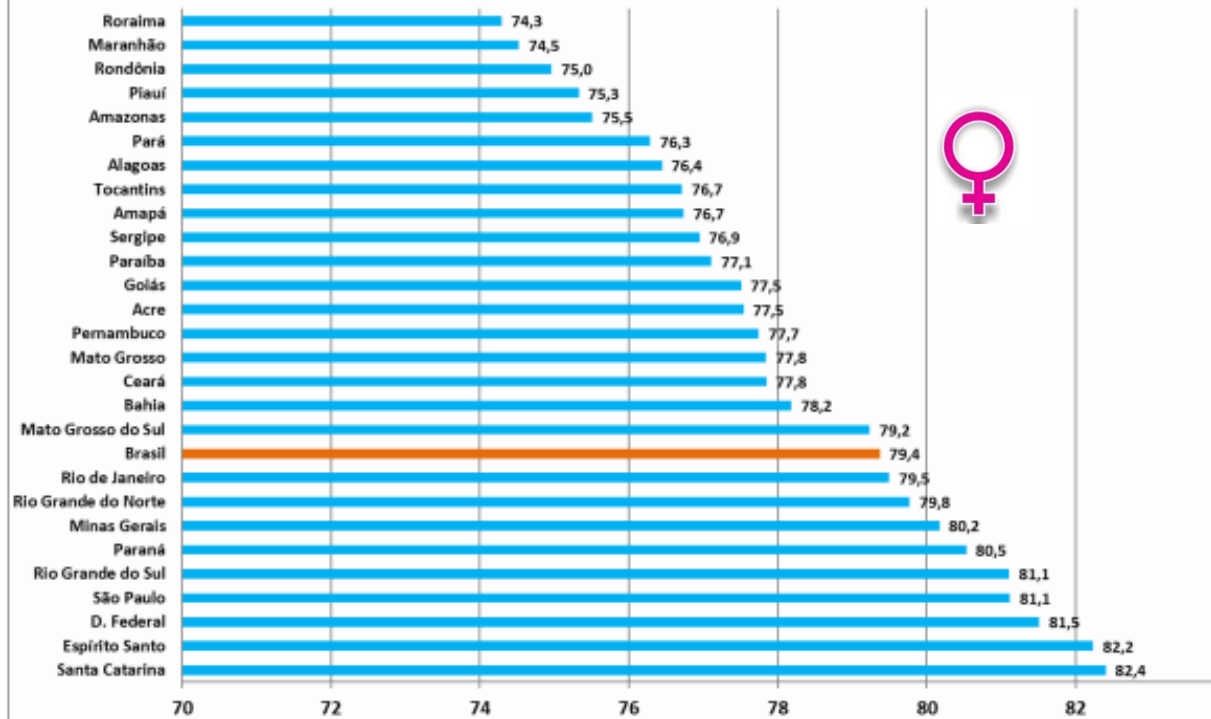
Fonte: Projeção da população do Brasil e Unidades da Federação por sexo e idade para o período 2000-2030.

# Life Expectancy / UF

**Gráfico 5 - Unidades da Federação - Esperança de vida ao nascer - Homens - 2016**



**Gráfico 6 - Unidades da Federação - Esperança de vida ao nascer - Brasil - Mulheres - 2016**



Fonte: Projeção da população do Brasil e Unidades da Federação por sexo e idade para o período 2000-2030.

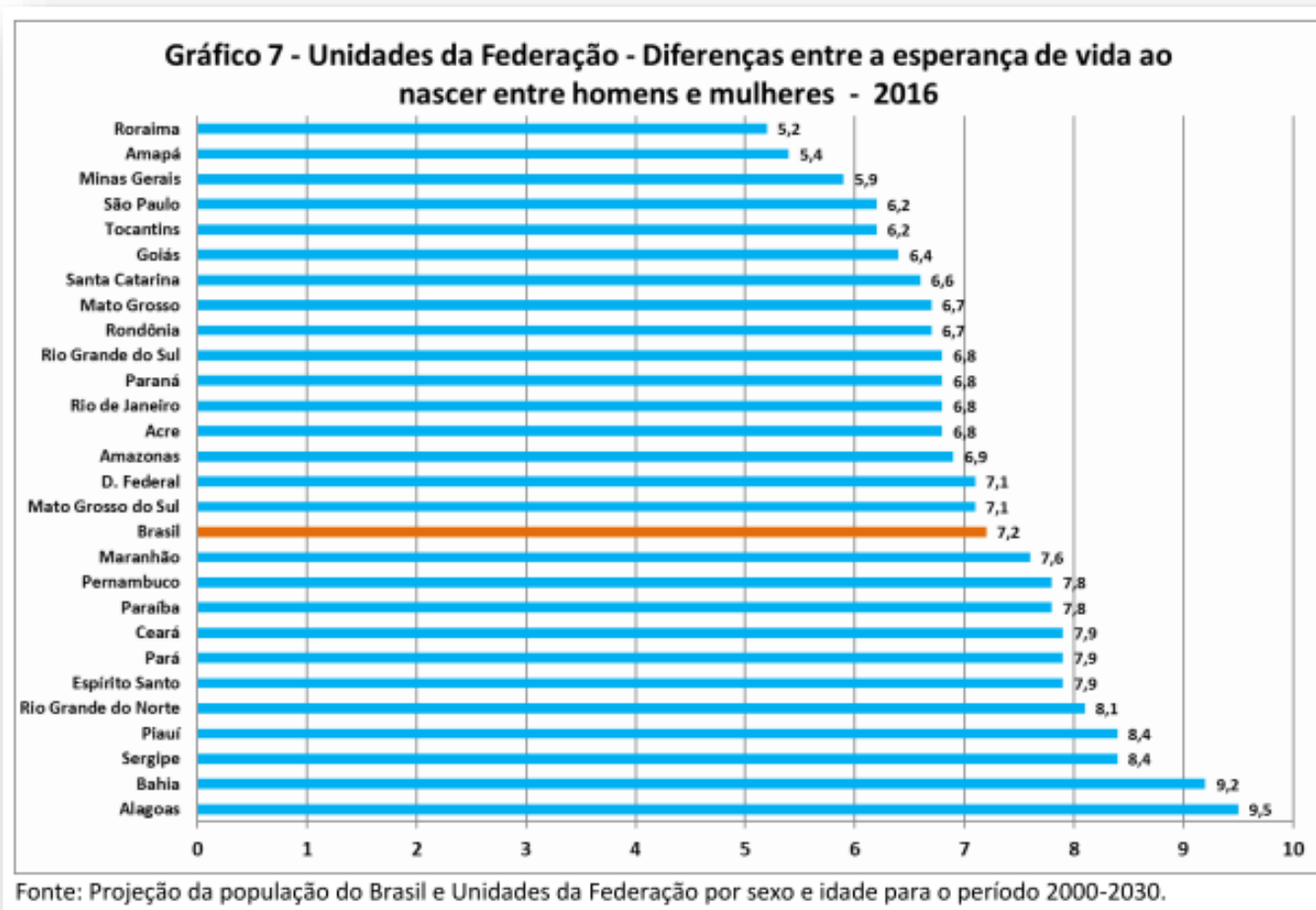
Os maiores diferenciais de mortalidade por sexo refletem os altos níveis de mortalidade de jovens e adultos jovens por causas violentas, que incidem diretamente nas magnitudes das esperanças de vida ao nascer da população masculina. A maior diferença entre as expectativas de vida de homens e mulheres foi no Estado de Alagoas, 9,5 anos a favor das mulheres, seguido da Bahia, 9,2 anos e Sergipe, 8,4 anos (Gráfico 7).

Fonte: Projeção da população do Brasil e Unidades da Federação por sexo e idade para o período 2000-2030.

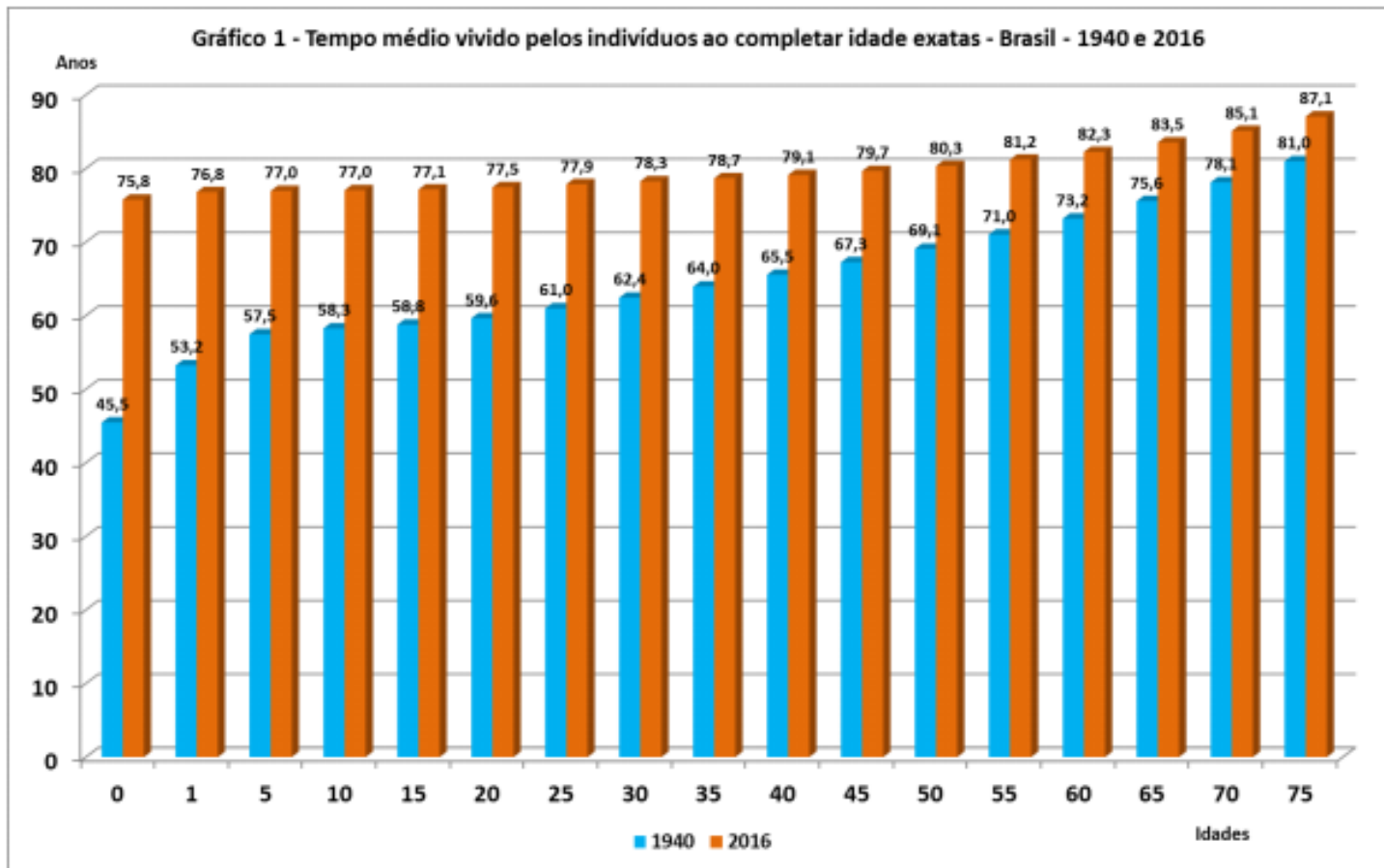
[ftp://ftp.ibge.gov.br/Tabuas\\_Completas\\_de\\_Mortalidade/Tabuas\\_Completas\\_de\\_Mortalidade\\_2016/tabua\\_de\\_mortalidade\\_2016\\_analise.pdf](ftp://ftp.ibge.gov.br/Tabuas_Completas_de_Mortalidade/Tabuas_Completas_de_Mortalidade_2016/tabua_de_mortalidade_2016_analise.pdf)

# Life Expectancy / UF

The higher sex-mortality differentials reflect the high levels of mortality among young people and young adults due to violent causes that directly affect the magnitudes of life expectancy at birth in the male population. The largest difference between the life expectancy of men and women was in the State of Alagoas, 9.5 years in favor of women, followed by Bahia, 9.2 years and Sergipe, 8.4 years (Graph 7).



# Comparing 1940 x 2016



Fonte: Tábua Construída para 1940 e Tábua completa de mortalidade 2016.

In 1940, an individual completing 50 years had a life expectancy of 19.1 years, living on average 69.1 years. With the mortality in this period, a single 50-year-old in 2016 would have a life expectancy of 30.3 years, expecting to live on average up to 80.3 years, that is, 11.3 years longer than an individual of the same age in 1940.

The highest life expectancy at birth for both sexes was found between countries in 2015, belongs to Japan, 83.7 years, followed closely by Italy, Singapore and Switzerland, all in the 83 years .

Tabela 2 - Expectativa de vida ao nascer - Brasil - 1940/2015

Ano	Expectativa de vida ao nascer			Diferencial entre os sexos (anos)
	Total	Homem	Mulher	
1940	45,5	42,9	48,3	5,4
1950	48,0	45,3	50,8	5,6
1960	52,5	49,7	55,5	5,9
1970	57,6	54,6	60,8	6,2
1980	62,5	59,6	65,7	6,1
1991	66,9	63,2	70,9	7,8
2000	69,8	66,0	73,9	7,9
2010	73,9	70,2	77,6	7,4
2015	75,5	71,9	79,1	7,2
$\Delta(1940/2015)$	30,0	29,0	30,8	

Fontes: 1940 1950,1960 e 1970 - Tábuas construídas no âmbito da Gerência de Estudos e Análises da Dinâmica Demográfica.

1980 e 1991 - ALBUQUERQUE, Fernando Roberto P. de C. e SENNA, Janaína R. Xavier "Tábuas de Mortalidade por Sexo e Grupos de Idade - Grandes e Unidades da Federação - 1980, 1991 e 2000. Textos para discussão, Diretoria de Pesquisas, IBGE, Rio de Janeiro, 2005.16

2000 em c  
Indicadores Sociais  
da população do Br

Tabela 4 - Expectativa de vida aos 65 anos - Brasil - 1940/2016

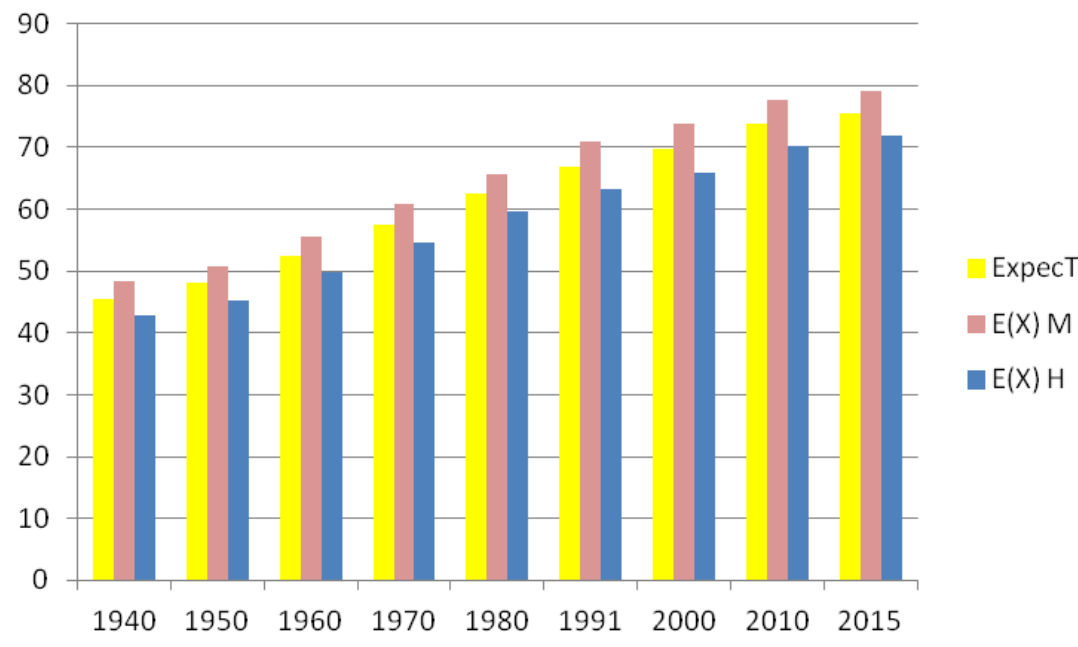
Ano	Expectativa de vida aos 65 anos			Diferencial (anos) (M-H)
	Total	Homem	Mulher	
1940	10,6	9,3	11,5	2,2
1950	10,8	9,6	11,8	2,2
1960	11,4	10,1	12,5	2,4
1970	12,1	10,7	13,4	2,6
1980	13,1	12,2	14,1	1,9
1991	15,4	14,3	16,4	2,0
2000	15,8	14,2	17,2	2,9
2010	17,6	16,0	19,0	3,0
2014	18,3	16,6	19,7	3,1
2016	18,5	16,8	20,0	3,1
$\Delta(1940/2016)$	7,9	7,5	8,5	

Fontes: 1940 1950,1960 e 1970 - Tábuas construídas no âmbito da Gerência de Estudos e Análises da Dinâmica Demográfica.

1980 e 1991 - ALBUQUERQUE, Fernando Roberto P. de C. e SENNA, Janaína R. Xavier "Tábuas de Mortalidade por Sexo e Grupos de Idade - Grandes e Unidades da Federação - 1980, 1991 e 2000. Textos para discussão, Diretoria de Pesquisas, IBGE, Rio de Janeiro, 2005.16

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de Pesquisas. Coordenação de População e  
nálises da Dinâmica Demográfica. Projeção da  
idade para o período 2000-2060.





# Mortality

## BR Life Expectancy/ sex / Region (IBGE, 2009)

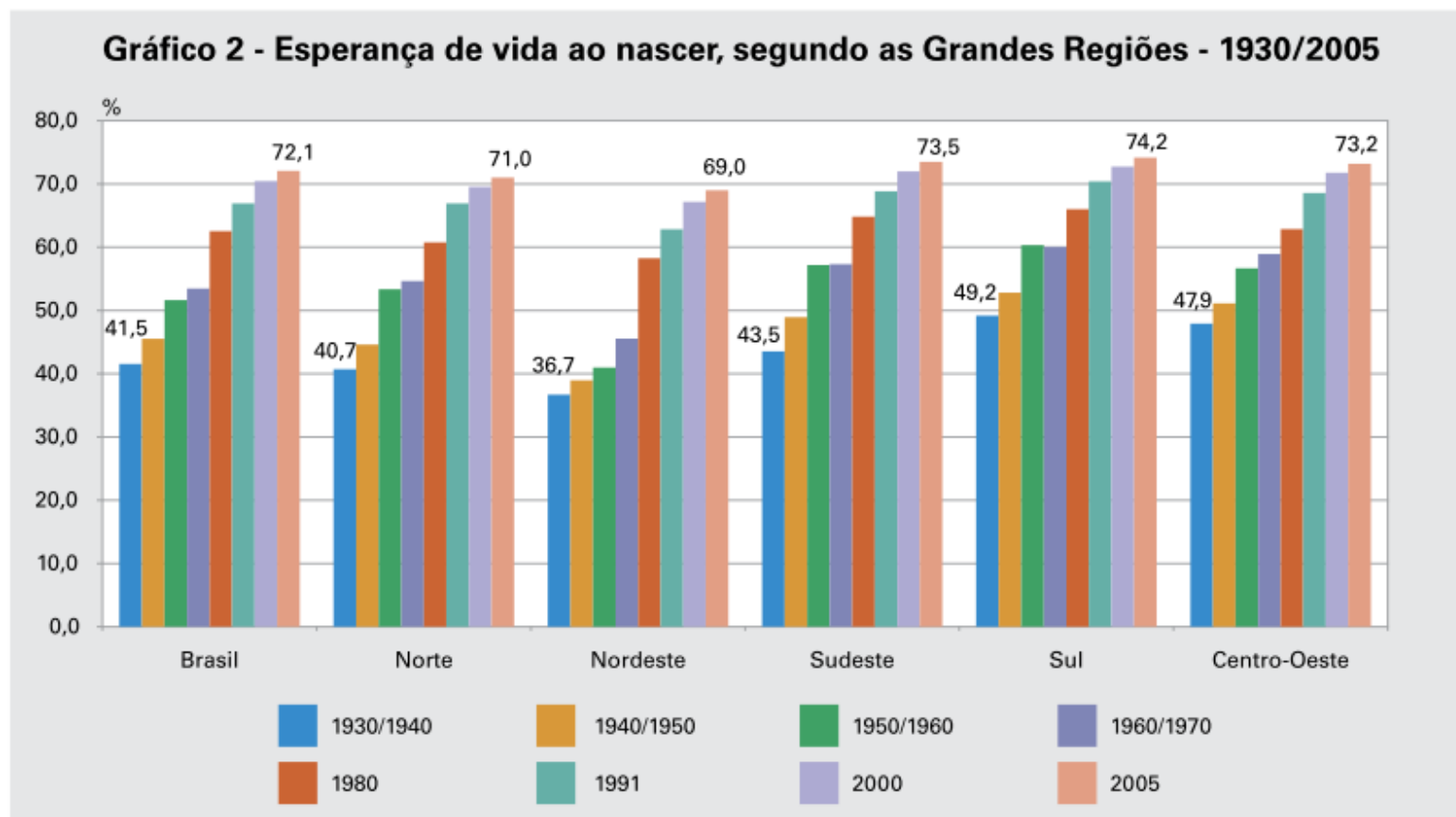
**Tabela 2 - Esperança de vida ao nascer, por sexo, segundo as Grandes Regiões - 1980/2005**

Grandes Regiões	Esperança de vida ao nascer, por sexo											
	1980			1991			2000			2005		
	Total	Ho-mens	Mu-lheres	Total	Ho-mens	Mu-lheres	Total	Ho-mens	Mu-lheres	Total	Ho-mens	Mu-lheres
<b>Brasil</b>	<b>62,5</b>	<b>59,6</b>	<b>65,7</b>	<b>66,9</b>	<b>63,2</b>	<b>70,9</b>	<b>70,4</b>	<b>66,7</b>	<b>74,4</b>	<b>72,1</b>	<b>68,4</b>	<b>75,9</b>
Norte	60,8	58,2	63,7	66,9	63,7	70,3	69,5	66,8	72,4	71,0	68,2	74,0
Nordeste	58,3	55,4	61,3	62,8	59,6	66,3	67,2	63,6	70,9	69,0	65,5	72,7
Sudeste	64,8	61,7	68,2	68,8	64,5	73,4	72,0	67,9	76,3	73,5	68,5	77,7
Sul	66,0	63,3	69,1	70,4	66,7	74,3	72,7	69,4	76,3	74,2	70,8	77,7
Centro-Oeste	62,9	60,5	65,6	68,6	65,2	72,0	71,8	68,4	75,3	73,2	69,8	76,7

Fonte: Projeto IBGE/Fundo de População das Nações Unidas - UNFPA/BRASIL (BRA/02/P02), População e Desenvolvimento: Sistematização das Medidas e Indicadores Sociodemográficos Oriundos da Projeção da População por Sexo e Idade, por Método Demográfico, das Grandes Regiões e Unidades da Federação para o Período 1991/2030.

# Mortality

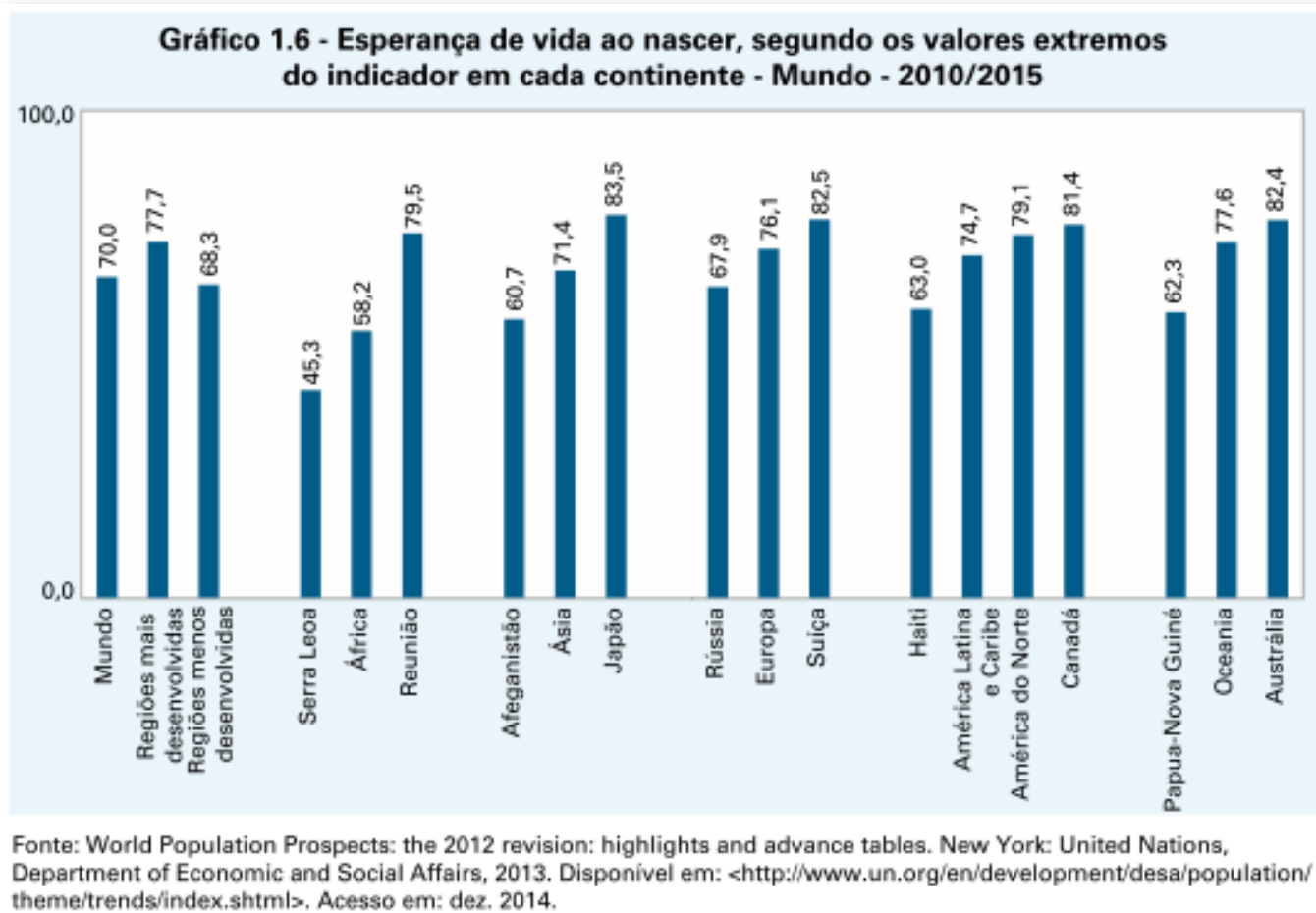
## BR Life Expectancy/ Region (IBGE, 2009)



Fontes: IBGE, Censo Demográfico 1940/2000 e Pesquisa Nacional por Amostra de Domicílios 2005.

# Mortality

## Life Expectancy by Continent (IBGE, 2014)



In the world context, (UN) life expectancy at birth is 70.0 years in the period 2010/2015.

The life expectancy of Brazilians (74.8 years) was very close to that estimated for Latin America and the Caribbean (74.7 years), and substantially above the indicator estimate for the less developed regions (68.3 years).

"Life expectancy at birth is another indicator of mortality, related to the living and health conditions of the population, and expresses the average number of years of life a newborn is expected to live by maintaining the observed mortality pattern in the period.

In 2000, life expectancy at birth for Brazilians was 69.8 years, to 74.8 years in 2013. "

# Global Life Expectancy

*Projected global life expectancy at birth\**

1990-1995



2010-2015



2045-2050



2095-2100



Source: United Nations Department of Economic and Social Affairs,  
Population Division, *World Population Prospects: The 2017 Revision*  
Produced by: United Nations Department of Public Information

\*Life expectancy data from the *World Population Prospects* are average values referring to five-year periods.



## World Population Prospects – 2017 Revision: Global life expectancy

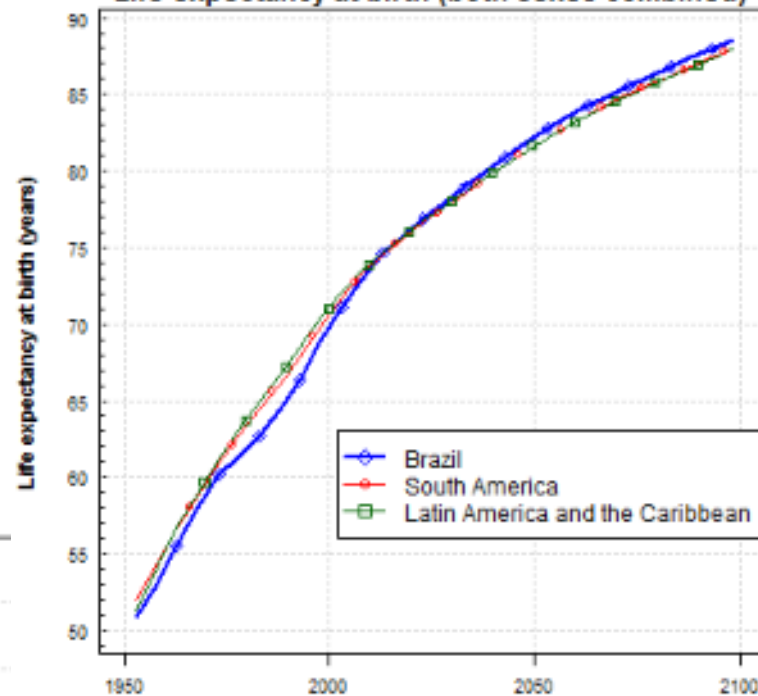
21 June 2017

Related information

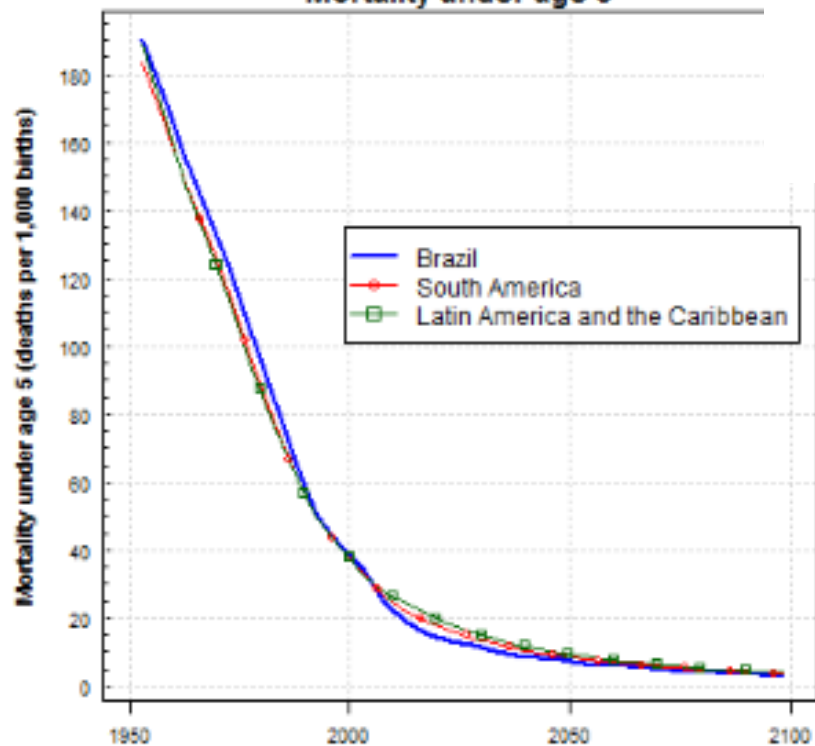
► [World Population Prospects - 2017 Revision](#)

<https://www.un.org/development/desa/publications/graphic/wpp2017-global-life-expectancy>

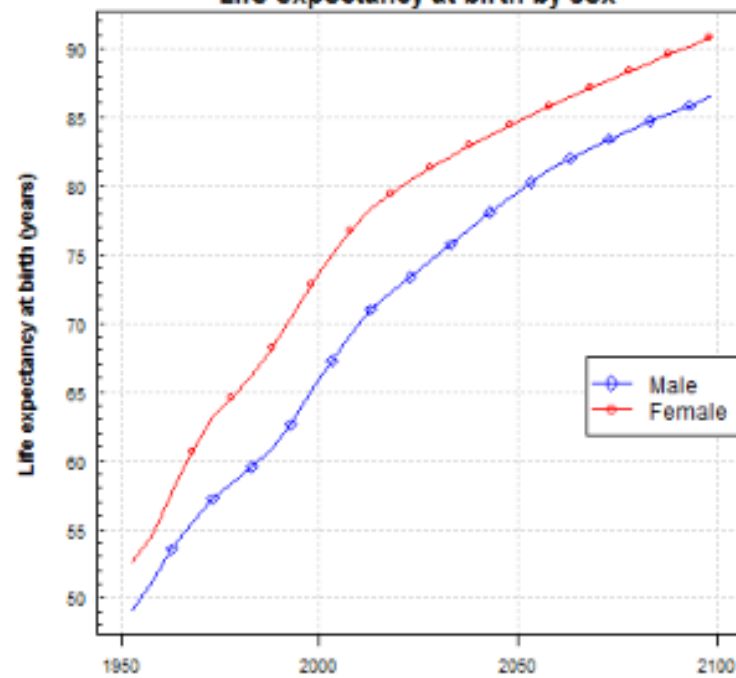
Life expectancy at birth (both sexes combined)



Mortality under age 5

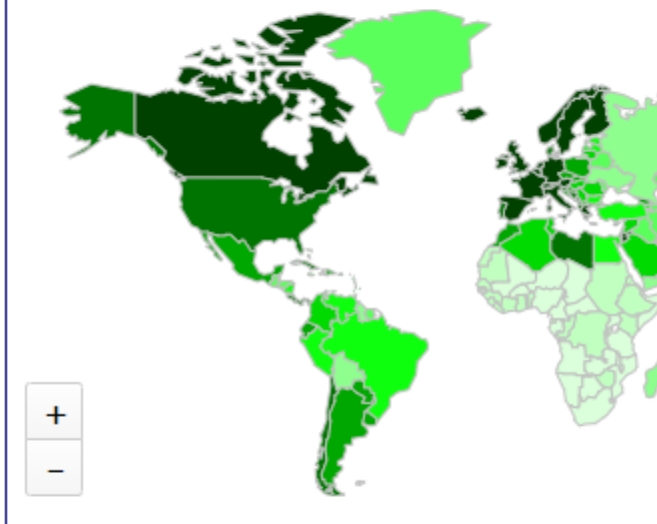


Life expectancy at birth by sex



← 1980 1981 ... 2017 **2018** 2019 ... 2049 2050

### The World: Life Expectancy (2018)



Rank	Country	Years	Year
1.	Monaco	89.37	2018 (Est.)
2.	Japan	85.52	2018 (Est.)
3.	Singapore	85.47	2018 (Est.)
4.	Macau	84.57	2018 (Est.)
5.	San Marino	83.39	2018 (Est.)
6.	Andorra	82.91	2018 (Est.)
7.	Guernsey	82.68	2018 (Est.)
8.	Hong Kong	82.59	2018 (Est.)
9.	Australia	82.38	2018 (Est.)
10.	Italy	82.35	2018 (Est.)
11.	Canada	82.02	2018 (Est.)
12.	Channel Islands	82.02	2018 (Est.)
13.	Liechtenstein	82.01	2018 (Est.)
14.	France	81.86	2018 (Est.)
15.	Spain	81.83	2018 (Est.)
16.	Sweden	81.76	2018 (Est.)
17.	Switzerland	81.75	2018 (Est.)
18.	Israel	81.66	2018 (Est.)
19.	Iceland	81.61	2018 (Est.)
20.	Anguilla	81.59	2018 (Est.)

### Rank Country Years

128.	Brazil	74.3
127.	Latvia	74.41
126.	Egypt	74.42
125.	Grenada	74.75
124.	Montserrat	74.83
123.	Venezuela	74.98

# Article discussion

1. Summary
2. Important subjects
3. Caveats

Population TFT (The Economist)

[https://www.youtube.com/watch?v=0CNC\\_VJ11CM](https://www.youtube.com/watch?v=0CNC_VJ11CM)

Population x CC (The Gardian)

<https://www.youtube.com/watch?v=SxbprYyjyyU>

UN Population Division

- World Population Prospects 2017 (<https://esa.un.org/unpd/wpp/>)



# Population Size – previous class



- **Results:**

- Annual Growth Rate ( **$r = 0.0117$ , ou  $1,17\% \text{a.a.}$** )

- Valor intercensitário para 2007

- $P_{2007} = P_{2000} (1 + r)^t \rightarrow 184.210.802$

- **183 987 291 recenseados**

- Se mantida esta taxa de crescimento,  
em quanto tempo a população duplicaria

**$T_2 = 60$  anos**

$$P_n = P_0(1 + r)^t$$

$$\frac{P_n}{P_0} = (1 + r)^t$$

$$\log \frac{P_n}{P_0} = t \log(1 + r)$$

$$t = \frac{\log \frac{P_n}{P_0}}{\log(1 + r)}$$