Mortality

Ernesto F. L. Amaral

October 06–08, 2020
Population and Society (SOCI 312)

TEXAS A&M UNIVERSITY

www.ernestoamaral.com

Outline

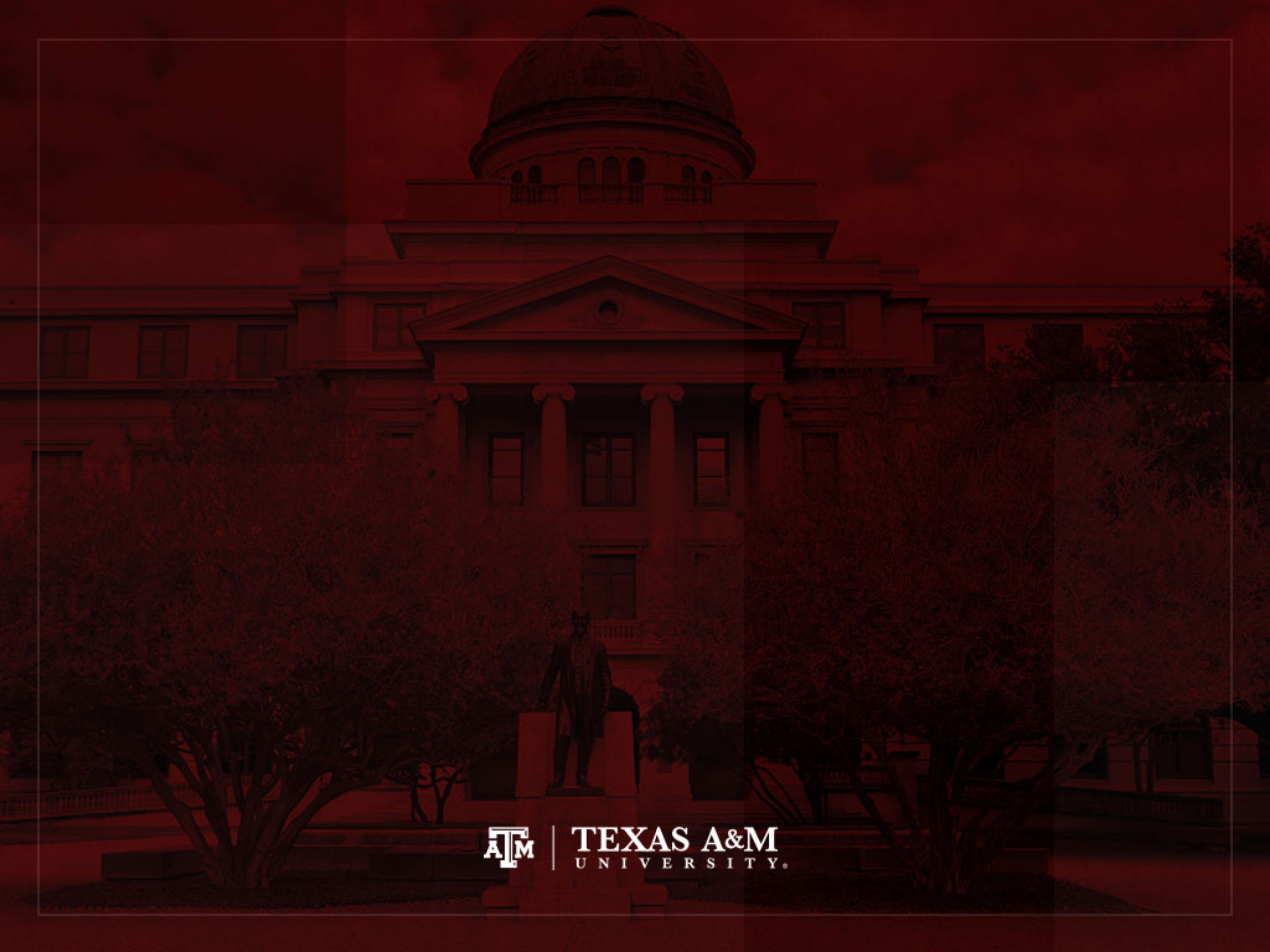
- Introduction
- Measurement of mortality
  - Standardization
  - Life table
- Short history of mortality in the world
- Mortality trends and causes of death
- Mortality and longevity in the United States
- Infant mortality
- Future course of mortality
- Coronavirus pandemic

Introduction

- The impact of mortality varies significantly according to social and demographic characteristics
  - Age
  - Sex
  - Race/ethnicity
  - Social class
  - Marital status
  - Area of residence
- Levels of development, medical conditions, and a host of other factors influence life expectancy

Changes in causes of death

- There have been major changes over the historical record in the main causes of death
- People used to die mainly of infectious and parasitic diseases
- Today the major causes of death in developed countries are heart disease, cancer, and stroke
- Major causes of death are different in countries with high and low levels of life expectancy


ATM
TEXAS A&M
UNIVERSITY

Measurement of mortality

- Quantification of mortality is central to demography

- Measurement of mortality dates back to John Graunt (1620–1674) and his analyses of the "Bills of Mortality"

- Mortality refers to the relative frequency of death in a population

Two concepts of mortality

- Life span
  - Numerical age limit of human life
  - Maximum recorded age at death
  - 122 years and 164 days, lived by the Frenchwoman Jeanne Louise Calment

- Life expectancy
  - Average expected number of years of life to be lived by a particular population at a given time

Crude death rate

- Crude death rate (*CDR*)

$$CDR = d / p * 1{,}000$$

  - *d*: deaths in the year
  - *p*: population at midyear

- Data for the United States for 2013

$$CDR = 2{,}596{,}993 / 316{,}497{,}531 * 1{,}000$$

$$CDR = 8.2$$

- World range of *CDR* in 2014
  - United Arab Emirates (UAE) and Qatar = 1
  - Lesotho = 21

CDR and age composition

- When *CDR*s are compared among countries, differences are sometimes due to differences in age composition
  - Previous examples mean that there are 8 times more deaths per 1,000 people in the US than in the UAE
  - Why is the CDR of the US eight times higher than of the UAE?
  - The main reason is that the UAE is much younger in average age than is the U.S.
  - Younger people have lower death rates

Young and old people

- Countries with
  - Large proportions of young people
  - Small proportions of old people
  - Usually have lower *CDR*s

- Countries with
  - Small proportions of young people
  - Large proportions of old people
  - Usually have higher *CDR*s

Changing age structure

- If age structure has changed over time
  - CDRs should not be used to compare the death experiences of the same population at different points in time
- US *CDR* did not change much in 54 years
  - CDR_{1960} = 9.5 per 1,000
  - CDR_{2014} = 8.2 per 1,000
- *CDR* is not capable of capturing the reduction in mortality when the population becomes older
  - The US became older between 1960 and 2014
  - Median age: 29 in 1960 and 37 in 2014

Crude rate

- *CDR* is a crude rate, because its denominator comprises the entire population
- However, population members are not equally at risk of experiencing death
- Risk of death varies by age, sex, race/ethnicity, socioeconomic status, and others
- Death rates vary considerably by age...

Age-specific death rates

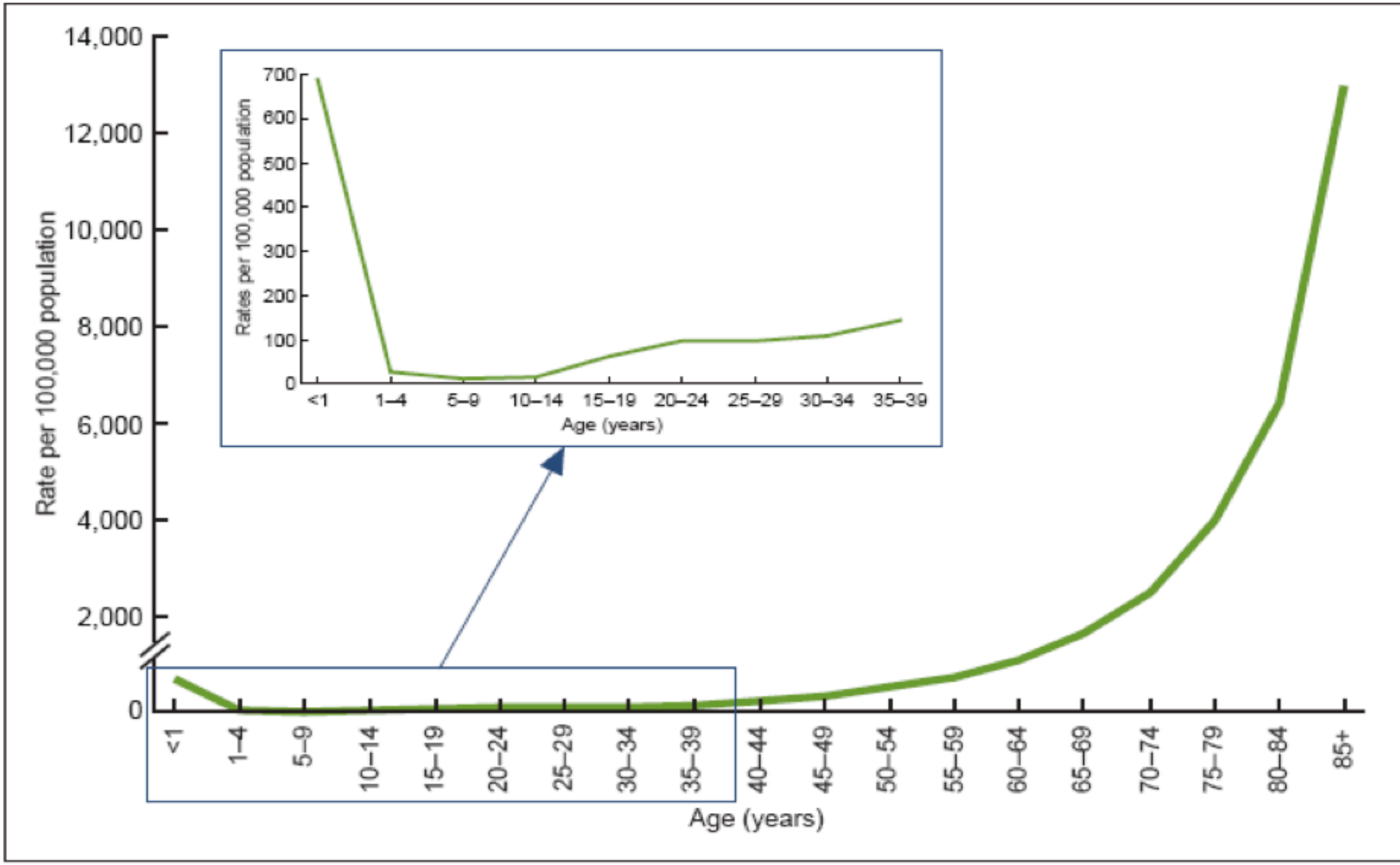
- Demographers use age-specific death rates as a more precise way to measure mortality

- Age-specific death rate (${}_{n}ASDR_{x}$ or ${}_{n}M_{x}$)

$$ {}_{n}M_{x} = {}_{n}d_{x} / {}_{n}p_{x} * 1{,}000 $$

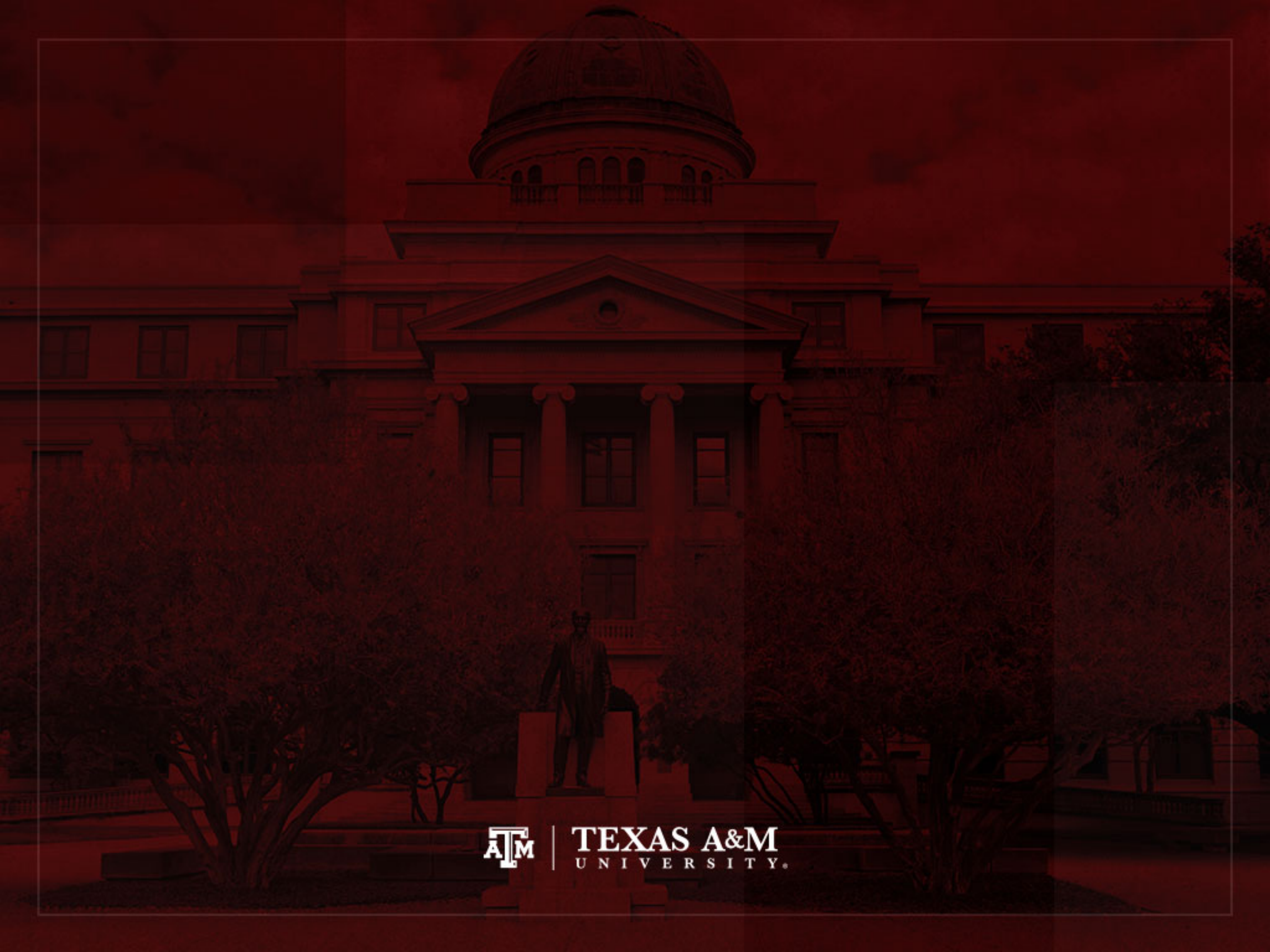
  - ${}_{n}d_{x}$: deaths to persons aged x to $x+n$
  - ${}_{n}p_{x}$: persons in the population who are aged x to $x+n$
  - n: width of the age group
  - x: initial year of the age group
  - For instance, *ASDR* for age group 15–19 is ${}_{5}M_{15}$

Age curve of mortality, US, 2007



Source: Minino, et al., 2009: 2.

Source: Poston, Bouvier 2017, p.169.


TEXAS A&M
UNIVERSITY

Standardization

- ${}_{n}ASDR_{x}$, and not *CDR*, should be used to compare the mortality experiences of countries with different age compositions
  - We use **standardization** to take into account age composition when we compare death rates among different countries
  - We can compare crude death rates for different countries or years
  - We need to adjust for differences in age structure
  - We estimate age-adjusted death rates and apply to a standard population

Mortality and fertility

- We cannot simply add up ${}_{n}ASDR_{x}$ and multiply by the width of the age interval
  - People die just once

- This makes sense for age-specific fertility rates (${}_{n}ASFR_{x}$) and total fertility rates (TFR)

$$TFR = \sum({}_{n}ASFR_{x} * n)$$

  - n: width of the age group
  - Women can have more than one child

Age standardization

- Young populations tend to have low *CDR*s
- Old populations tend to have high *CDR*s
- We estimate a variation of *CDR* that allows us to account for age composition when comparing death rates among different countries

$$CDR = \Sigma\ {}_nASDR_x * ({}_nP_x / P) * 1{,}000$$

  - P: total population
  - ${}_nP_x$: population in age group x
  - ${}_nASDR_x$: *ASDR* for people aged x to $x+n$

Source: Formula 7.4 (Poston, Bouvier 2017, p.171).

United States, 2006

Age group	Population	Prop. population	Deaths	Age-specific death rate (ASDR)
0-1	4,147,760	0.0139	27,126	0.00654
1-4	16,352,320	0.0548	4,742	0.00029
5-9	20,142,000	0.0675	2,820	0.00014
10-14	21,454,960	0.0719	3,862	0.00018
15-19	21,604,160	0.0724	13,827	0.00064
20-24	20,947,680	0.0702	19,062	0.00091
25-29	20,022,640	0.0671	18,020	0.00090
30-34	20,261,360	0.0679	21,477	0.00106
35-39	21,067,040	0.0706	32,233	0.00153
40-44	22,857,440	0.0766	52,801	0.00231
45-49	22,588,880	0.0757	77,028	0.00341
50-54	20,142,000	0.0675	99,300	0.00493
55-59	17,158,000	0.0575	127,312	0.00742
60-64	13,040,080	0.0437	149,961	0.01150
65-69	10,115,760	0.0339	180,061	0.01780
70-74	8,474,560	0.0284	234,830	0.02771
75-79	7,400,320	0.0248	321,914	0.04350
80-84	5,580,080	0.0187	388,262	0.06958
85-89	3,192,880	0.0107	353,005	0.11056
90-94	1,342,800	0.0045	234,681	0.17477
95-99	387,920	0.0013	107,283	0.27656
100+	89,520	0.0003	39,292	0.43892
Total	**298,400,000**	**0.9999**	**2,508,899**	**1.20116**

CDR per 1,000	8.41

Venezuela, 2006

Age group	Population	Prop. population	Deaths	Age-specific death rate (ASDR)
0-1	487,056	0.0219	7,905	0.01623
1-4	1,779,200	0.0800	1,139	0.00064
5-9	2,308,512	0.1038	739	0.00032
10-14	2,275,152	0.1023	933	0.00041
15-19	2,250,688	0.1012	3,286	0.00146
20-24	2,057,200	0.0925	4,896	0.00238
25-29	1,872,608	0.0842	4,138	0.00221
30-34	1,614,624	0.0726	3,278	0.00203
35-39	1,530,112	0.0688	3,290	0.00215
40-44	1,401,120	0.0630	4,049	0.00289
45-49	1,145,360	0.0515	4,707	0.00411
50-54	971,888	0.0437	5,520	0.00568
55-59	769,504	0.0346	5,964	0.00775
60-64	558,224	0.0251	6,548	0.01173
65-69	400,320	0.0180	7,514	0.01877
70-74	302,464	0.0136	8,584	0.02838
75-79	215,728	0.0097	9,212	0.04270
80-84	117,872	0.0053	8,877	0.07531
85-89	53,376	0.0024	6,816	0.12769
90-94	15,568	0.0007	3,241	0.20820
95-99	2,224	0.0001	724	0.32576
100+	2,224	0.0001	1,089	0.48975
Total	**22,240,000**	**0.9951**	**102,449**	**1.37655**

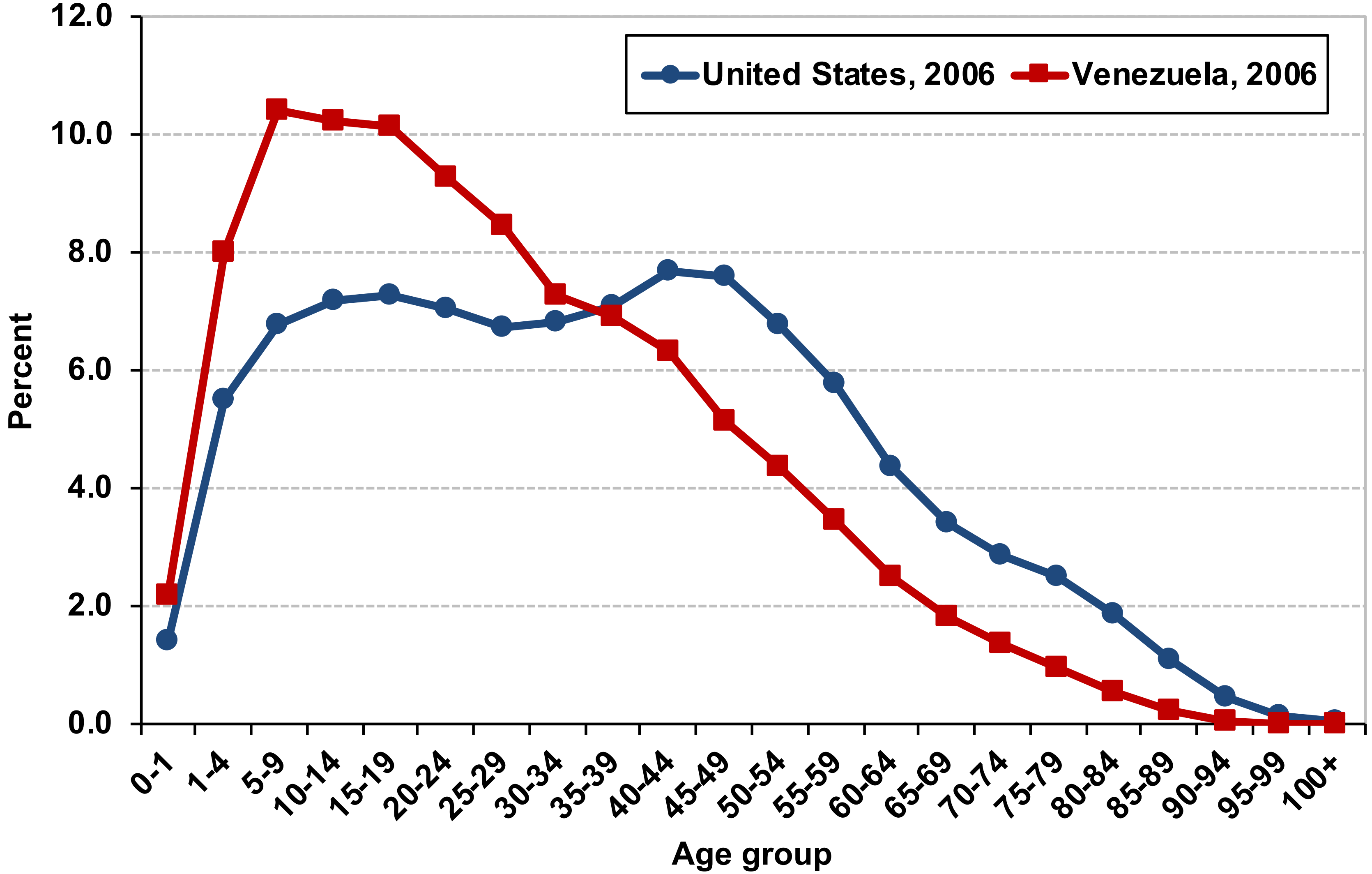
CDR per 1,000	4.61

Population distribution by country

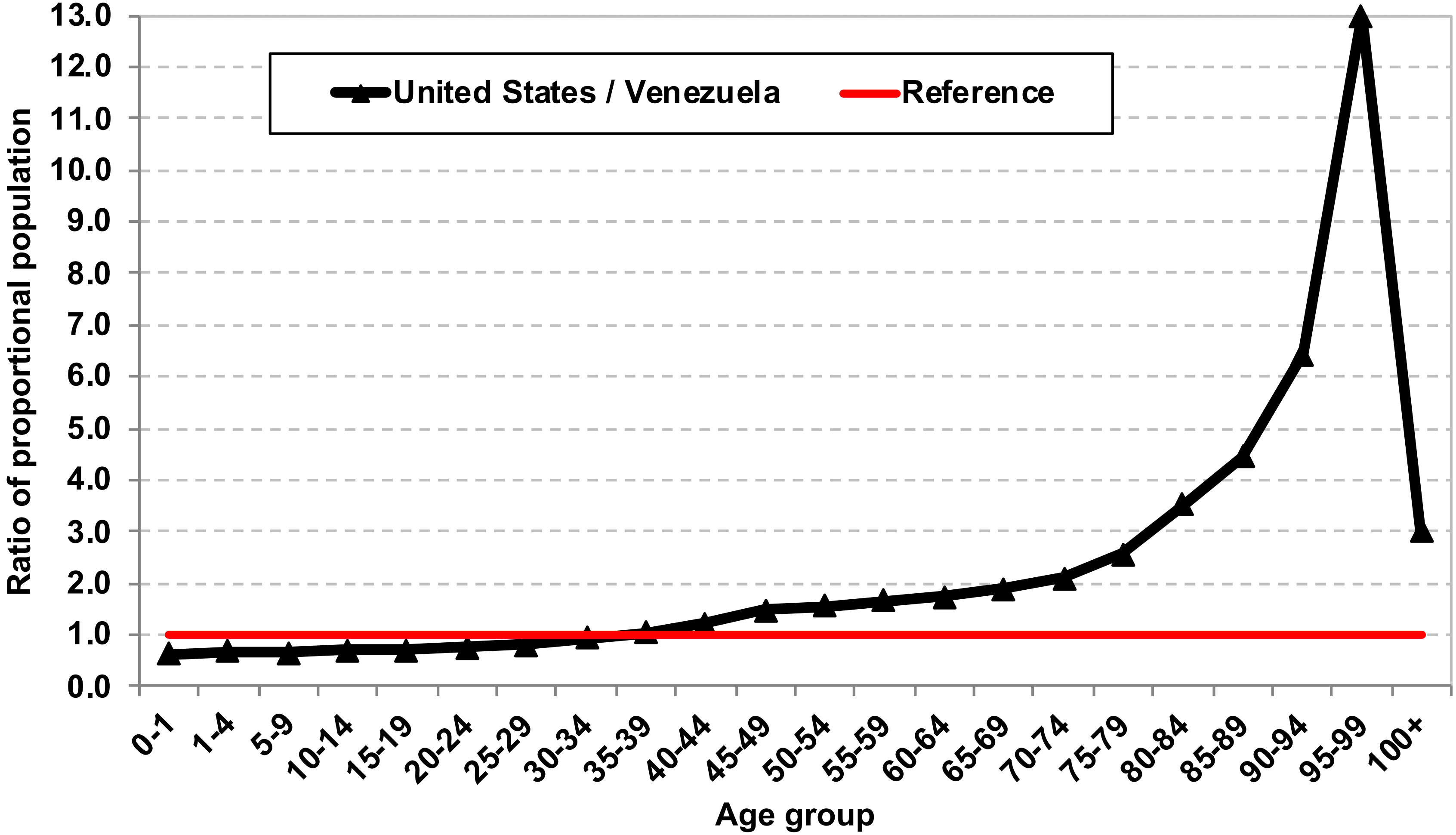
Age group	United States (%)	Venezuela (%)	Ratio United States / Venezuela
0-1	1.39	2.19	0.63
1-4	5.48	8.00	0.69
5-9	6.75	10.38	0.65
10-14	7.19	10.23	0.70
15-19	7.24	10.12	0.72
20-24	7.02	9.25	0.76
25-29	6.71	8.42	0.80
30-34	6.79	7.26	0.94
35-39	7.06	6.88	1.03
40-44	7.66	6.30	1.22
45-49	7.57	5.15	1.47
50-54	6.75	4.37	1.54
55-59	5.75	3.46	1.66
60-64	4.37	2.51	1.74
65-69	3.39	1.80	1.88
70-74	2.84	1.36	2.09
75-79	2.48	0.97	2.56
80-84	1.87	0.53	3.53
85-89	1.07	0.24	4.46
90-94	0.45	0.07	6.43
95-99	0.13	0.01	13.00
100+	0.03	0.01	3.00
Total	**99.99**	**99.51**	**1.00**

- The U.S. has an older population than Venezuela
- This is causing $CDR_{US} > CDR_{VE}$

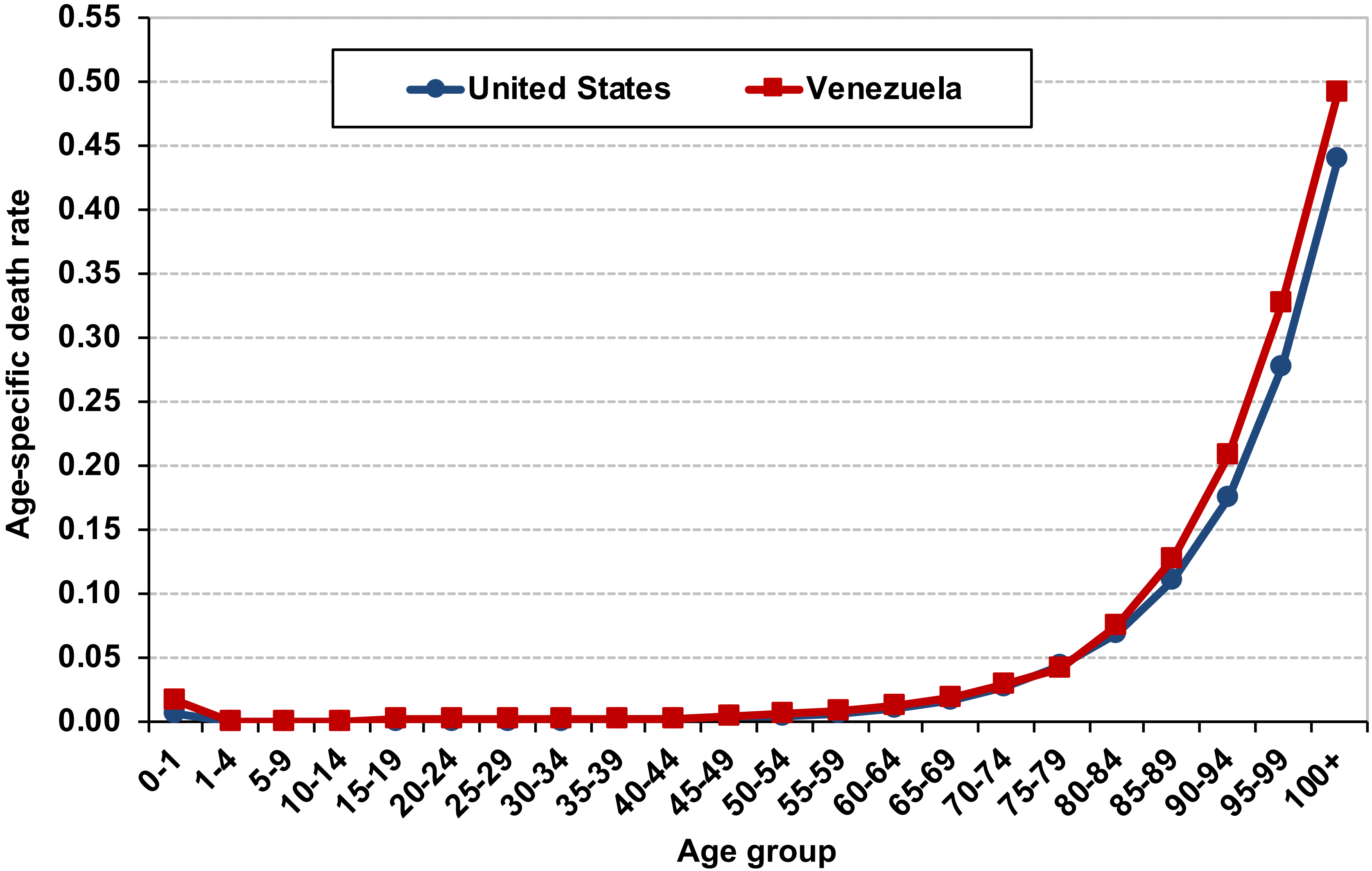
Age structure



The U.S. has an older population than Venezuela



Age-specific death rates, 2006



Standardize Venezuela's *CDR*

Standardization Age group	Venezuela (observed rates)	United States (standard prop. population)	Venezuela's rates times U.S. prop. population
0-1	0.01623	0.0139	0.0002
1-4	0.00064	0.0548	0.0000
5-9	0.00032	0.0675	0.0000
10-14	0.00041	0.0719	0.0000
15-19	0.00146	0.0724	0.0001
20-24	0.00238	0.0702	0.0002
25-29	0.00221	0.0671	0.0001
30-34	0.00203	0.0679	0.0001
35-39	0.00215	0.0706	0.0002
40-44	0.00289	0.0766	0.0002
45-49	0.00411	0.0757	0.0003
50-54	0.00568	0.0675	0.0004
55-59	0.00775	0.0575	0.0004
60-64	0.01173	0.0437	0.0005
65-69	0.01877	0.0339	0.0006
70-74	0.02838	0.0284	0.0008
75-79	0.04270	0.0248	0.0011
80-84	0.07531	0.0187	0.0014
85-89	0.12769	0.0107	0.0014
90-94	0.20820	0.0045	0.0009
95-99	0.32576	0.0013	0.0004
100+	0.48975	0.0003	0.0001
Total		**0.9999**	**0.0097**

CDR per 1,000	**9.68**

Source: Application of formula 7.4 (Poston, Bouvier 2017, p.171).

Another way... same results...

Standardization Age group	United States (standard population)	Venezuela (observed rates)	Venezuela (standardized deaths)
0-1	4,148,175	0.0162	67,325
1-4	16,353,955	0.0006	10,467
5-9	20,144,014	0.0003	6,446
10-14	21,457,106	0.0004	8,797
15-19	21,606,321	0.0015	31,545
20-24	20,949,775	0.0024	49,860
25-29	20,024,642	0.0022	44,254
30-34	20,263,386	0.0020	41,135
35-39	21,069,147	0.0022	45,299
40-44	22,859,726	0.0029	66,065
45-49	22,591,139	0.0041	92,850
50-54	20,144,014	0.0057	114,418
55-59	17,159,716	0.0078	132,988
60-64	13,041,384	0.0117	152,975
65-69	10,116,772	0.0188	189,892
70-74	8,475,408	0.0284	240,532
75-79	7,401,060	0.0427	316,025
80-84	5,580,638	0.0753	420,278
85-89	3,193,199	0.1277	407,740
90-94	1,342,934	0.2082	279,599
95-99	387,959	0.3258	126,381
100+	89,529	0.4898	43,847
Total	**298,400,000**		**2,888,718**

CDR per 1,000	**9.68**

Comparing crude death rates

- $CDR_{\text{United States original}}$

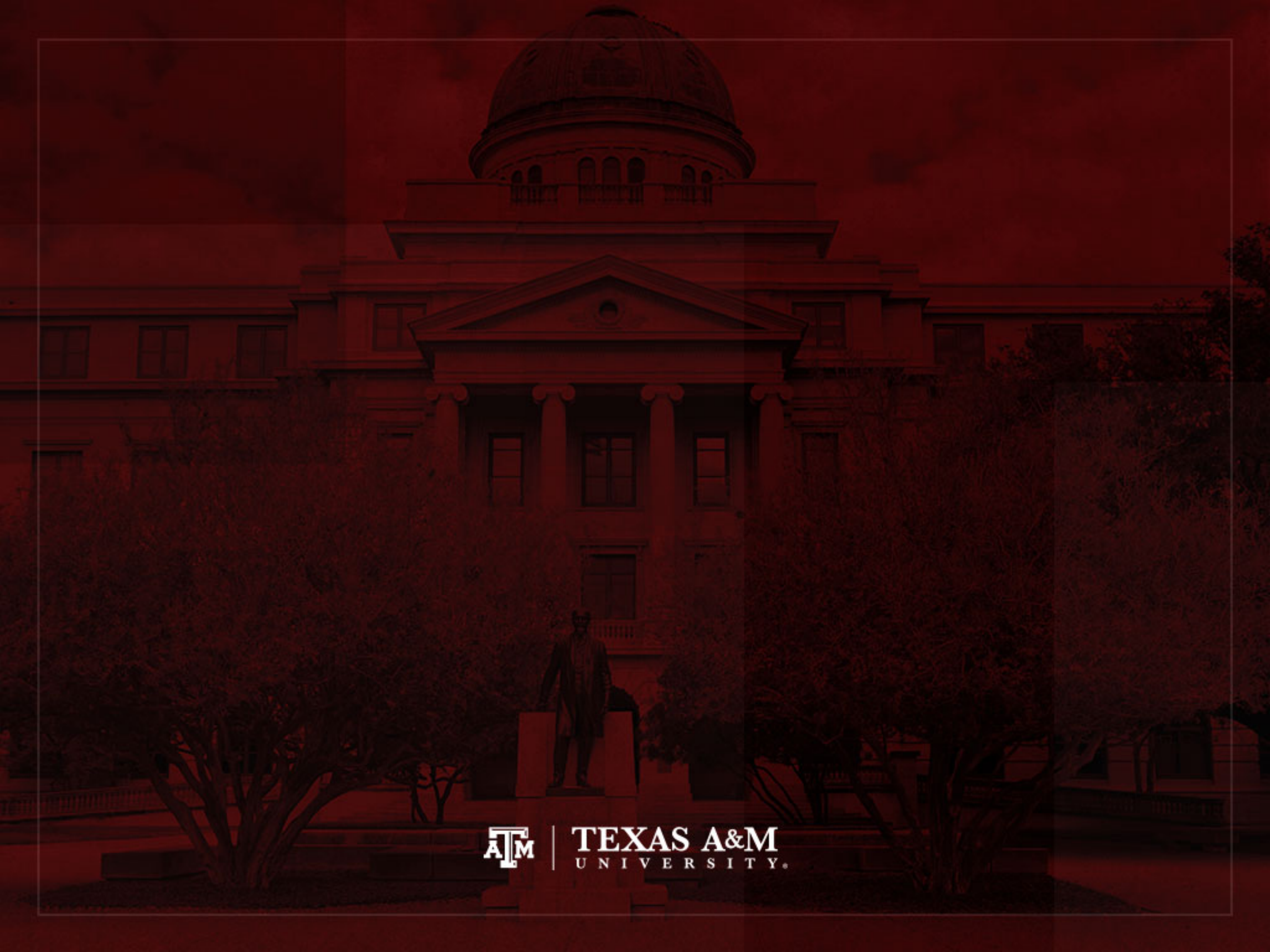
= 8.41 deaths per 1,000

- $CDR_{\text{Venezuela original}}$

= 4.61 deaths per 1,000

- $CDR_{\text{Venezuela standardized}}$

= 9.68 deaths per 1,000


ATM
TEXAS A&M
UNIVERSITY

Life table

- One of the most important and elegant measures of the mortality experiences of a population is the life table
- It dates back to John Graunt (1620–1674) and his “Bills of Mortality”
- Demographers use the life table to determine life expectancy, not only at birth but at any age

Important information from life table

- Like the total fertility rate (*TFR*), the life table is a synthetic or hypothetical measure

- It tells us how many years of life, on average, may a person expect to live if the person during his or her lifetime is subjected to the age-specific probabilities of dying of a particular country or population at a given time

Example: United States, 2010

- Let's say that the population of the U.S. in 2010 had a life expectancy of birth of 78.7 years

- This means that if a cohort of persons, throughout the years of their life, were subjected to the *ASDR*s ($_nM_x$) of the total population in the U.S. in 2010
  - They would live, on average, 78.7 years

Examples of Life expectancy

- Life expectancy at birth is a primary indicator of quality of life

2013	Life expectancy	
	Male	**Female**
World	69	73
More developed countries	75	82
Less developed countries (except China)	65	69
Japan	80	86
Lesotho	42	45
Sierra Leone	45	46

Limitations of e_0

- We need to be aware of the fact that when considering life expectancy at birth (e_0), infant mortality plays a very important role

- When e_0 is low, a major reason is their very high infant mortality rate

- When comparing values of life expectancy at birth across countries, we should not think of e_0 as a modal age at death

Abridged life table

- An abridged life table is calculated for age groups
- Usually for five-year age groups
- Rather than for single-year age groups

Radix and mortality probabilities

- A life table starts with a population (a radix) of 100,000 persons born alive at age 0
  - This number is arbitrary, but conventional
  - It can also be 1,000 or 1
- From each age to the next, the population is decremented according to age-specific mortality probabilities until all members have died
  - The mortality schedule is fixed and does not change over the life of the population

Life table for U.S. population, 2010

Life Table for the Total Population, United States, 2010

(1) Age range	(2) $_nq_x$	(3) l_x	(4) $_nd_x$	(5) $_nL_x$	(6) T_x	(7) e_x
<1	0.006123	100,000	612	99,465	7,866,027	78.7
1–4	0.001071	99,388	106	397,294	7,766,561	78.1
5–9	0.000573	99,281	57	496,250	7,369,267	74.2
10–14	0.000708	99,224	70	495,989	6,873,017	69.3
15–19	0.002463	99,154	244	495,240	6,377,028	64.3
20–24	0.004317	98,910	427	493,529	5,881,789	59.5
25–29	0.004791	98,483	472	491,249	5,388,260	54.7
30–34	0.005497	98,011	539	488,744	4,897,011	50.0
35–39	0.006913	97,472	674	485,753	4,408,267	45.2
40–44	0.009979	96,798	966	481,758	3,922,514	40.5
45–49	0.016044	95,833	1,538	475,584	3,440,756	35.9
50–54	0.024343	94,295	2,295	466,066	2,965,173	31.4
55–59	0.035106	92,000	3,230	452,347	2,499,106	27.2
60–64	0.049847	88,770	4,425	433,348	2,046,759	23.1
65–69	0.074406	84,345	6,276	406,912	1,613,411	19.1
70–74	0.112315	78,069	8,768	369,612	1,206,499	15.5
75–79	0.174782	69,301	12,113	317,694	836,886	12.1
80–84	0.274384	57,188	15,692	248,038	519,193	9.1
85–89	0.430820	41,497	17,878	162,723	271,155	6.5
90–94	0.615282	23,619	14,532	79,720	108,432	4.6
95–99	0.783397	9,087	7,119	24,670	29,212	3.2
100+	1.00000	1,968	1,968	4,542	4,542	2.3

Source: Arias (2014: 62).

Basic life table columns

1. Age intervals of each group
2. ${}_nq_x$: probability of dying between age *x* and age *x*+*n*
3. l_x: number of survivors at each age x
4. ${}_nd_x$: number of deaths between age *x* and age *x*+*n*
5. ${}_nL_x$: number of years lived by all persons who enter the age interval while in the age interval
6. T_x: number of years lived by the population in the age interval and in all subsequent intervals
7. e_x: remaining life expectancy at each age

1. Age intervals of each group

- Age groups refer to the range of years between two birthdays

- The age group 5–9 refers to the five-year interval between the fifth and the tenth birthdays

2. Probabilities of dying ($_nq_x$)

- The most basic column of the life time shows probabilities of dying for each age group ($_nq_x$)
  - These are probabilities that persons alive at the beginning of an age interval will die during the interval, before they reach the start of the next age interval

$$_nq_x = {}_nd_x / l_x$$

  - For last age group, $_nq_x$=1.0 because everybody dies

Rates and probabilities

- Difference between mortality rates (${}_nM_x$) and mortality probabilities (${}_nq_x$) is the denominator
- ${}_nM_x$: denominator is midyear population
- ${}_nq_x$: denominator is population alive at the beginning of the age interval

3. Number of survivors (l_x)

- Number of people alive at the beginning of the age interval (l_x)
  - Known as "the little l column"
- It is calculated by subtracting the number of people dying (${}_nd_x$) from the l_x value in the age interval immediately preceding the one being calculated
- Example of U.S. life table in 2010
  - Of the 99,224 people alive at the beginning of the age interval 10–14 (l_{10})
  - 70 of them die during the age interval (${}_5d_{10}$)
  - Thus, the value of l_{15} is 99,154 = 99,224 – 70

4. Number of deaths (${}_nd_x$)

- Number of people who die during a particular age interval (${}_nd_x$)

$${}_nd_x = l_x * {}_nq_x$$

- For the number of people who die during the age interval of 40–44

$${}_5d_{40} = {}_5q_{40} * l_{40}$$

$${}_5d_{40} = 0.009979 * 96{,}798$$

$${}_5d_{40} = 966$$

5. Years lived in age interval ($_nL_x$)

- Total number of years lived by all persons who enter that age interval while in the age interval ($_nL_x$)
  - Known as "the big L column"
- Example of U.S. life table in 2010
  - 98,011 persons are alive at the beginning of age interval 30–34 (l_{30})
  - If none of them died during the age interval, they would have lived 490,055 years (98,011 times 5)
  - But 539 of them died ($_5d_{30}$)

Different formulas for ${}_{n}L_{x}$

- Demographers assume that deaths are roughly distributed during the five-year period for many of the age intervals

- This assumption does not apply to the first few age intervals
  - There are several formulas to produce the nLx value for the first few age groups

- At the other age extreme, 100+ in the life table, another formula is used

6. Years lived in current and subsequent age intervals (T_x)

- Total number of years lived by the population in the age interval and in all subsequent age intervals (T_x)
  - We sum ${}_nL_x$ from the oldest age backwards to get T_x

$$T_x = \sum_{i=x}^{w} L_i$$

  - L_i: entry i in the ${}_nL_x$ column
  - $\sum_{i=x}^{w}$: sum of the ${}_nL_x$ column starting at entry x through the last ${}_nL_x$ entry (w)

Example of T_x

- Example of U.S. life table in 2010

$$T_{95} = {}_5L_{95} + {}_\infty L_{100}$$

$$T_{95} = 24,670 + 4,542$$

$$T_{95} = 29,212$$

7. Remaining life expectancy (e_x)

- Average number of years of life remaining at the beginning of the age interval (e_x)
- It provides life expectancy at any age

$$e_x = T_x / l_x$$

- Example of U.S. life table in 2010

$$e_0 = T_0 / l_0 = 7{,}866{,}027 / 100{,}000 = 78.7$$

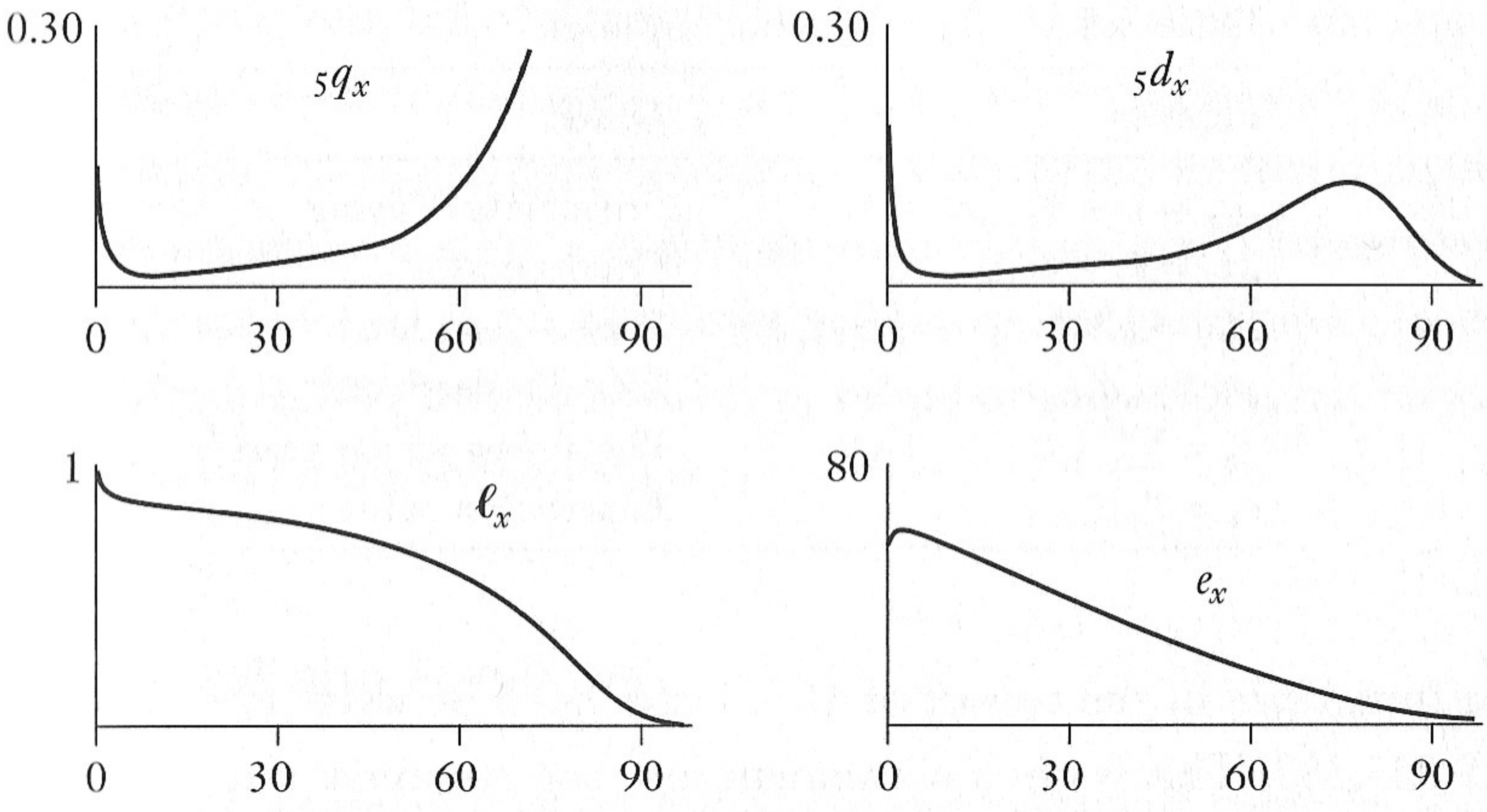
$$e_{25} = T_{25} / l_{25} = 5{,}388{,}260 / 98{,}483 = 54.7$$

  – Persons aged 25–29 can expect to live an additional 54.7 years

Average age at death ($x + e_x$)

- e_x is the expectation of future life beyond age x
  - It is not an average age at death
- We add x and e_x to obtain the average age at death for cohort members who survive to age x
  - Not all lifetables include $x + e_x$
  - The $x + e_x$ column always go up
- e_x does not always go down
  - It often goes up after the first few years of life, because babies who survive infancy are no longer subject to the high risks of infancy

Typical shapes of lifetable functions

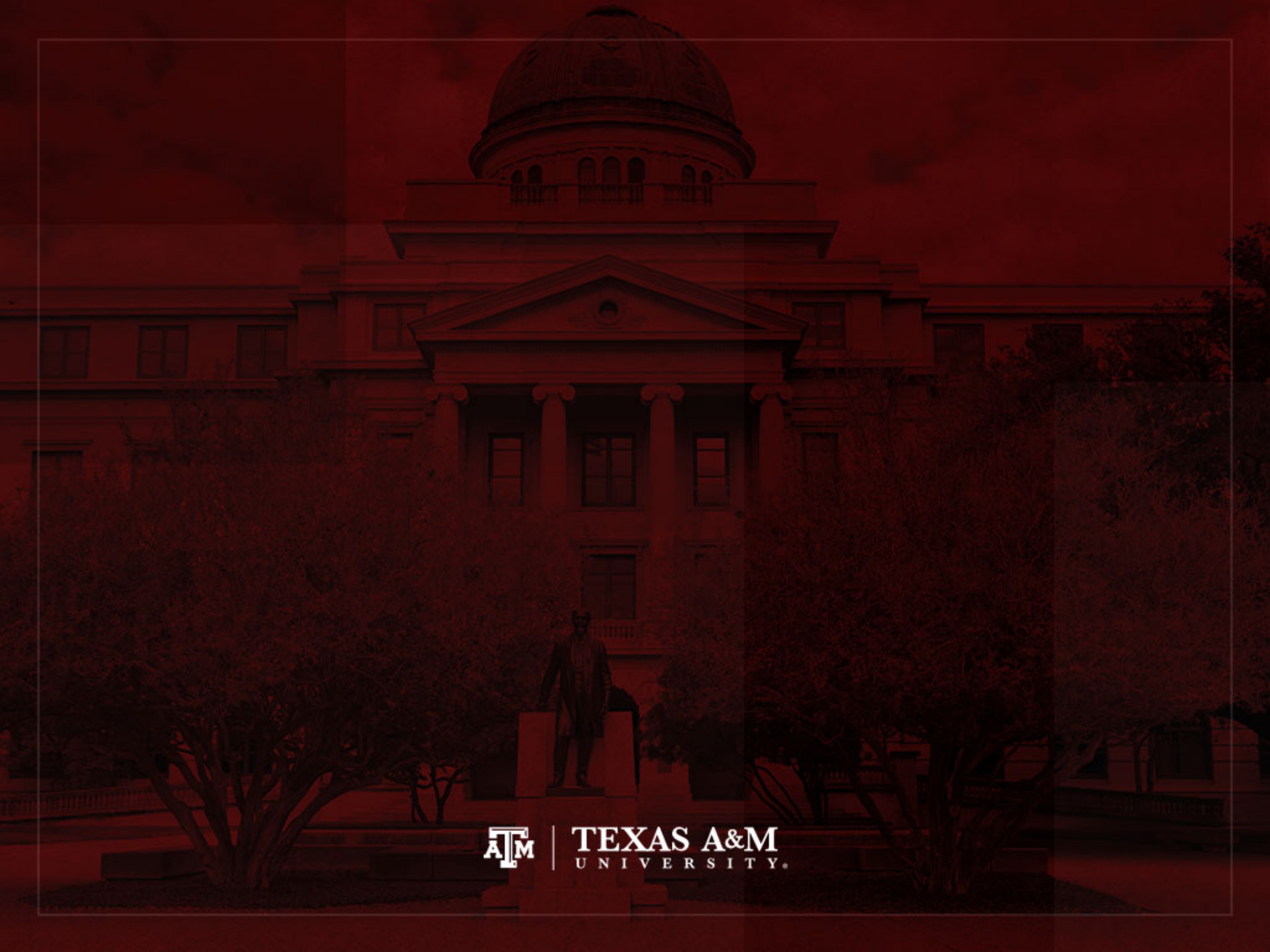


Source: Wachter, 2014, p. 61.

Stable population

- Alfred Lotka (1880–1949) used life tables in the development of his stable population theory

- If a population that is closed to migration experiences constant schedules of age-specific fertility and mortality rates
  - It will develop a constant age distribution
  - It will grow at a constant rate, irrespective of its initial age distribution


TEXAS A&M
UNIVERSITY

Life table (extra)

- Estimate overall mortality of population
  - **Assumption**: age-specific rates for the period continue unchanged into the future
  - **Synthetic cohort**: imaginary cohort of new born babies would experience a life table from a specific period
  - **Life expectancy**: average age at death for a hypothetical cohort born in a particular year and being subjected to the risks of death experienced by people of all ages in that year

Life table, U.S. women, 2010

Age interval	Number of females in the population	Number of deaths in the population	Age-specific death rates in the interval	Probabilities of death (proportion of persons alive at beginning who die during interval	Of 100,000 hypothetical people born alive: Number alive at beginning of interval	Number dying during age interval	Number of years lived: In the age interval	In this and all subsequent age intervals	Expectation of life: Average number of years of live remaining at beginning of age interval
x to $x + n$	${}_nP_x$	${}_nD_x$	${}_nM_x$	${}_nq_x$	l_x	${}_nd_x$	${}_nL_x$	T_x	e_x
Under 1	1,976,387	11,503	0.00582	0.005791	100,000	579	99,508	8,098,622	81.0
1–4	7,905,548	1,976	0.00025	0.000999	99,421	99	397,445	7,999,114	80.5
5–9	9,959,019	1,095	0.00011	0.000550	99,322	55	496,471	7,601,670	76.5
10–14	10,097,332	1,313	0.00013	0.000650	99,267	65	496,173	7,105,199	71.6
15–19	10,736,677	3,436	0.00032	0.001599	99,202	159	495,615	6,609,025	66.6
20–24	10,571,823	4,757	0.00045	0.002247	99,044	223	494,662	6,113,410	61.7
25–29	10,466,258	5,652	0.00054	0.002696	98,821	266	493,440	5,618,747	56.9
30–34	9,965,599	6,876	0.00069	0.003444	98,555	339	491,925	5,125,308	52.0
35–39	10,137,620	10,138	0.00100	0.004988	98,215	490	489,852	4,633,382	47.2
40–44	10,496,987	17,005	0.00162	0.008067	97,725	788	486,656	4,143,531	42.4
45–49	11,499,506	29,094	0.00253	0.012570	96,937	1,219	481,639	3,656,874	37.7
90–94	1,023,979	165,495	0.16162	0.575549	29,621	17,048	105,484	148,164	5.0
95–99	288,981	78,398	0.27129	0.808265	12,573	10,162	37,458	42,680	3.4
100+	44,202	20,403	0.46159	1.000000	2,411	2,411	5,222	5,222	2.2

Probability of dying ($_nq_x$)

- Need to convert age-specific death rates ($_nM_x$) to probabilities of dying ($_nq_x$)
- Probability of death relates the number of deaths during any given number of years to the number of people who started out being alive and at risk of dying

$$_nq_x = (n)(_nM_x) / 1+(a)(n)(_nM_x)$$

  - *(a)(n)*: average years lived per person by people dying in the interval. a=0.5 implies that deaths are distributed evenly over an age interval. For 0–1 age, a=0.85. For 1–4 age, a=0.60.
  - For last group, q=1.0.

Number of deaths ($_nd_x$) and alive (l_x)

- The life table assumes an initial population of 100,000 births (radix), which is subjected to the mortality schedule
  - Radix can also be 1
- Number of people dying during age interval ($_nd_x$) equals probability of death times number alive at beginning (l_x)

$$_nd_x = (_nq_x)(l_x)$$

- Subtracting those who died in the previous age interval gives the number of people still alive at the beginning of next age interval

$$l_{x+n} = l_x - {_nd_x}$$

Number of years lived ($_nL_x$)

- Number of years lived ($_nL_x$) has to consider that some people die before the end of the age interval

- The lower the death rates, more people will survive through an entire age interval

$$_nL_x = n(l_x - a_n d_x)$$

  - *a*: usually 0.5, which implies that deaths are distributed evenly over an age interval. For 0–1 age, *a*=0.85. For 1–4 age, *a*=0.60

- $_nL_x$ for the oldest, open-age interval

$$L_{100+} = l_{100} / M_{100}$$

  - l_{100}: number of survivors to oldest age
  - M_{100}: death rate at the oldest age

Cumulative number of years lived (T_x)

- Number of years lived are added up, cumulating from the oldest to the youngest ages

- Total number of years lived in a given age interval and all older age intervals (T_x)

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

- At the oldest age, T_x equals ${}_nL_x$

Life expectancy (e_x)

- Expectation of life is the average remaining lifetime
- It is the total years remaining to be lived at exact age x
- Division of total number of years lived (T_x) by number of people alive at that exact age (l_x)

$$e_x = T_x / l_x$$

- This index summarizes the level of mortality prevailing in a given population at a particular time

Probability of surviving (p_x)

- Probability of surviving from birth to age x is designated p_x

$$p_x = l_x / l_0$$

- We can also estimate the probability of surviving from one particular age group to the subsequent age group

Crude death and birth rates

- Crude death rate (CDR) equals total number of deaths (l_0) divided by total population (T_0)
- Crude birth rate (CBR) equals total number of births (l_0) divided by total population (T_0)

$$CDR = CBR = l_0 / T_0 = 1 / (T_0 / l_0) = 1 / e_0$$

Alternative interpretations

- **Synthetic cohort** (history of a hypothetical cohort)
  - Lifetime mortality experience of a single cohort of newborn babies, who are subject to specific age-specific mortality rates
  - Used in public health/mortality studies, calculation of survival rates for estimating population, fertility, net migration...
- **Stationary population**
  - Results from unchanging schedule of age-specific mortality rates and a constant annual number of births/deaths (radix)
  - Used in the comparative measurement of mortality and in studies of population structure

Same interpretation

- **x to x+n**
  - Period of life between two exact ages
  - For instance, 20–25 means the 5-year interval between the 20th and 25th birthdays

- **$_nq_x$**
  - Proportion of persons in the cohort alive at the beginning of an indicated age interval (x) who will die before reaching the end of that age interval (x+n)
  - Probability that a person at his/her x^{th} birthday will die before reaching his/her $x+n^{th}$ birthday

- **e_x (life expectancy)**
  - Average remaining lifetime (in years) for a person who survives to the beginning of the indicated age interval

l_x

- **Synthetic cohort**
  - Number of persons living at the beginning of the indicated age interval (x) out of the total number of births assumed as the radix of the table
- **Stationary population**
  - Number of persons who reach the beginning of the age interval each year

${}_nd_x$

- **Synthetic cohort**
  - Number of persons who would die within the indicated age interval (x to x+n) out of the total number of births assumed in the table
- **Stationary population**
  - Number of persons that die each year within the indicated age interval

${}_nL_x$

- **Synthetic cohort**
  - Number of person-years that would be lived within the indicated age interval (x to x+n) by the cohort of 100,000 births assumed

- **Stationary population**
  - Number of persons in the population who at any moment are living within the indicated age interval

T_x

- **Synthetic cohort**
  - Total number of person-years that would be lived after the beginning of the indicated age interval by the cohort of 100,000 births assumed
- **Stationary population**
  - Number of persons in the population who at any moment are living within the indicated age interval and all higher age intervals

Interpretation as stationary population

ABRIDGED LIFE TABLE FOR THE FEMALE POPULATION OF THE UNITED STATES: 2007

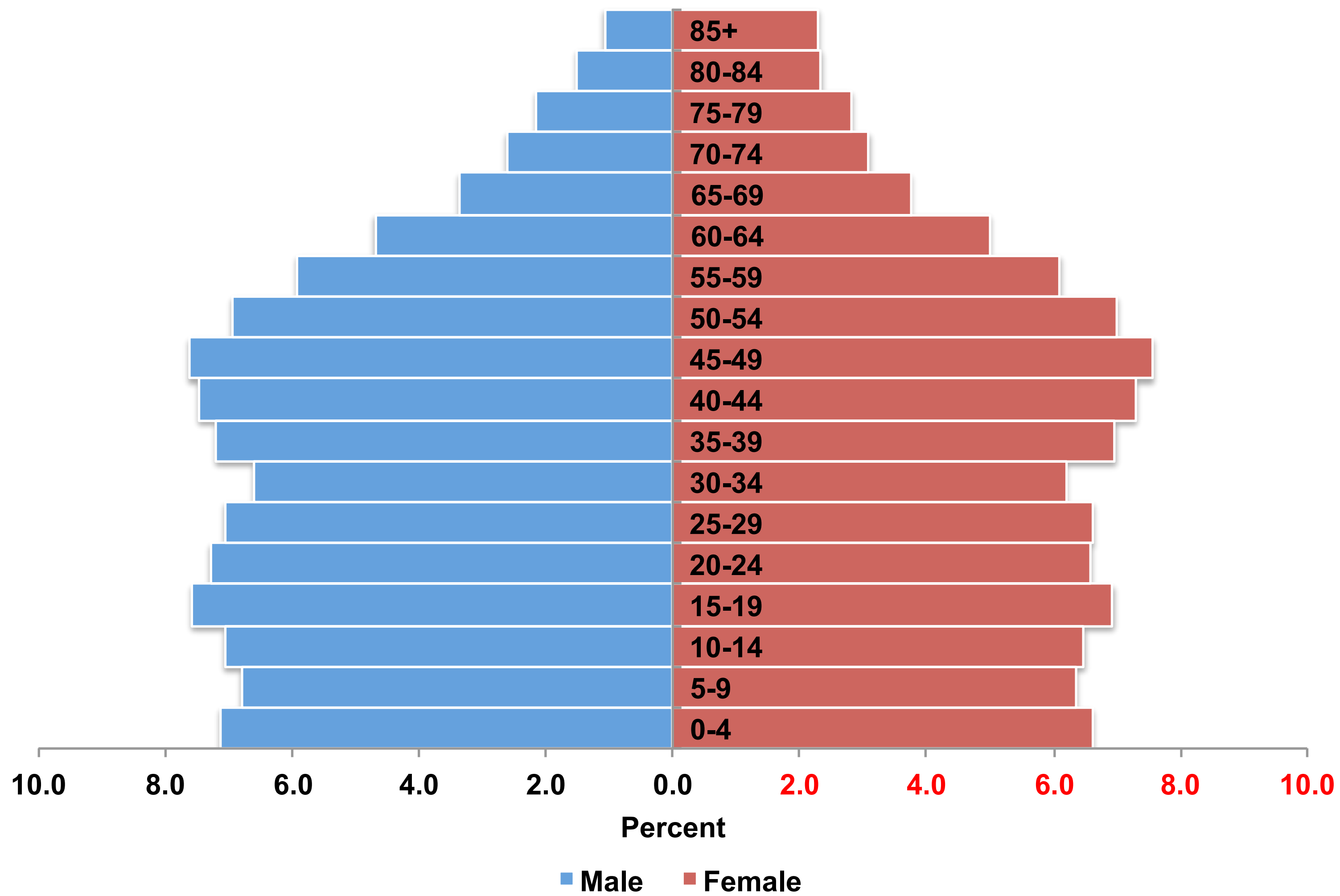
Age group	Width	Population	Deaths	Age-specific death rates	Proportion dying	Of 100,000 born alive: # living at beginning of interval	Of 100,000 born alive: # dying during interval	Stationary population: In the age interval	Stationary population: In this and following ages	Average remaining lifetime
	n	nPx	nDx	nMx	nqx	lx	ndx	nLx	Tx	ex
0	1	1,998,761	12,845	0.0064	0.0064	100,000	641	99,684	8,103,588	81.0
1-4	4	8,109,371	2,069	0.0003	0.0010	99,359	101	397,248	8,003,904	80.6
5-9	5	9,720,587	1,192	0.0001	0.0006	99,258	61	496,150	7,606,656	76.6
10-14	5	9,918,543	1,370	0.0001	0.0007	99,197	68	495,828	7,110,506	71.7
15-19	5	10,617,178	3,741	0.0004	0.0018	99,129	175	495,242	6,614,678	66.7
20-24	5	10,073,754	4,925	0.0005	0.0024	98,954	242	494,215	6,119,436	61.8
25-29	5	10,122,681	5,824	0.0006	0.0029	98,713	284	492,910	5,625,222	57.0
30-34	5	9,469,789	6,956	0.0007	0.0037	98,429	361	491,314	5,132,312	52.1
35-39	5	10,666,827	11,126	0.0010	0.0052	98,068	510	489,165	4,640,998	47.3
40-44	5	11,155,652	18,375	0.0016	0.0082	97,558	800	485,944	4,151,834	42.6
45-49	5	11,572,428	29,834	0.0026	0.0128	96,757	1,240	480,926	3,665,890	37.9
50-54	5	10,709,011	40,396	0.0038	0.0187	95,518	1,786	473,463	3,184,963	33.3
55-59	5	9,339,919	50,868	0.0054	0.0269	93,732	2,521	462,827	2,711,501	28.9
60-64	5	7,636,068	62,624	0.0082	0.0402	91,211	3,670	447,543	2,248,674	24.7
65-69	5	5,725,079	74,499	0.0130	0.0631	87,541	5,528	424,827	1,801,131	20.6
70-74	5	4,738,379	96,395	0.0203	0.0971	82,012	7,962	391,395	1,376,304	16.8
75-79	5	4,314,403	139,360	0.0323	0.1500	74,050	11,109	343,929	984,910	13.3
80-84	5	3,582,388	192,519	0.0537	0.2378	62,941	14,970	278,566	640,981	10.2
85+	---	3,511,395	464,781	0.1324	1.0000	47,971	47,971	362,415	362,415	7.6

ABRIDGED LIFE TABLE FOR THE MALE POPULATION OF THE UNITED STATES: 2007

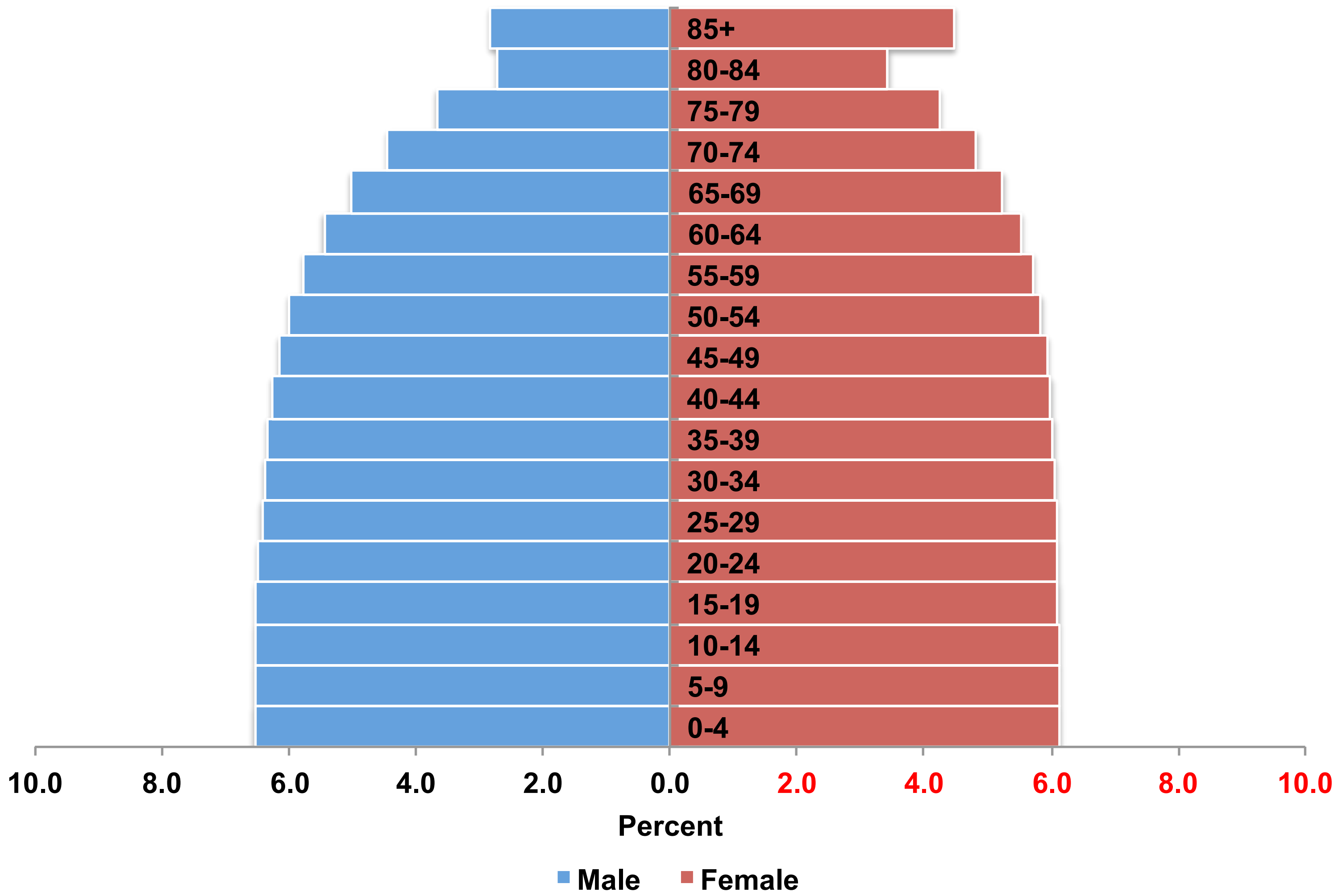
Age group	Width	Population	Deaths	Age-specific death rates	Proportion dying	Of 100,000 born alive: # living at beginning of interval	Of 100,000 born alive: # dying during interval	Stationary population: In the age interval	Stationary population: In this and following ages	Average remaining lifetime
	n	nPx	nDx	nMx	nqx	lx	ndx	nLx	Tx	ex
0	1	2,079,846	16,293	0.0078	0.0078	100,000	780	99,615	7,582,342	75.8
1-4	4	8,507,893	2,634	0.0003	0.0012	99,220	123	396,648	7,482,726	75.4
5-9	5	10,095,353	1,519	0.0002	0.0008	99,097	75	495,313	7,086,078	71.5
10-14	5	10,484,813	2,066	0.0002	0.0010	99,022	98	494,887	6,590,765	66.6
15-19	5	11,252,863	9,558	0.0008	0.0042	98,925	419	493,658	6,095,878	61.6
20-24	5	10,828,130	15,758	0.0015	0.0073	98,505	714	490,881	5,602,220	56.9
25-29	5	10,489,470	15,107	0.0014	0.0072	97,791	702	487,338	5,111,340	52.3
30-34	5	9,802,132	14,685	0.0015	0.0075	97,089	725	483,776	4,624,002	47.6
35-39	5	10,684,227	19,755	0.0018	0.0092	96,364	887	479,777	4,140,226	43.0
40-44	5	11,085,591	30,350	0.0027	0.0136	95,477	1,299	474,390	3,660,450	38.3
45-49	5	11,318,167	47,904	0.0042	0.0210	94,179	1,974	466,332	3,186,060	33.8
50-54	5	10,313,298	66,552	0.0065	0.0318	92,205	2,931	454,237	2,719,728	29.5
55-59	5	8,790,943	81,590	0.0093	0.0454	89,274	4,055	436,954	2,265,491	25.4
60-64	5	6,979,426	92,028	0.0132	0.0640	85,218	5,451	413,393	1,828,537	21.5
65-69	5	5,003,042	100,492	0.0201	0.0959	79,767	7,651	380,904	1,415,144	17.7
70-74	5	3,889,104	117,852	0.0303	0.1414	72,116	10,196	336,467	1,034,240	14.3
75-79	5	3,192,676	149,669	0.0469	0.2107	61,920	13,046	278,295	697,773	11.3
80-84	5	2,235,826	171,134	0.0765	0.3220	48,874	15,739	205,629	419,478	8.6
85+	---	1,606,146	248,866	0.1549	1.0000	33,135	33,135	213,850	213,850	6.5

Source: Formulas from Kintner (2003); Population data from 2007 ACS; Death data from CDC ((http://www.cdc.gov/nchs/data/dvs/mortfinal2007_worktable310.pdf).

Population, U.S., 2007



${}_nL_x$ from previous life tables, U.S., 2007

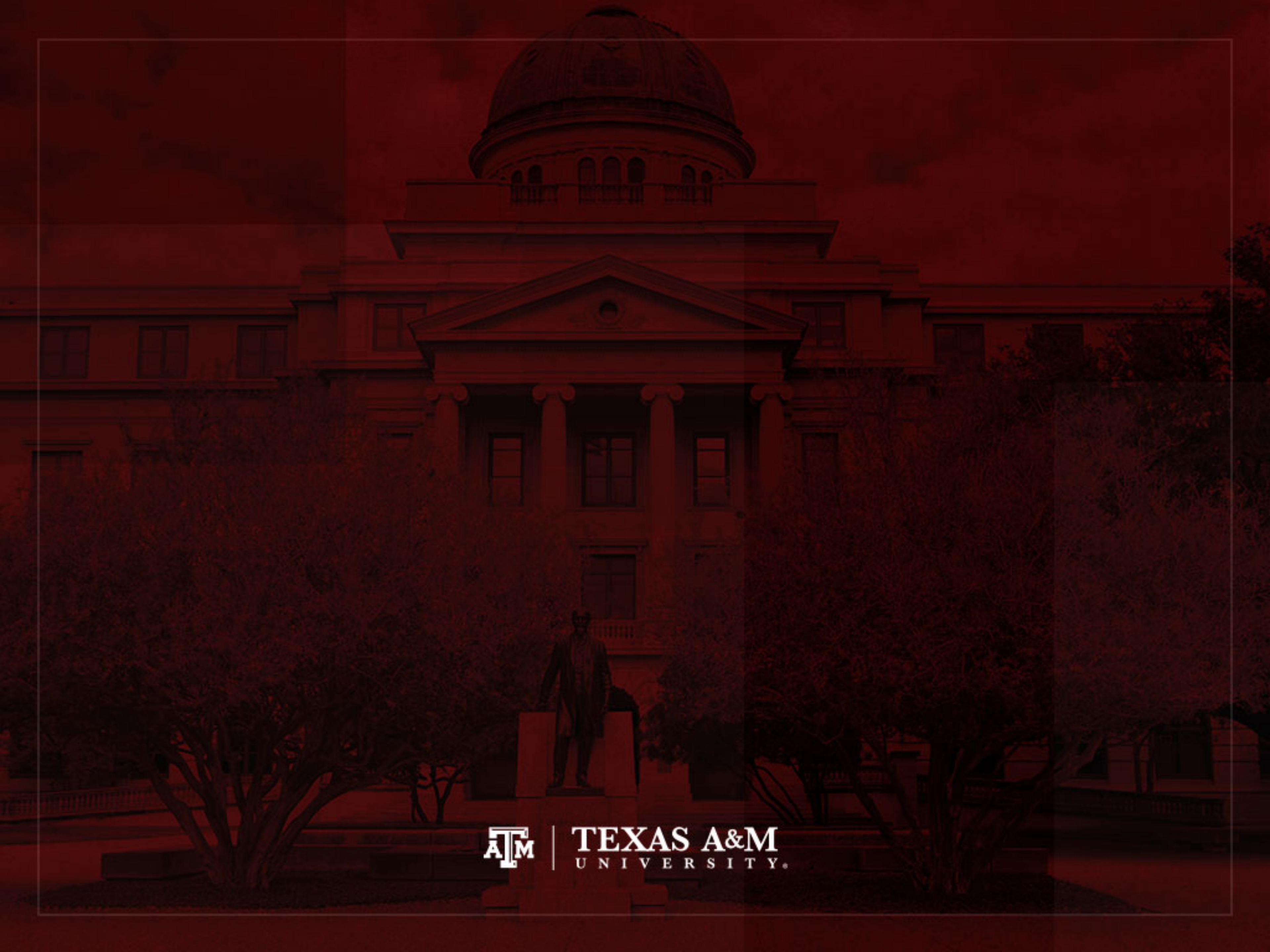


Problems with life tables

- We saw life tables based on complete empirical data
- We might experience some issues
  - Have partial information to build our life table
  - Have data for only some age groups
  - Information for some ages may be more reliable than for other ages
  - Have ideas about mortality level, but not a full life table to make projections
- We can use model life tables to solve these issues

Model life tables

- A life table constructed from mathematical formulas is called a model life table
  - Use mathematical formulas to fill in missing parts
  - Have a whole life table from partial information
  - Identify suspicious and poor quality data with model expectations
  - Supply standard assumptions for projections
  - Find regularities for the invention of indirect measures
  - Reconstruct rates from historical counts of births and deaths (inverse projection)


TEXAS A&M
UNIVERSITY

Short history of mortality in the world

- Defining the health and mortality transition
- Health and mortality changes over time
- Life span and longevity
- Disease and death over the life cycle
- Causes of poor health and death
- Health and mortality inequalities

Source: Weeks, 2015, Chapter 5, pp. 139–188.

Morbidity and mortality

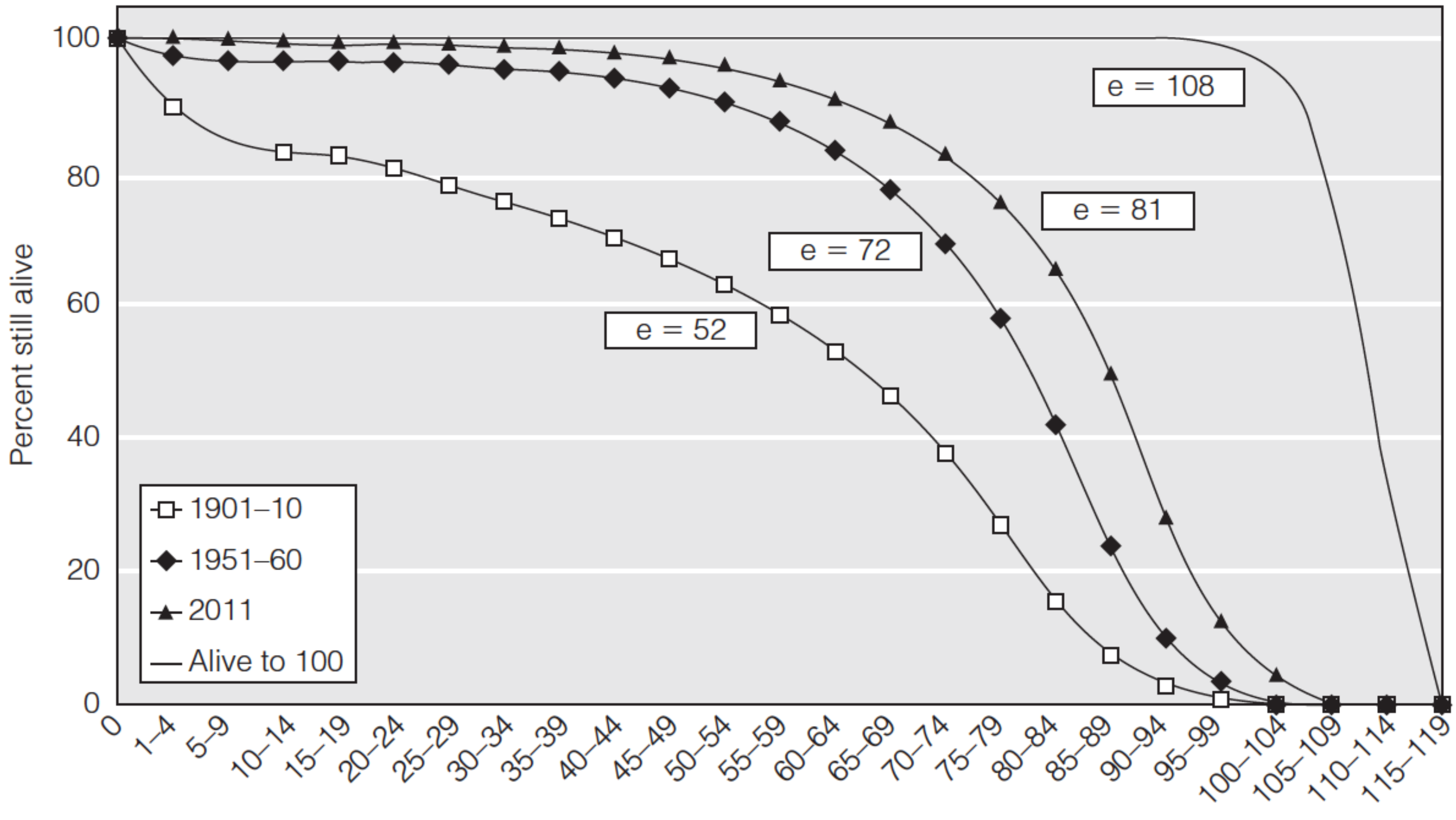
- Health, death: two sides of morbidity, mortality
  - Morbidity: prevalence of disease in a population
  - Mortality: pattern of death

- Health and mortality transition
  - Epidemiologic transition (Omran 1971)
  - Shift from prevailing poor health (high morbidity) and high death rates (high mortality) primarily from communicable diseases, occurring especially among the young...
  - To prevailing good health and low deaths rates from infectious diseases, with most people dying at older ages from degenerative diseases

Death at older ages

- For virtually all of human history, early death was commonplace
- Beginning about 200 years ago, we have been steadily pushing death to older ages
- The survival of more people to ever older ages is a key contribution to the demographic transition
- Most people now survive to advanced ages and die pretty quickly
- The variability by age in mortality is compressed, leading to an increased rectangularization of mortality...

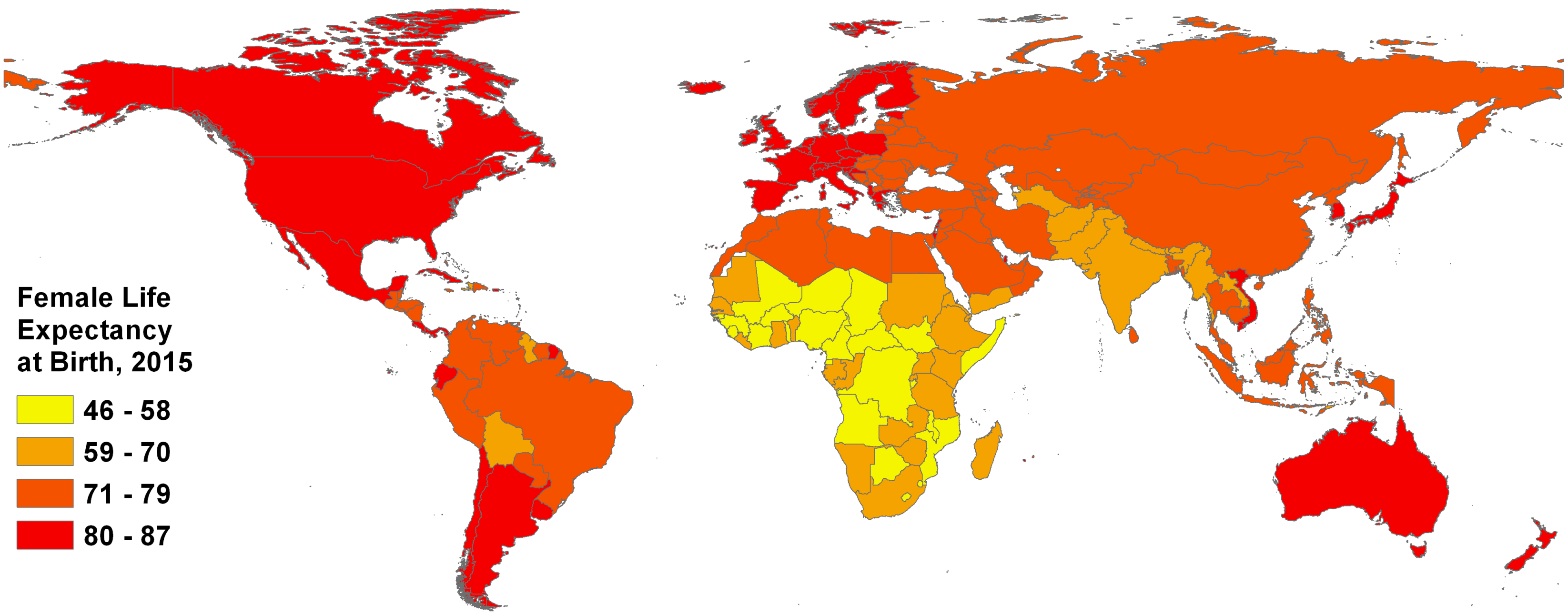
Rectangularization of mortality, United States



Changes over time

- For most of history, life expectancy fluctuated between 20 and 30 years
- About 2/3 of babies survived to their first birthday, and about 1/2 were still alive at age five
  - Now it's 99%
- Around 10% of people made it to age 65 in a pre-modern society
  - Now it's 90%

Female life expectancy at birth



Health improvements

Period and regions	Life expectancy (females)	% surviving to age				Births required for ZPG
		1	5	25	65	
Premodern	20	63	47	34	8	6.1
	30	74	61	50	17	4.2
US/Europe, late 18th/early 19th	40	82	73	63	29	3.3
Lowest Sub-Saharan	46	89	82	75	34	2.7
World average circa 2015	73	98	98	97	77	2.1
Mexico	78	99	99	98	84	2.1
United States	81	99	99	99	88	2.1
Canada	84	99	99	99	91	2.1
Japan (highest in the world)	86	99	99	99	93	2.1

The Roman era

- Life expectancy in the Roman era is estimated to have been 22 years

- People who reached adulthood were not too likely to reach a very advanced age, although of course some did

The Middle Ages

- The plague (black death) hit Europe in the 14th century, having spread west from Asia
  - An estimated 1/3 of the population of Europe may have perished from the disease between 1346 and 1350
- It appears to be the same disease that exists today
  - Not really known why it was so fatal in the past
  - Probably due to generally poor health and few resources to battle the disease

The Columbian exchange

- Columbus and other European explorers took diseases, horses, and guns to the Americas
  - Brought back new foods and few new diseases
- One explanation for relative ease with which Spain dominated Latin America after arriving around 1500
  - Explorers had immunity to the diseases they brought
  - Compared to the devastation the diseases affected indigenous populations

Industrial Revolution, 1760–1840

- Plague and Little Ice Age had receded
- Income improved nutrition, housing, and sanitation
- Life expectancy in Europe and the U.S.: ≈ 40 years
  - Was population growth a cause or effect of rising living standards?
- There were as many deaths to children under 5 as there were at 65 and over
  - Infectious diseases were still the dominant reasons for death, but their ability to kill was diminishing

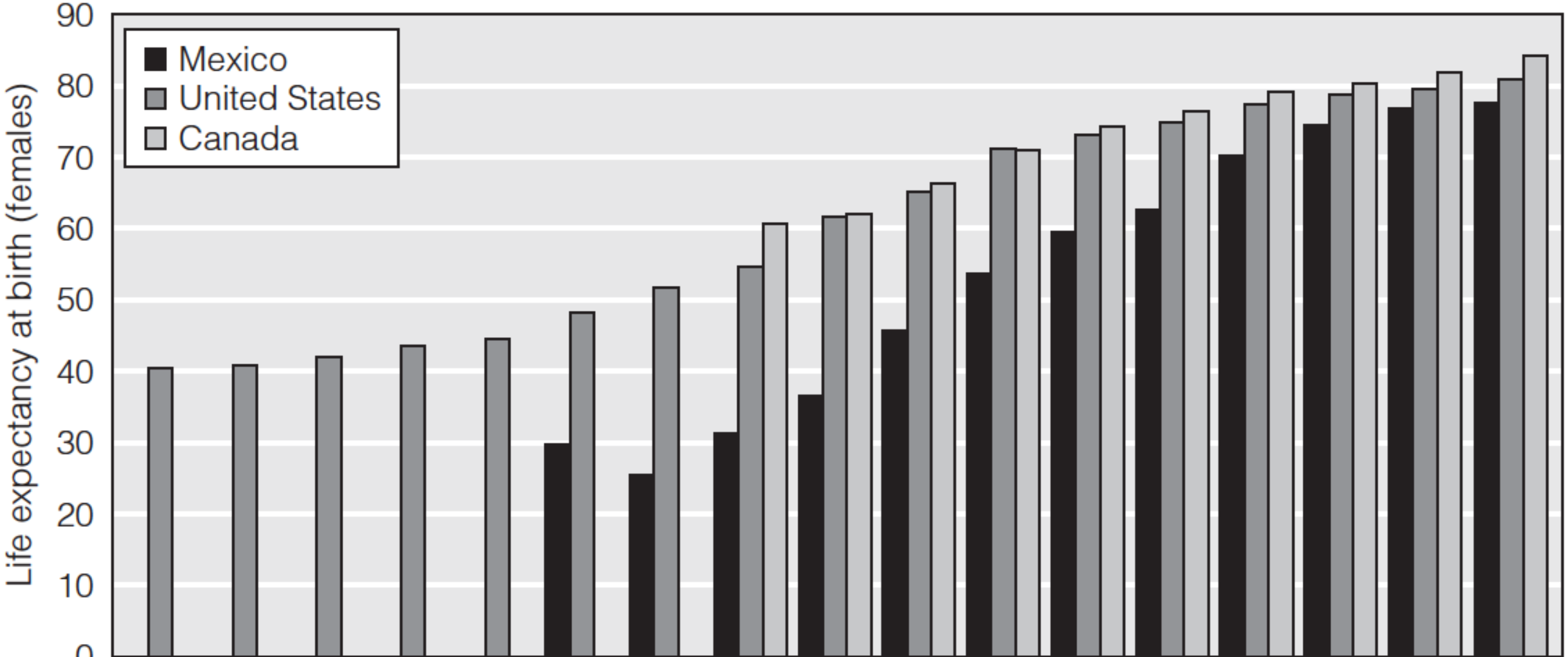
19^{th} century

- Key elements in postponing death
  - Belief in the power of human intervention (Western science)
  - Improved nutrition: occurred first in Western Europe
  - Clean water, toilets, bathing facilities
  - Sewerage in cities: sanitation studies in Liverpool
  - Small pox vaccinations: Edward Jenner in England
- Validation of germ theory
  - Ignaz Semmelweis in Vienna: pioneer of antiseptic procedures
  - Joseph Lister in Glasgow: cleanliness principals in surgery
  - Louis Pasteur in Paris: formal experiments about germs, diseases

20th century

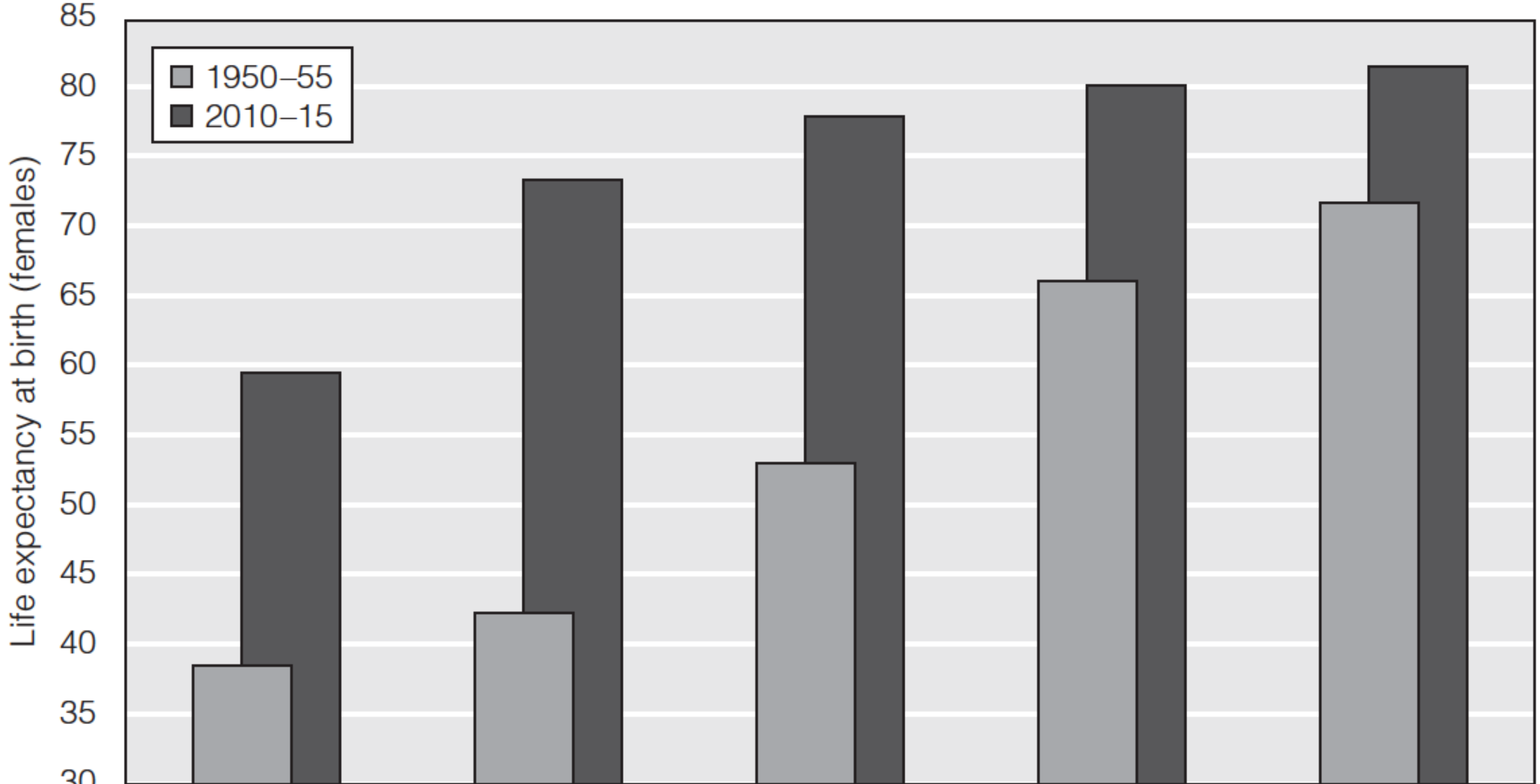
- Health as a social movement
  - Leading to government-organized universal health care systems in all rich countries except the U.S.
- Antibiotics emerging around WWII
- More vaccinations
- Oral rehydration therapy for infants and adults
- Advanced diagnoses, drugs, and other treatments for degenerative diseases to keep older people alive longer

Improvements in life expectancy



	1850	1860	1870	1880	1890	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010
Mexico						29.8	25.4	31.5	36.7	45.7	53.7	59.5	62.7	70.3	74.5	76.9	77.7
United States	40.5	40.9	42	43.5	44.5	48.3	51.8	54.6	61.6	65.2	71.1	73.1	74.8	77.4	78.8	79.6	80.9
Canada								60.6	62.1	66.3	70.9	74.3	76.5	79.1	80.4	81.9	83.5

World War II: a turning point



	Africa	Asia	Latin America	Europe	North America
1950–55	38.6	42.4	53.1	66.1	71.7
2010–15	59.6	73.4	77.9	80.1	81.5

Postponing death

- Two ways to postpone death to the oldest possible ages

- Prevent diseases from occurring or spreading when they do occur (prevention)
  - Vaccinations, clean water, sanitation, good nutrition
  - No physicians needed

- Curing people of disease when they are sick
  - Diagnostic technology, drugs, skilled physicians

Nutrition transition and obesity

- Poor were skinny because only the rich could afford to access enough quantities of food
  - Not any more
- Nutrition transition is a worldwide shift toward
  - Diet high in fat and processed foods
  - Diet low in fiber
  - Less exercise
  - Increases in degenerative diseases

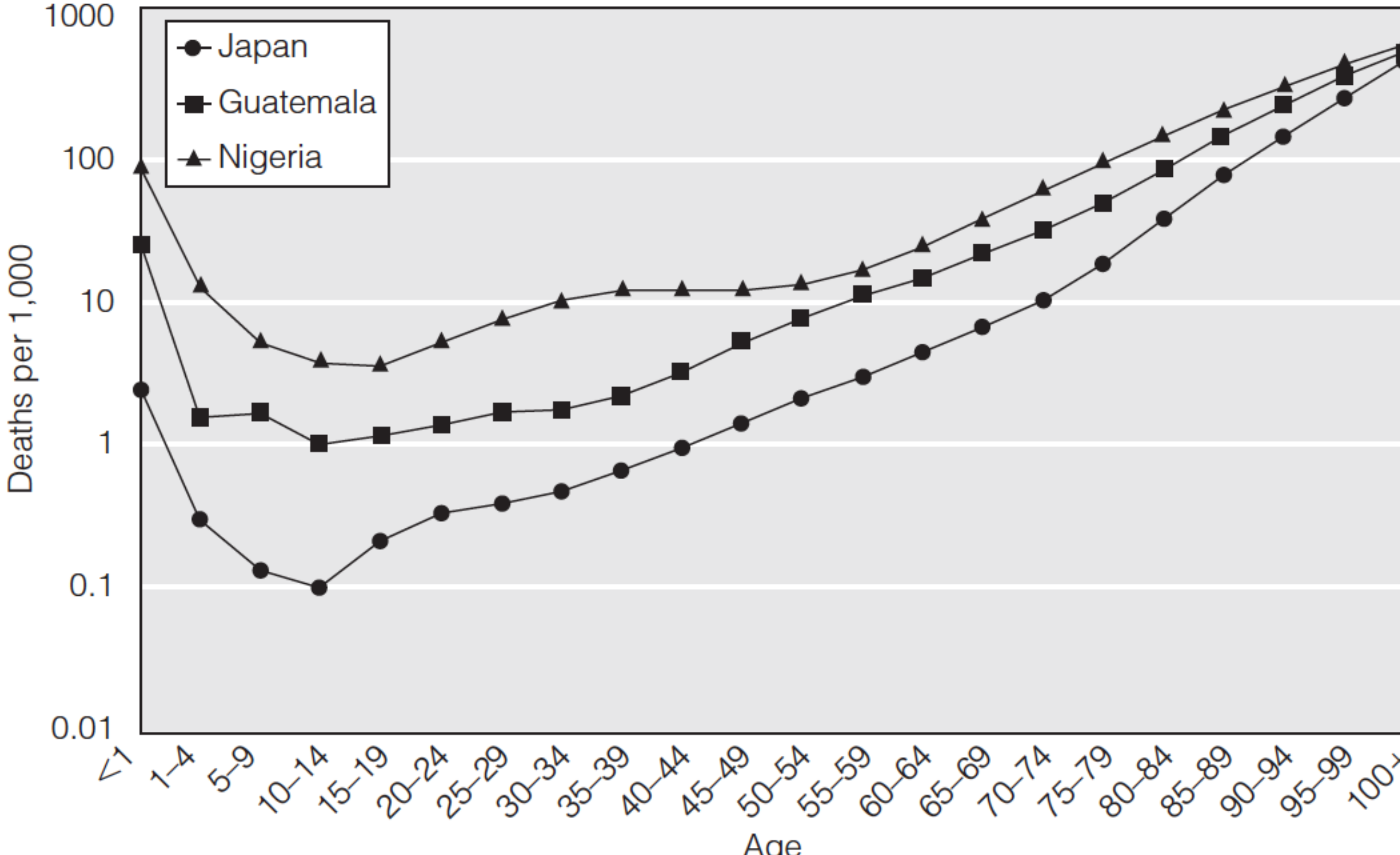
Life span and longevity

- Life span: oldest age to which human beings can survive
  - 122 years and 164 days (by 2016)
  - It is almost entirely a biological phenomenon
- Longevity/life expectancy: age at which we actually die
  - Expected number of years to be lived, on average, by a particular population at a particular time
  - Currently about 71 for all humans
  - It has biological and social components
- Populations with high mortality tend to have high morbidity
  - This is not a one-to-one relationship
  - We may live longer even though not being very healthy

Mortality by age

- Humans are like most other animals with respect to the general pattern of death by age
  - The very young and the old are most vulnerable
  - Young adults are least likely to die
- Risks of death are relatively low
  - After the initial year of life, lasting at least until middle age
  - Corresponds to reproductive ages
- Beyond middle age
  - Mortality increases
  - Although at a decelerating rate

Highest death rates, 2011: very young and the old



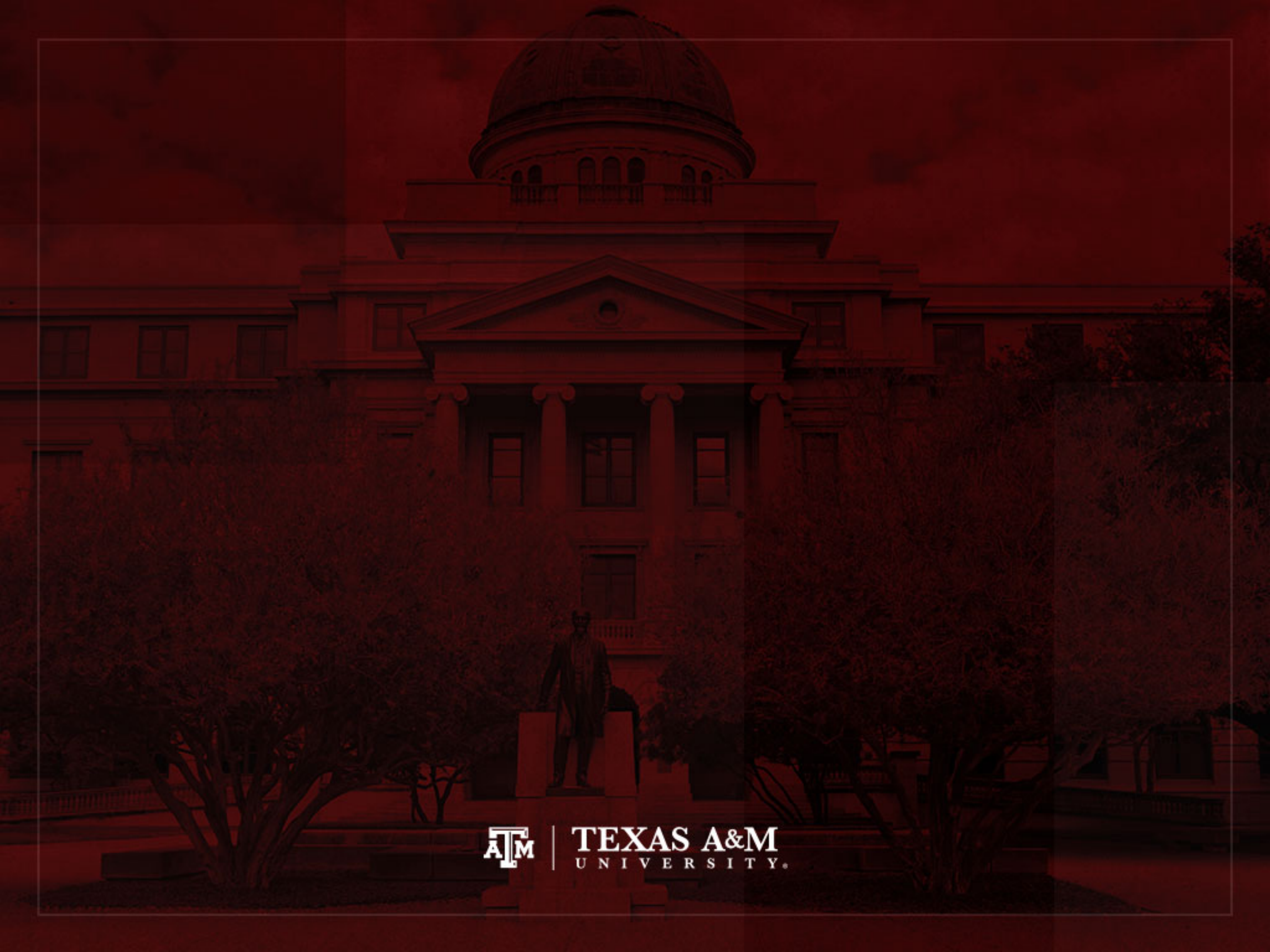
Mortality by sex (gender)

- Women (sex)
  - Have a lower probability of death at every age from the moment of conception'

- Women (gender)
  - Unless society intervenes with a lower status for women that gives them less food, less access to health care, less education, lower earnings...

Other mortality differentials

- Urban and rural differentials
  - Urban now better than rural
- Neighborhood inequalities
  - Slums are bad for your health
- Educational differentials
  - Better educated live longer
- Social status differentials
  - The rich live longer
- Race and ethnicity differentials
  - Being different will be used against you
- Marital status
  - Being married is good for your health


ATM
TEXAS A&M
UNIVERSITY

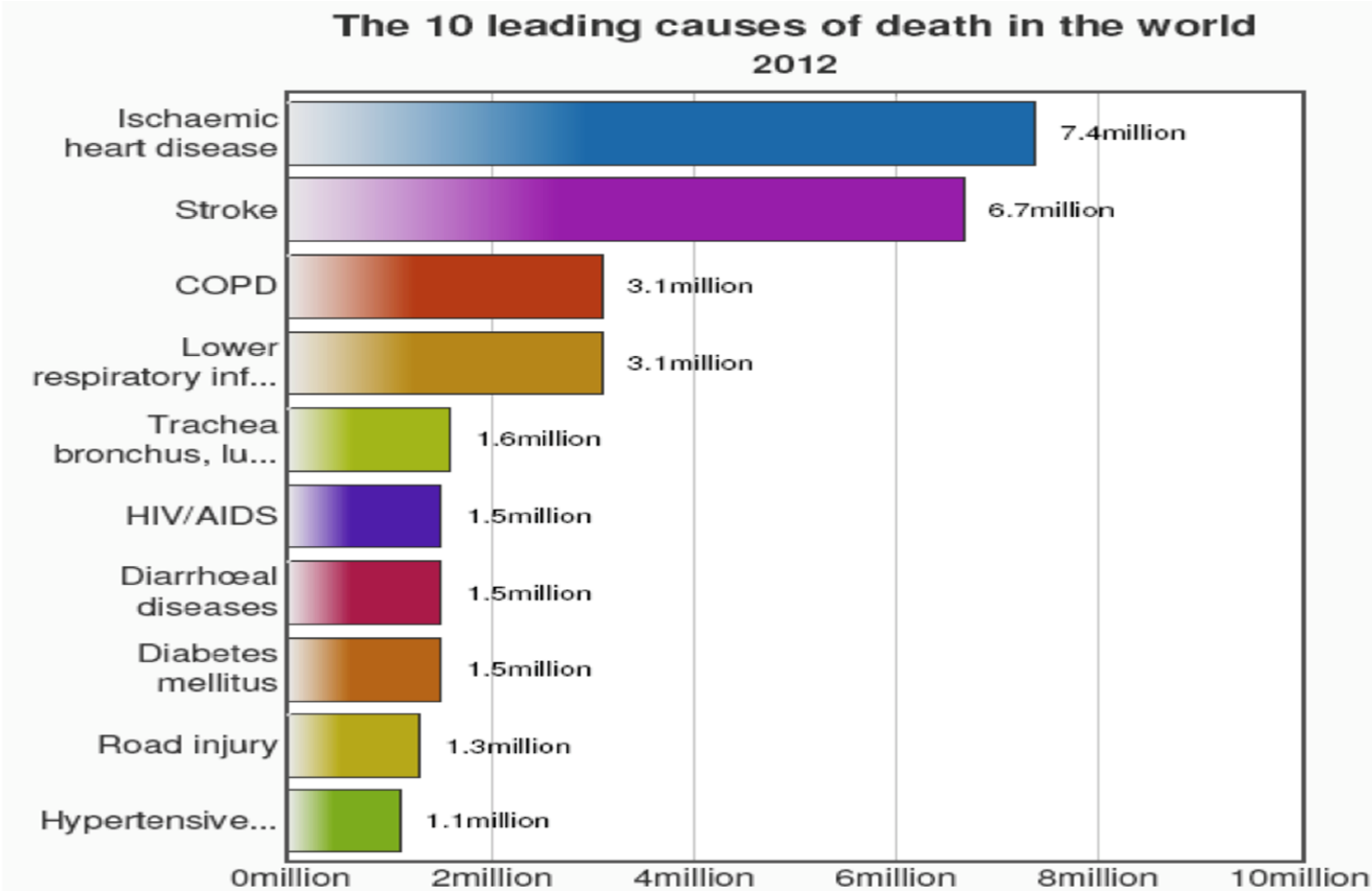
Mortality trends and causes of death

- Categories of diseases according to the World Health Organization
  - Communicable diseases
  - Noncommunicable diseases
  - Injuries

Communicable diseases

- Bacterial (e.g., tuberculosis)
- Viral (e.g., measles)
- Protozoan (e.g., malaria)
- Maternal conditions
  - Lack of prenatal care
  - Delivering somewhere besides a hospital
  - Seeking an unsafe abortion
- Perinatal conditions
  - "Surrounding birth" — just before and just after birth
- Nutritional deficiencies

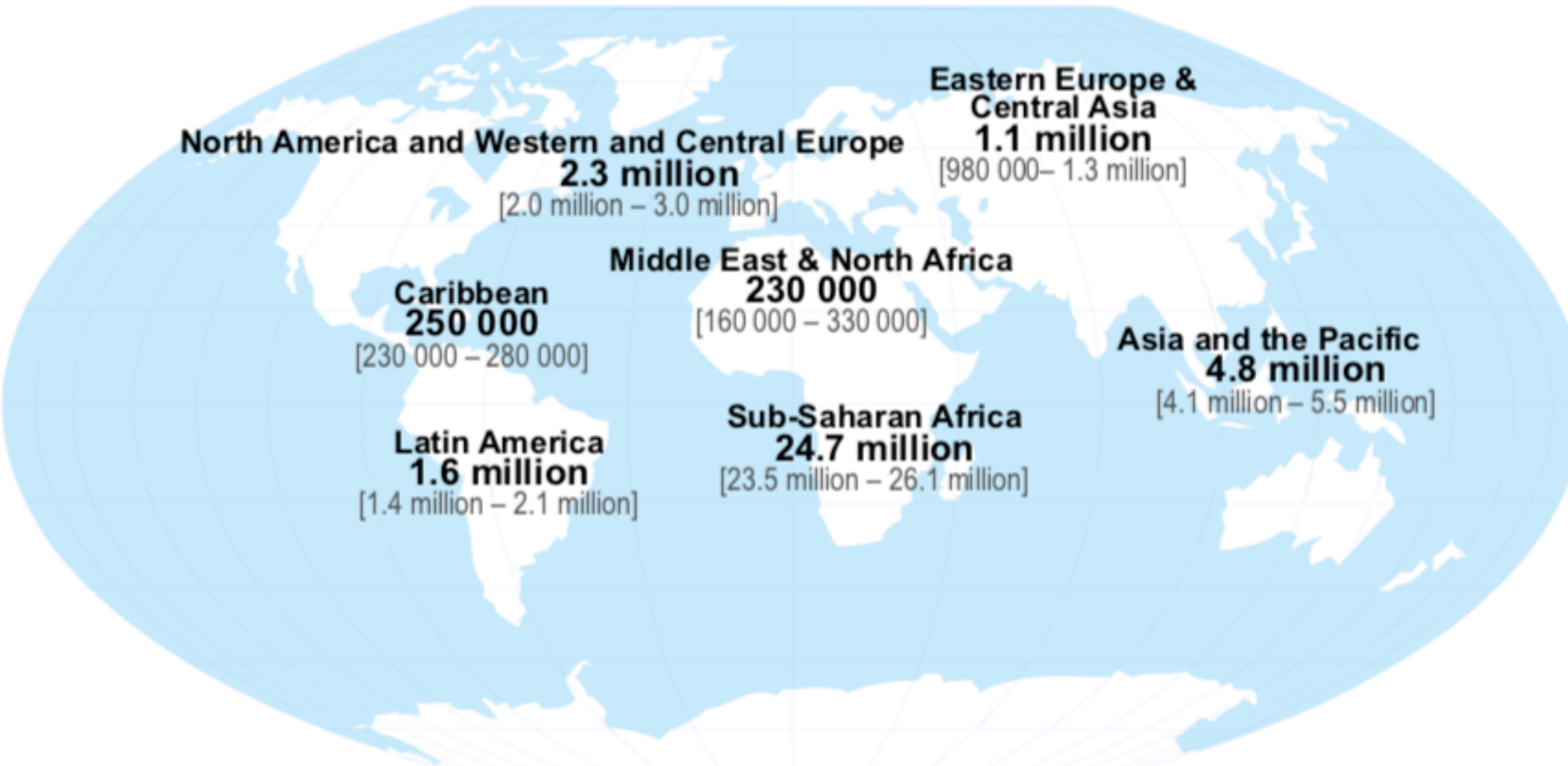
Cause of death	Broad category of cause	Number of deaths in world 2011 (millions)	Top ten death rates (per 100,000 population), 2011			
			High income countries	Upper middle income countries	Lower middle income countries	Low income countries
Ischemic heart disease	Non-Com.	7.0	119	120	93	47
Stroke	Non-Com.	6.2	69	126	75	56
Lower respiratory infection	Com.	3.2	32	22	60	98
Chronic obstructive pulmonary disease (COPD)	Non-Com.	3.0	32	45	51	
Diarheal diseases	Com.	1.9			47	69
HIV/AIDS	Com.	1.6			24	70
Tranchea bronchus, lung cancers	Non-Com.	1.5	51	28		
Diabetes mellitus	Non-Com.	1.4	21	20	20	
Road injury	Injury	1.3		21	19	
Prematurity	Com.	1.2			27	43
Alzheimer's disease and other dementias	Non-Com.		48			
Colon rectal cancers	Non-Com.		27			
Hypertensive heart disease	Non-Com.		20	18		
Breast cancer	Non-Com.		16			
Malaria	Com.					38
Tuberculosis	Com.				22	32
Protein-energy malnutrition	Com.					32
Birth asphyxia and birth trauma	Com.					30
Liver cancer	Non-Com.			19		
Stomach cancer	Non-Com.			18		
Life expectancy at birth (both sexes)			80	74	66	60



Source: World Health Organization. Available at: http://www.who.int/mediacentre/factsheets/fs310/en/ (accessed April 29, 2016)

Source: Poston, Bouvier, 2017.

Adults and children estimated to be living with HIV, 2013

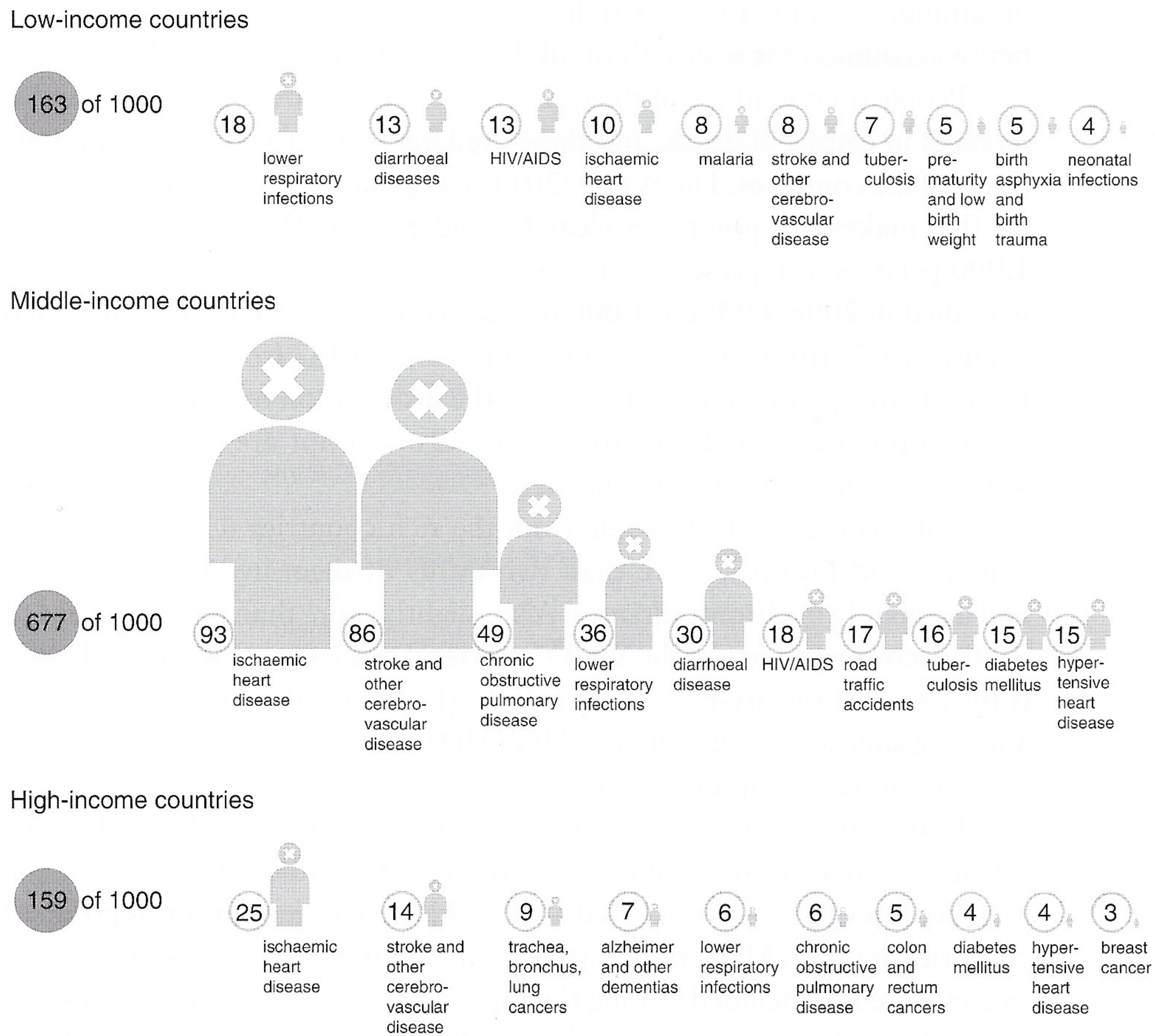


Total: 35.0 million

95% confidence interval: [33.2 million – 37.2 million]

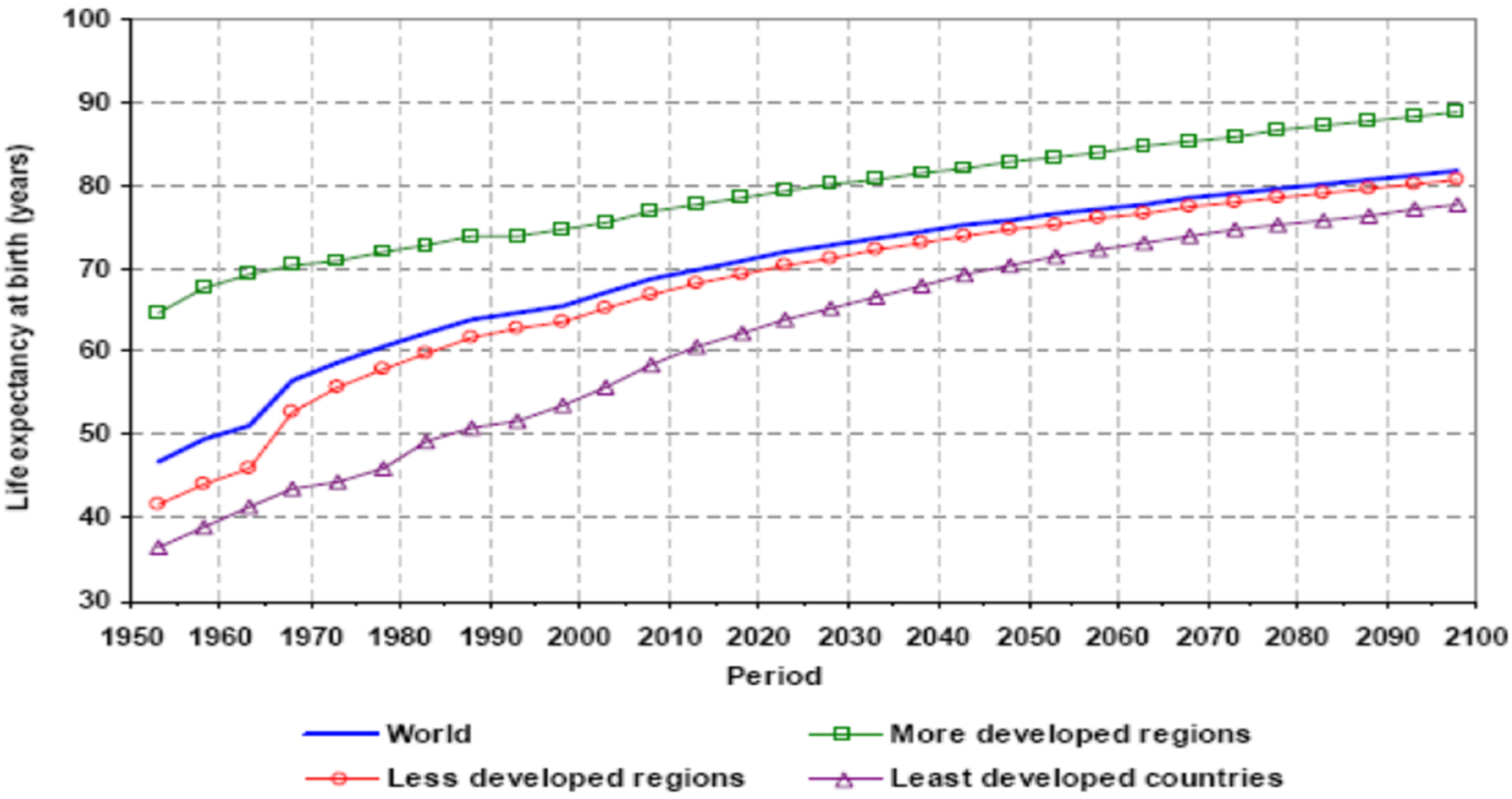
Source: UNAIDS (http://www.unaids.org/sites/default/files/media_asset/01_Epi_slides_2014July.pdf).

Top ten causes of death, 2008



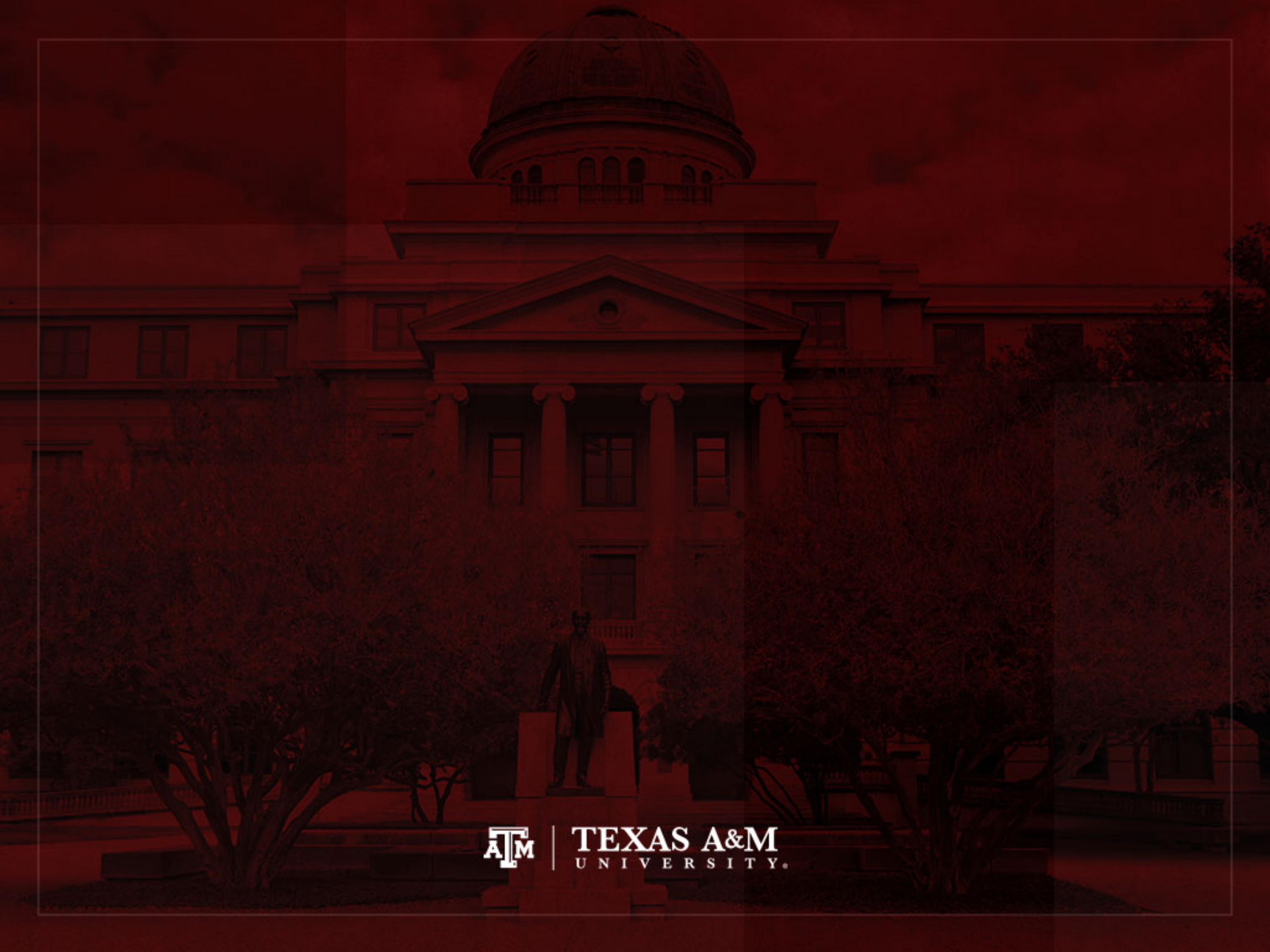
Source: World Health Organization, 2011; Poston, Bouvier, 2017.

Figure 7.6. Life Expectancy at Birth: World and More developed, Less developed, and Least developed regions, 1950 to 2100



Source: United Nations, 2013d: 16.

Source: Poston, Bouvier, 2017.


TEXAS A&M
UNIVERSITY

Mortality and longevity in the U.S.

- Mortality started dropping gradually
  - In response to changes in the socioeconomic conditions and the environment of modernization
  - Much of the mortality reduction started to happen before the initiations of any appreciable public health measures
- Life expectancy increased
  - 46 for males and 48 for females in 1900
  - 76 for males and 81 for females in 2013

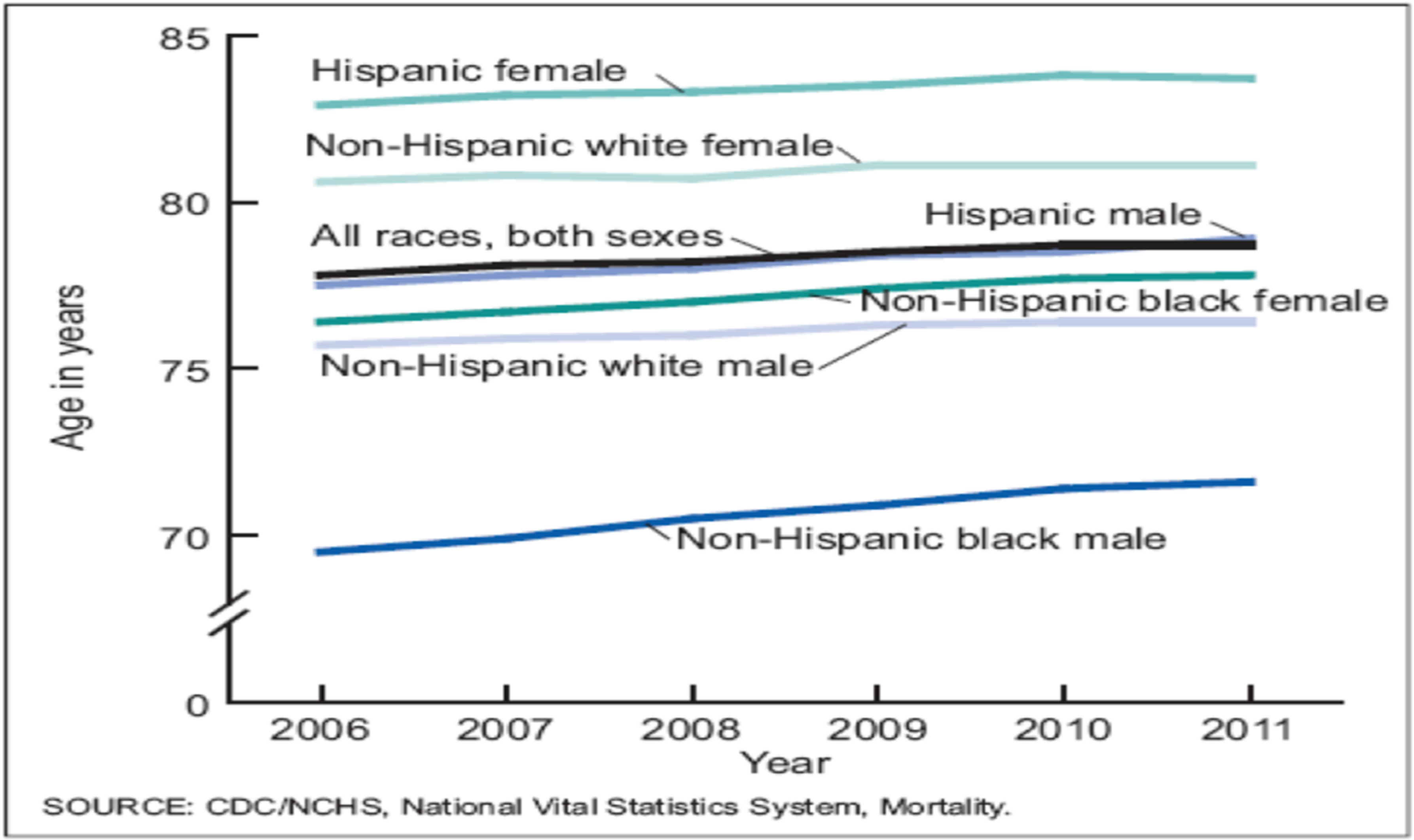
Mortality in the United States

- Most improvements happened from 1900 to 1950
  - Germ theory: control of infectious and parasitic diseases
  - Boiling bottles and milk, washing hands, protecting food from flies, isolating sick children, ventilating rooms, improving water supply, sewage disposal
- Since 1950s, life expectancy improvements is due to prevention and control of chronic diseases
  - Heart disease, stroke...

Hispanic paradox

- The Hispanic epidemiological paradox is the empirical finding that Hispanics have death rates of about the same magnitude as, and sometimes lower than, whites
- Also known as the Latino mortality paradox
- These findings are more evident for those of Mexican origin

Life expectancy at birth by race/ethnicity: U.S., 2006–2011



Source: Poston, Bouvier, 2017.

Explaining the Hispanic paradox

- Data artifacts
  - **Underreporting** of Hispanic-origin identification on death certificates
  - **Misstatement of age**, perhaps overstatement, at the older ages
- Migration effects
  - **Healthy migrant effect:** self-selection of immigrants in better physical and mental health
  - **Salmon bias:** Mexican Americans in poor health return to Mexico at old ages (return migrant effect)
- Cultural effects
  - **Better dietary** practices of Latinos and **stronger family** obligations and relationships

Racial crossover

- Life expectancy at birth is the lowest for blacks compared with Hispanics and whites
- For most of their lives, blacks have higher death rates than Hispanics and whites
- The situation changes at the very oldest ages
- By late life, death rates for blacks become lower than those for whites, and in some cases lower than those for Hispanics

Life expectancy at ages 70, 80, 90, and 100 by race/ethnicity and sex: United States, 2010

	Hispanics		NH-Whites		NH-Blacks	
Age	Males	Females	Males	Females	Males	Females
70	15.4	18.0	14.2	16.4	12.8	15.7
80	9.0	10.8	8.1	9.6	7.8	9.6
90	4.5	5.4	4.0	4.8	4.4	5.2
100	2.3	2.6	2.0	2.3	2.5	2.8

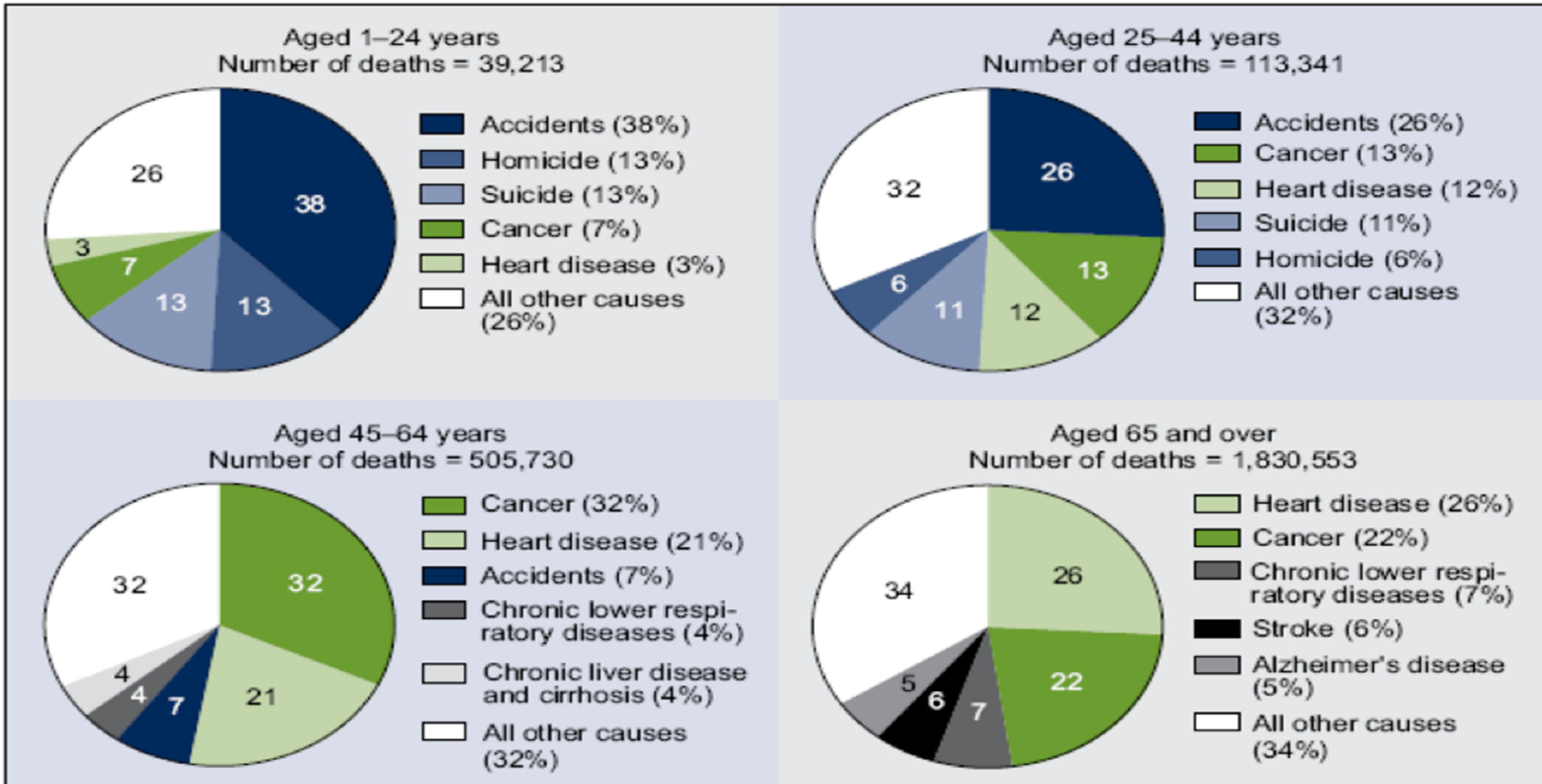
Source: Poston, Bouvier, 2017.

Explaining the racial crossover

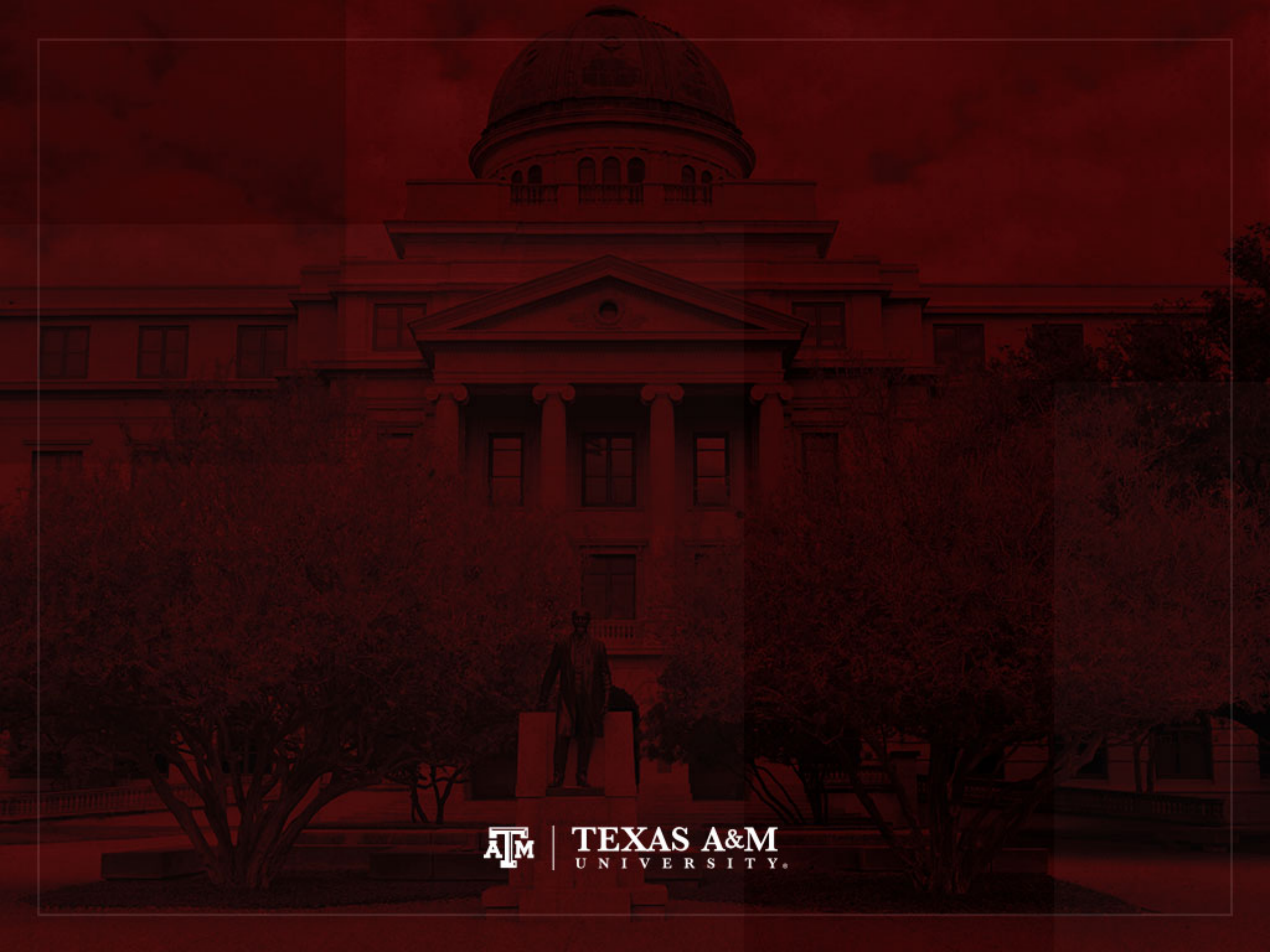
- Age misreporting on death certificates
  - Overstatement of age
  - But this would only postpone crossover to later ages, not eliminating it

- Population heterogeneity in frailty
  - The surviving elderly black population is a more robust group of disadvantaged individuals
  - The more frail blacks die before the age of 80 or 90
  - This produces a more robust group of blacks that live longer than the majority

Percent distribution of five leading causes of death by age group: United States, 2011



Source: Poston, Bouvier, 2017.


ATM
TEXAS A&M
UNIVERSITY

Infant mortality

- The infant mortality rate (IMR) is the most common measure of infant death
  - It is the number of deaths in a year to children under age 1 per 1,000 babies born in the year
- Declining infant mortality is key to population growth
- Reduction attributable especially to the development of oral rehydration therapy (ORT)
  - A solution of salts and sugars taken orally
  - Treats diarrhea: A major cause of death in young children
  - Developed in labs, tested in the field, especially Bangladesh
  - One of its founders still holds a teaching position at Harvard School of Public Health (Dr. Richard Cash)

Infant mortality, 2015

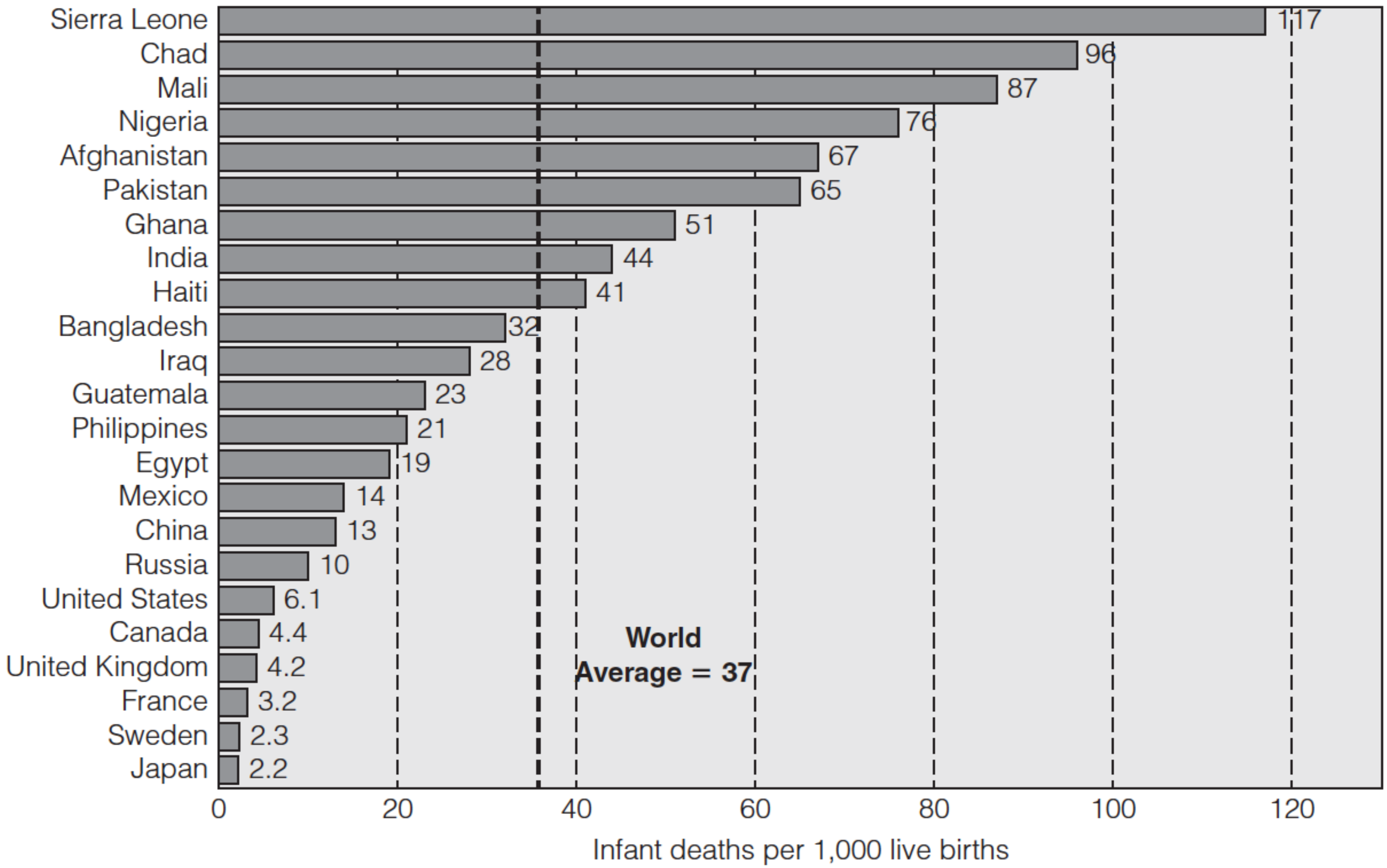
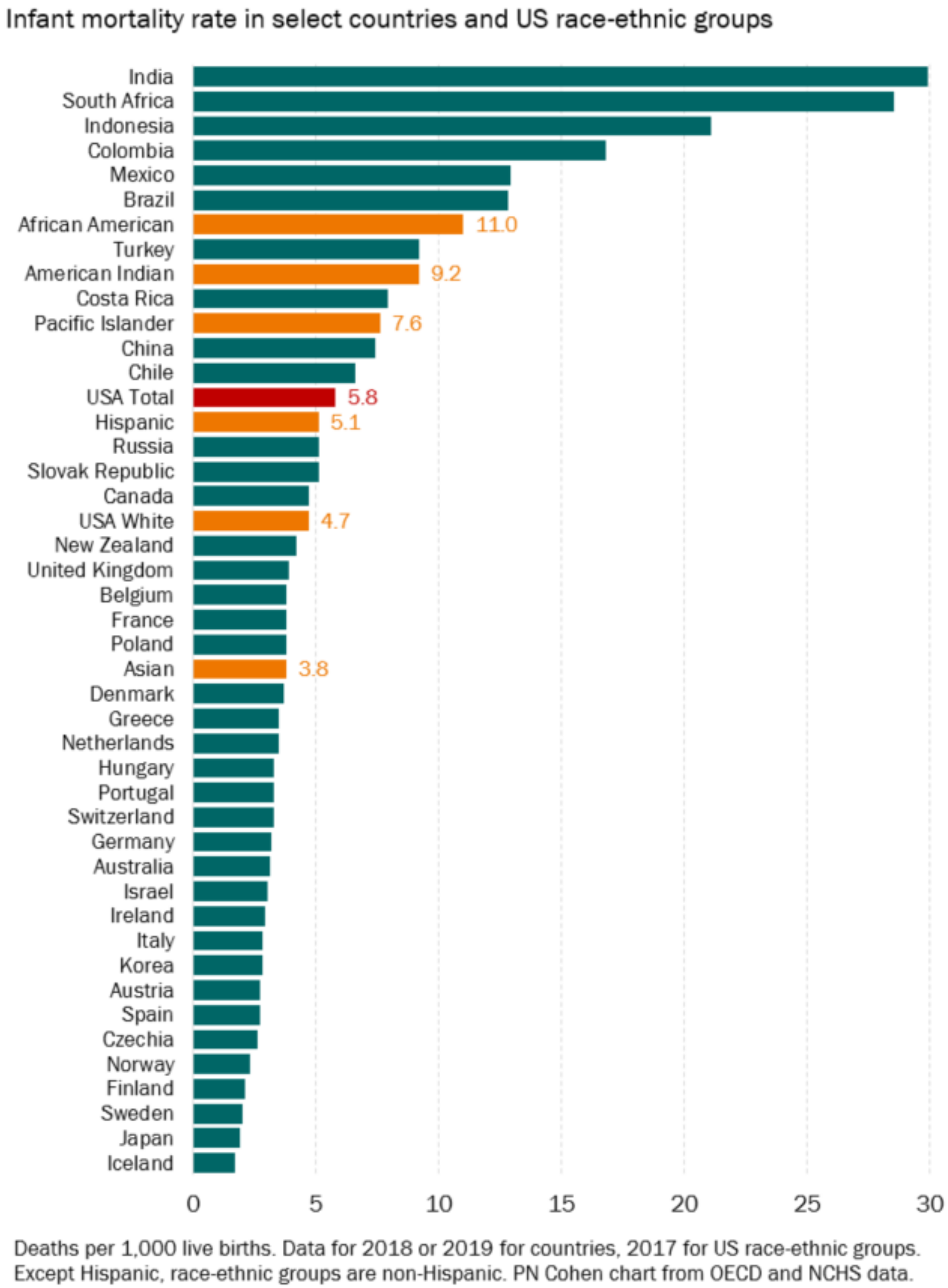


Table 7.4. Countries with the Highest and the Lowest Infant Mortality Rates in the World, 2013

Highest infant mortality rates		Lowest infant mortality rates	
Central African Republic	116	Iceland	1.8
Congo, Dem. Rep.	109	Finland	1.8
Chad	96	Japan	1.9
Angola	96	Singapore	2.0
Guinea-Bissau	94	Estonia	2.1
Sierra Leone	92	Sweden	2.3

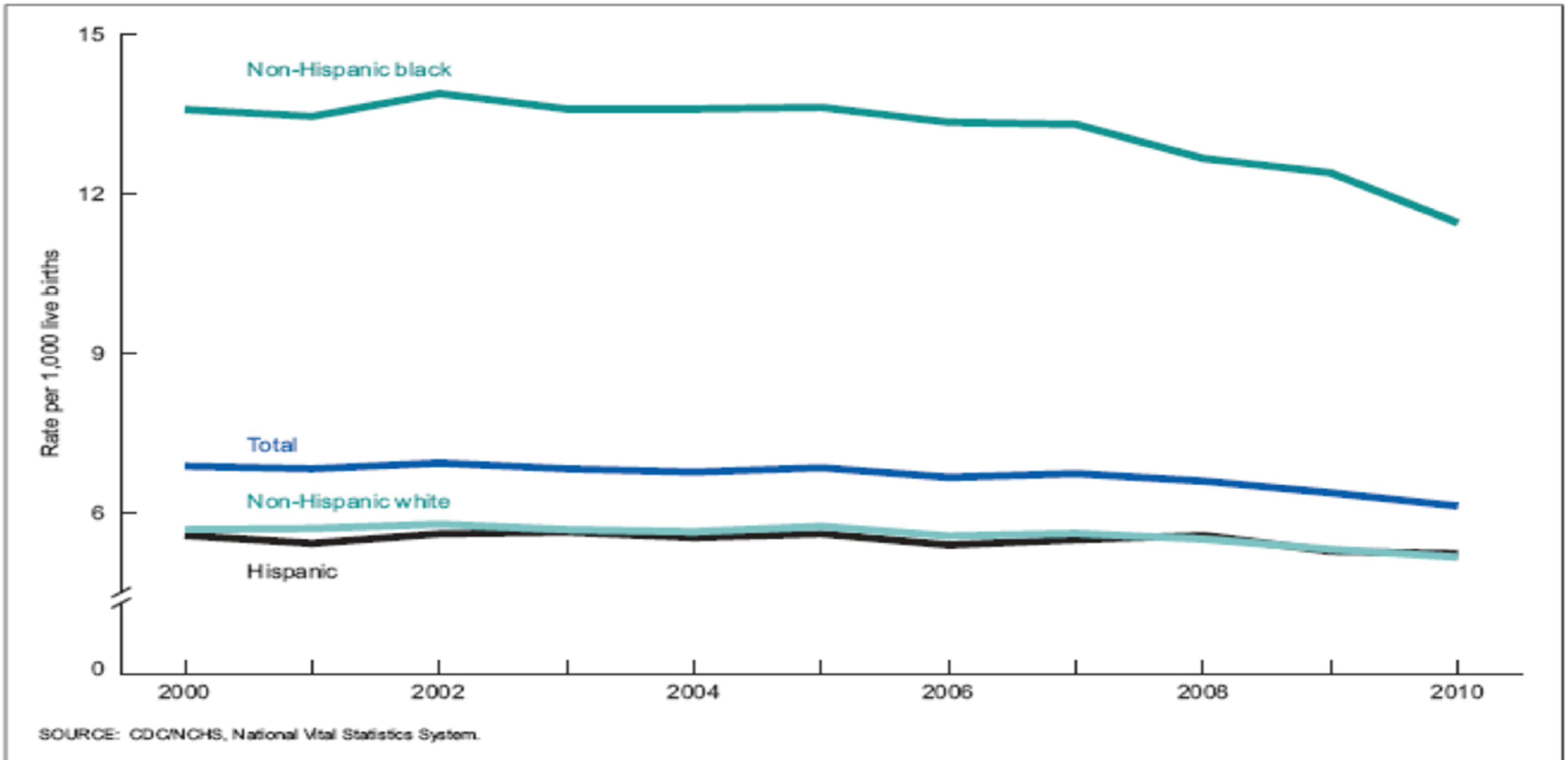
Source: Population Reference Bureau, 2014.

Source: Poston, Bouvier, 2017.



Source: Professor Philip N. Cohen, Department of Sociology, University of Maryland.

Infant mortality rates by mother's race/ethnicity: United States, 2000–2010



Source: Poston, Bouvier, 2017.

Neonatal and postneonatal mortality rates

- The infant mortality rate (IMR) may be thought of as the sum of two rates
- Neonatal mortality rate (NMR)
  – Deaths of babies aged 28 days or less per 1,000 live births
- Postneonatal mortality rate (PMR)
  – Deaths of babies aged between 29 days and 1 year per 1,000 live births

Source: Poston, Bouvier, 2017.

Neonatal mortality rates and number of neonatal deaths

Region	Neonatal mortality rate (deaths per 1,000 live births)			Number of neonatal deaths (thousands)	
	1990	2013	Decline (percent) 1990–2013	1990	2013
Developed regions	8	3	55	118	48
Developing regions	36	22	40	4,554	2,714
Northern Africa	30	13	56	109	53
Sub-Saharan Africa	46	31	32	977	1,066
Latin America and the Caribbean	22	9	58	255	101
Caucasus and Central Asia	26	15	42	51	26
Eastern Asia	25	8	69	784	150
Excluding China	12	8	35	11	7
Southern Asia	51	30	42	1,940	1,086
Excluding India	49	30	39	578	338
South-eastern Asia	27	14	47	321	160
Western Asia	28	14	50	111	67
Oceania	26	21	19	5	6
World	**33**	**20**	**40**	**4,672**	**2,763**

Source: Poston, Bouvier, 2017.

Endogenous and exogenous

- **Endogenous cause of death** in an infant can occur because of genetic issues or conditions associated with fetal development or the birth process

- **Exogenous cause of death** is due mainly to environmental or external factors, such as infections or accidents

Source: Poston, Bouvier, 2017.

Causes of neonatal deaths

- The main causes of neonatal deaths are **endogenous conditions**
- Congenital malformations, chromosomal abnormalities, complications of delivery, low birthweight, genetic disorders…
- However, endogenous causes dominate infant mortality mainly in the early days of life, and not for the entire first month of life

Source: Poston, Bouvier, 2017.

Causes of postneonatal deaths

- Postneonatal mortality rate was 18 per 1,000 live births for the world in 2013
  - Rate was 2 in developed countries
- Deaths in postneonatal period and in first few years of life are mainly due to **exogenous causes**
  - Infectious disease, accidents, injury
- Improved living standards, better healthcare, and public health programs have greater effects on exogenous causes than on endogenous causes

Source: Poston, Bouvier, 2017.

Stillbirth rate (SBR)

- Stillbirths (miscarriages, fetal deaths)
  - A stillbirth is a fetus not born alive and is not registered as a death
  - SBR: stillbirths per 1,000 live births plus stillbirths in the year
  - Stillbirths are often identified in hospital reports dealing with obstetric procedures
- WHO: interventions can be planned if we know at what point before birth the fetus died
  - 2.6 million stillbirths in the world in 2009
  - 18.9 stillbirths per 1,000 live births plus stillbirths

Source: Poston, Bouvier, 2017.

Perinatal mortality rate (PeMR)

- PeMR relates to stillbirths and deaths of babies who lived for only seven days or less per 1,000 live births plus stillbirths in the year
- **Endogenous** causes of mortality in the 1st week after birth are similar to the causes of stillbirths
- PeMR in 2010
  - World (47)
  - Developed world (10); less developed world (50)
  - Czech Republic and Singapore (4); Mauritania (111)
- U.S.: 6.5 in 2006; 6.3 in 2011

Source: Poston, Bouvier, 2017.

Maternal mortality ratio (MMR)

- MMR measures the extent to which mothers die immediately before, during, or after giving birth because of problems associated with the pregnancy or childbirth
  - **Numerator:** number of deaths in a year of women dying as a result of complications of pregnancy, childbirth, and the puerperium (condition of the woman immediately following childbirth)
  - **Denominator:** live births occurring in the year
  - Multiplied by 100,000, because it is increasingly rare in developed countries

Source: Poston, Bouvier, 2017.

Examples of maternal deaths

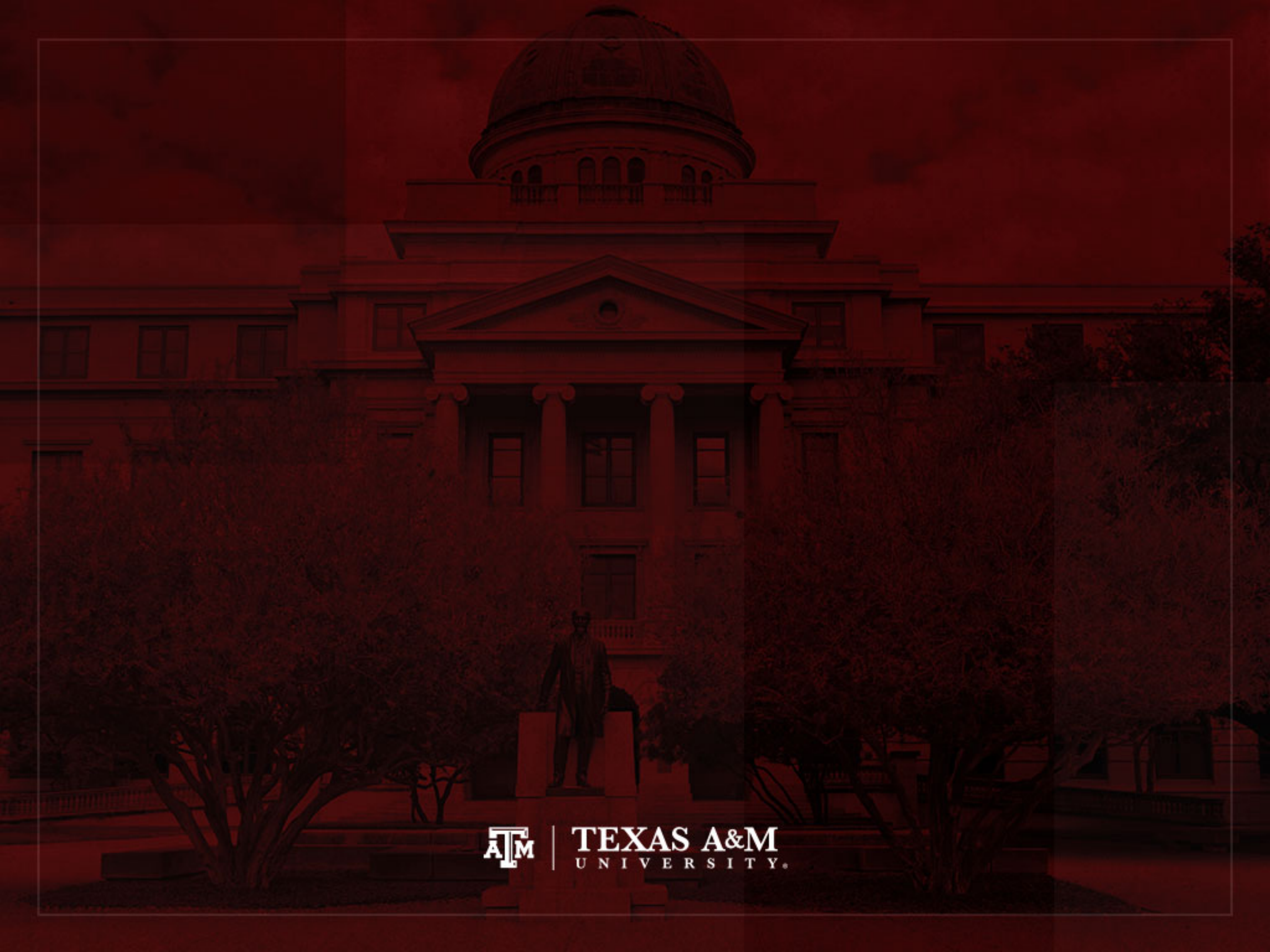
- World
  - 529,000 maternal deaths in 2000
  - 313,000 maternal deaths in 2015
- Developing regions in 2015
  - 99% of all maternal deaths
  - 66% in sub-Saharan Africa
  - 21% in southern Asia
- MMR in 2015
  - World: 216 per 100,000 live births
  - Sierra Leone: 1,360
  - Sub-Saharan Africa: 546
  - U.S., Iran, Hungary: 21
  - Greece, Singapore (3); Estonia (2)

Source: Poston, Bouvier, 2017.

Factors associated with MMR

- Maternal deaths are mostly due to age, parity (number of children), birth spacing
  - Younger and older women are more likely, compared to women in their 20s and 30s
  - High-parity women are at high risk
  - Women with short birth intervals are also at high risk
- Other factors
  - Chronic disease and malnutrition, poverty, unwanted pregnancies, inadequate prenatal and obstetric care, lack of access to a hospital

Source: Poston, Bouvier, 2017.


TEXAS A&M
UNIVERSITY

Future course of mortality

- Is it likely that mortality rates will continue to fall resulting in even higher levels of life expectancy than those attained by developed countries?

- There are two positions
  - One argues for a limit
  - The other argues against one

- Poston argues against a fixed biological maximum life expectancy (more optimistic view)

Mortality reversals

- Modern medical and public health techniques will surely bring about further reductions in mortality from the major causes

- However, there is evidence since the early 1980s of mortality reversals
  - First in Eastern Europe
  - Later in sub-Saharan Africa

Eastern Europe

- What is causing mortality reversals in Eastern Europe?
- Possible factors include
  - Lack of preventative health programs
  - Inadequate quality of medical services
  - Smoking and alcohol abuse
  - General neglect of individual health
- These were caused by
  - Lack of life choices under the former communist regimes
  - Unemployment, relative deprivation, and inability to cope with economic challenges of the capitalist regime

Sub-Saharan Africa

- The AIDS epidemic has halted or reversed gains in life expectancy in many of the sub-Saharan African countries

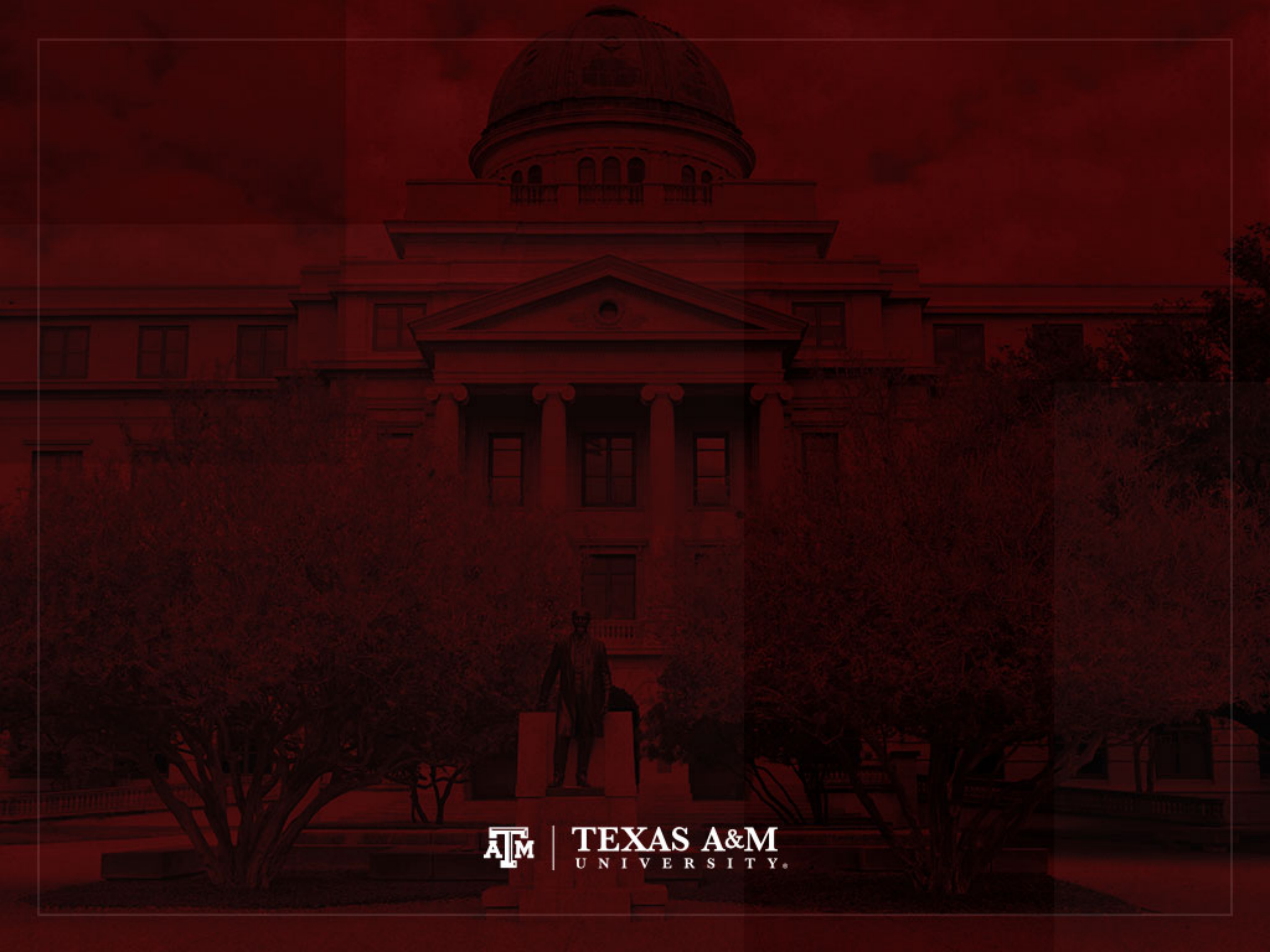
Degenerative diseases

- Degenerative diseases are the major causes of death in the developed world
- Future improvements in the treatment of these diseases is likely
  - However, eliminating a specific degenerative disease would result in small increases to life expectancy because these diseases occur to older individuals
  - Eliminating heart disease would raise life expectancy in the U.S. by 5 years, and eliminating cancer would raise it by 3 years

Important question

- The important question is not “will life expectancy increase?”

- The important question is “by how much will life expectancy increase?”


TEXAS A&M
UNIVERSITY

Coronavirus pandemic, August 24, 2020

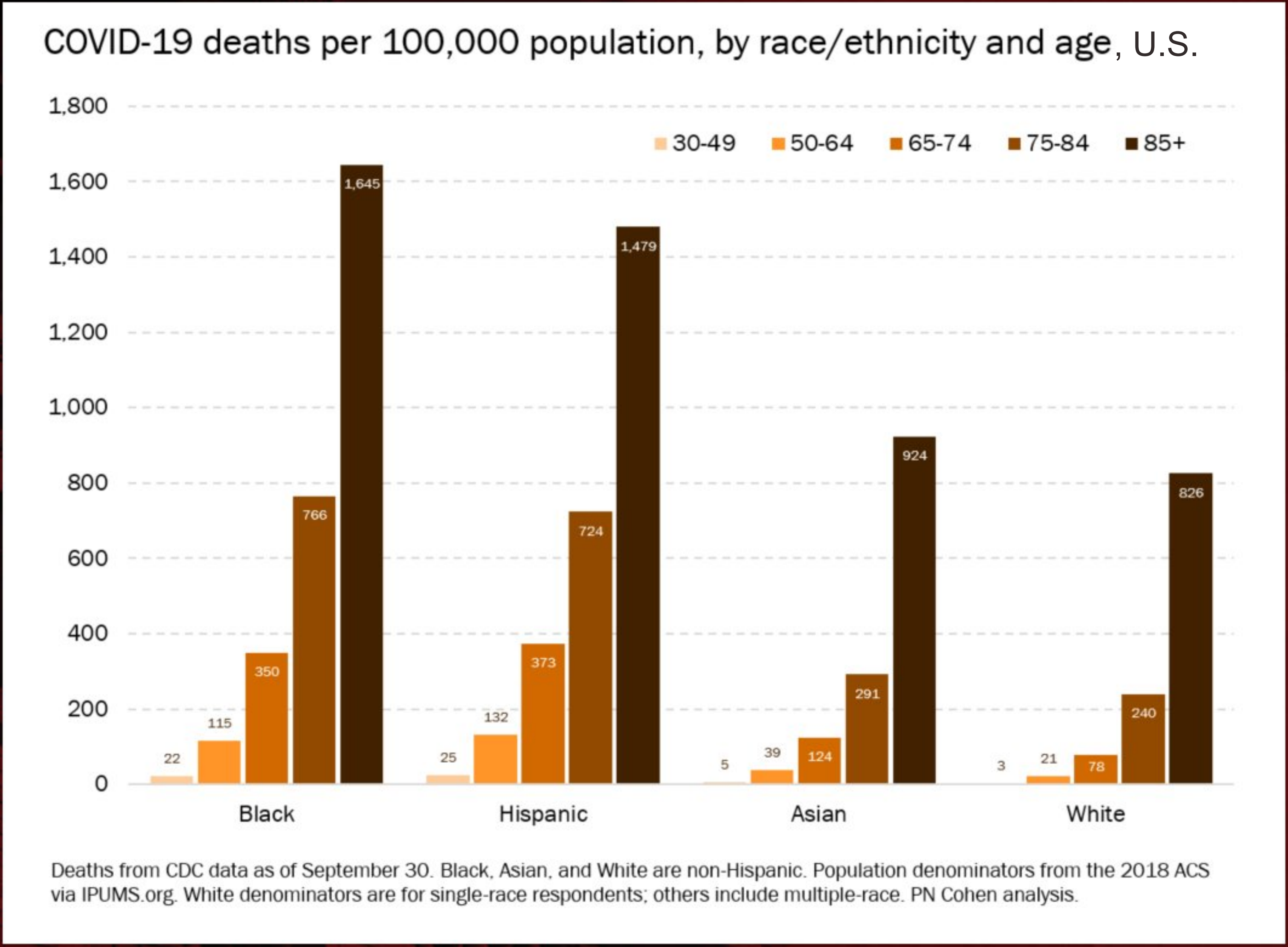
#	Country, Other	Total Cases	New Cases	Total Deaths	New Deaths	Total Recovered	Active Cases	Serious, Critical	Tot Cases/ 1M pop	Deaths/ 1M pop	Total Tests	Tests/ 1M pop	Population
	World	23,809,061	+6,189	817,005	+431	16,358,235	6,633,821	61,715	3,054	104.8			
1	USA	5,915,630		181,114		3,217,981	2,516,535	16,483	17,856	547	76,883,479	232,071	331,293,410
2	Brazil	3,627,217		115,451		2,778,709	733,057	8,318	17,046	543	14,144,344	66,473	212,784,888
3	Mexico	563,705	+3,541	60,800	+320	389,124	113,781	3,346	4,365	471	1,263,835	9,787	129,132,739
4	India	3,164,881		58,546		2,403,101	703,234	8,944	2,290	42	35,902,137	25,978	1,382,011,722
5	UK	326,614		41,433		N/A	N/A	72	4,807	610	15,177,265	223,394	67,939,531
6	Italy	260,298		35,441		205,662	19,195	65	4,306	586	8,053,551	133,231	60,448,212
7	France	244,854		30,528		85,199	129,127	399	3,750	468	6,000,000	91,890	65,295,389
8	Spain	420,809		28,872		N/A	N/A	658	9,000	617	8,517,446	182,162	46,757,536
9	Peru	600,438		27,813		407,301	165,324	1,525	18,174	842	3,006,993	91,014	33,038,913
10	Iran	361,150		20,776		311,365	29,009	3,848	4,292	247	3,062,422	36,392	84,150,494
11	Colombia	551,696		17,612		384,171	149,913	1,493	10,825	346	2,508,972	49,231	50,962,919
12	Russia	961,493		16,448		773,095	171,950	2,300	6,588	113	34,600,000	237,077	145,943,991
13	South Africa	611,450		13,159		516,494	81,797	539	10,291	221	3,564,065	59,983	59,418,339
14	Chile	399,568		10,916		372,464	16,188	1,014	20,875	570	2,231,463	116,583	19,140,575
15	Belgium	82,092	+156	9,996	+4	18,242	53,854	89	7,079	862	2,144,563	184,921	11,597,214
16	Germany	236,117		9,336		209,600	17,181	245	2,817	111	10,197,366	121,652	83,824,401
17	Canada	125,647		9,083		111,694	4,870	62	3,325	240	5,169,166	136,782	37,791,278
18	Argentina	350,867		7,366		256,789	86,712	1,960	7,753	163	1,105,878	24,435	45,257,261
19	Indonesia	155,412		6,759		111,060	37,593		567	25	2,056,166	7,506	273,950,524
20	Iraq	207,985		6,519		150,389	51,077	661	5,154	162	1,457,665	36,125	40,350,522

Source: https://www.worldometers.info/coronavirus/.

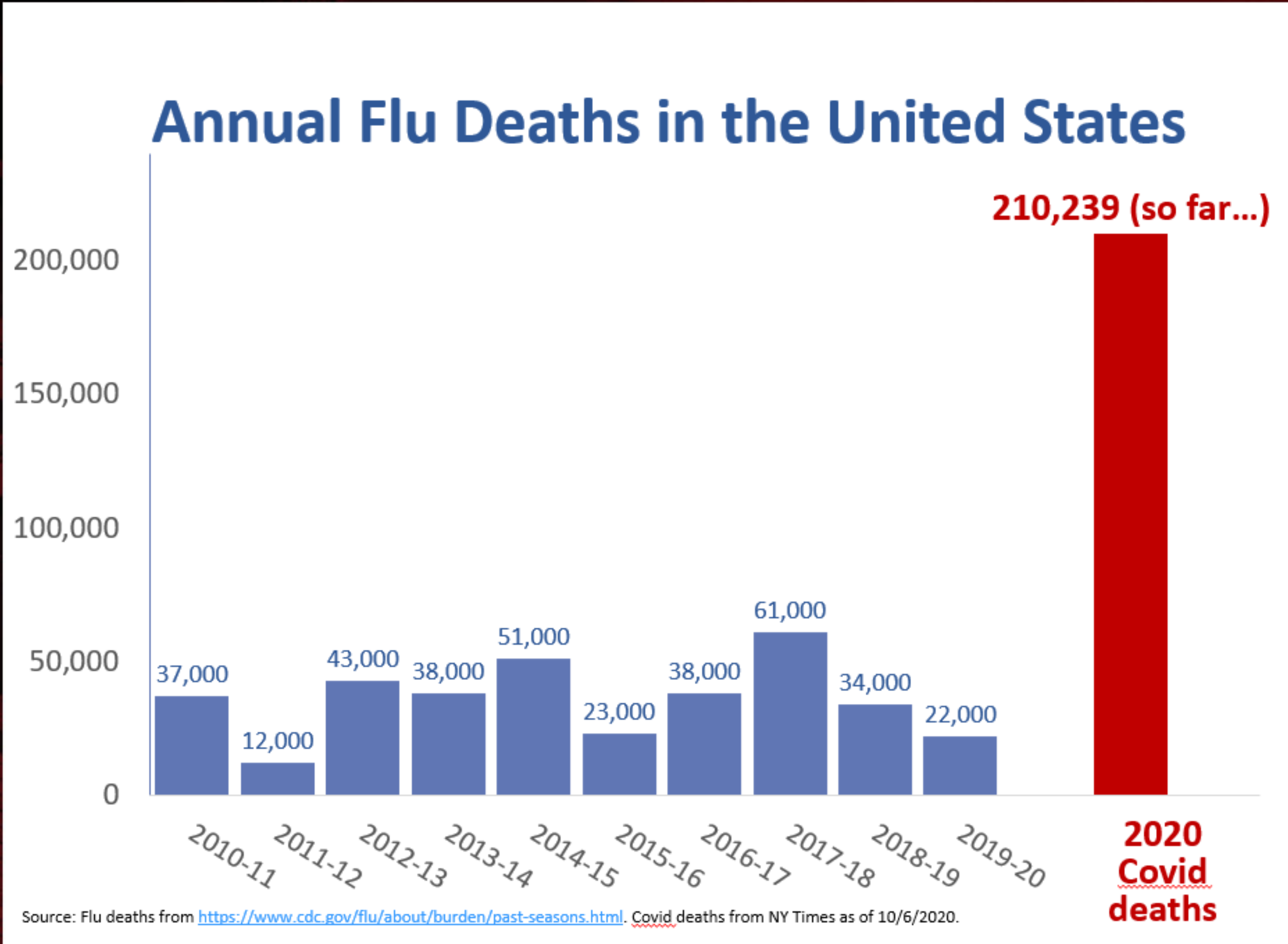
Coronavirus pandemic, October 20, 2020

#	Country, Other	Total Cases	New Cases	Total Deaths	New Deaths	Total Recovered	Active Cases	Serious, Critical	Tot Cases/ 1M pop	Deaths/ 1M pop	Total Tests	Tests/ 1M pop	Population
	World	40,912,578	+273,370	1,126,859	+4,100	30,495,871	9,289,848	73,305	5,249	144.6			
1	USA	8,477,082	+20,429	225,633	+411	5,516,324	2,735,125	15,487	25,565	680	127,223,140	383,676	331,589,837
2	Brazil	5,255,277	+4,150	154,327	+101	4,681,659	419,291	8,318	24,671	724	17,900,000	84,031	213,015,720
3	India	7,648,248	+53,512	115,938	+702	6,791,102	741,208	8,944	5,526	84	96,116,771	69,444	1,384,085,979
4	Mexico	854,926	+3,699	86,338	+171	623,494	145,094	2,617	6,610	668	2,187,985	16,917	129,339,873
5	UK	762,542	+21,331	43,967	+241	N/A	N/A	629	11,215	647	30,187,915	443,979	67,993,982
6	Italy	434,449	+10,874	36,705	+89	255,005	142,739	870	7,189	607	13,784,181	228,084	60,434,663
7	Spain	1,029,668	+13,873	34,210	+218	N/A	N/A	1,911	22,020	732	15,503,165	331,545	46,760,297
8	France	930,745	+20,468	33,885	+262	106,839	790,021	2,177	14,250	519	13,894,126	212,717	65,317,424
9	Peru	870,876		33,820		784,056	53,000	1,094	26,303	1,021	4,249,458	128,347	33,109,207
10	Iran	539,670	+5,039	31,034	+322	434,676	73,960	4,810	6,401	368	4,570,243	54,204	84,314,980
11	Colombia	965,883		29,102		867,961	68,820	2,115	18,922	570	4,467,051	87,511	51,045,852
12	Argentina	1,002,662		26,716		803,965	171,981	4,392	22,124	589	2,626,406	57,952	45,320,654
13	Russia	1,431,635	+16,319	24,635	+269	1,085,608	321,392	2,300	9,809	169	54,675,096	374,606	145,953,533
14	South Africa	705,254		18,492		635,257	51,505	546	11,846	311	4,565,980	76,697	59,532,742
15	Chile	494,478	+1,099	13,702	+26	466,643	14,133	770	25,800	715	3,955,343	206,377	19,165,653
16	Indonesia	368,842	+3,602	12,734	+117	293,653	62,455		1,344	46	4,123,624	15,028	274,392,799
17	Ecuador	154,115	+692	12,404	+9	134,187	7,524	365	8,696	700	499,671	28,193	17,723,023
18	Belgium	230,480	+8,227	10,443	+30	21,214	198,823	446	19,861	900	4,157,817	358,281	11,604,914
19	Iraq	434,598	+3,920	10,366	+49	366,134	58,098	466	10,734	256	2,665,530	65,834	40,488,958
20	Germany	378,145	+4,414	9,937	+38	298,300	69,908	851	4,509	118	19,276,507	229,851	83,865,285

Source: https://www.worldometers.info/coronavirus/.

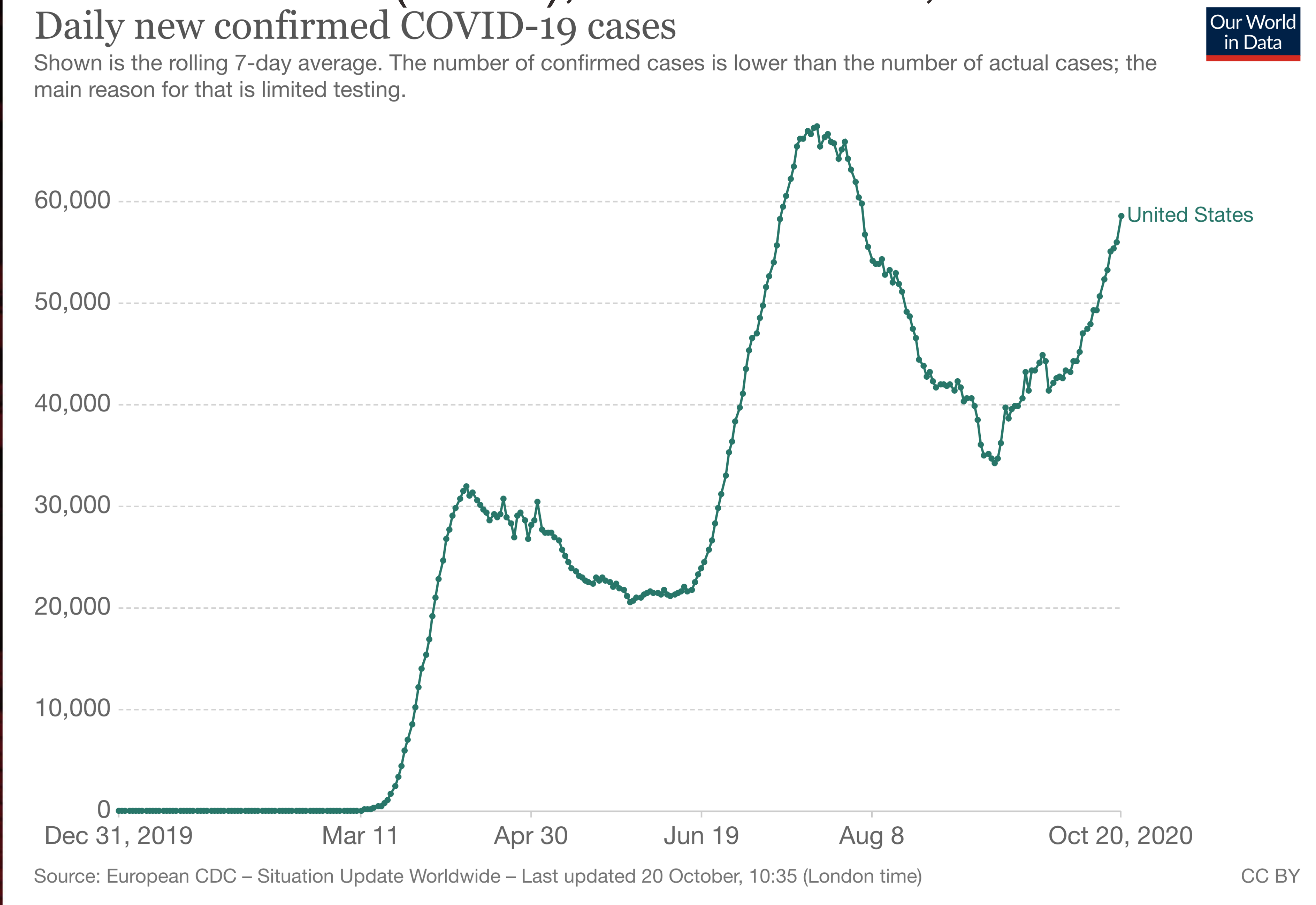


Source: Professor Philip N. Cohen, Department of Sociology, University of Maryland.



Annual Flu Deaths in the United States
210,239 (so far...)
200,000
150,000
100,000
50,000
0
37,000
12,000
43,000
38,000
51,000
23,000
38,000
61,000
34,000
22,000
2010-11
2011-12
2012-13
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020 Covid deaths
Source: Flu deaths from https://www.cdc.gov/flu/about/burden/past-seasons.html. Covid deaths from NY Times as of 10/6/2020.

New cases (linear), United States, 10/20/2020



Source: https://ourworldindata.org/coronavirus.

New deaths (linear), United States, 10/20/2020

Daily new confirmed COVID-19 deaths

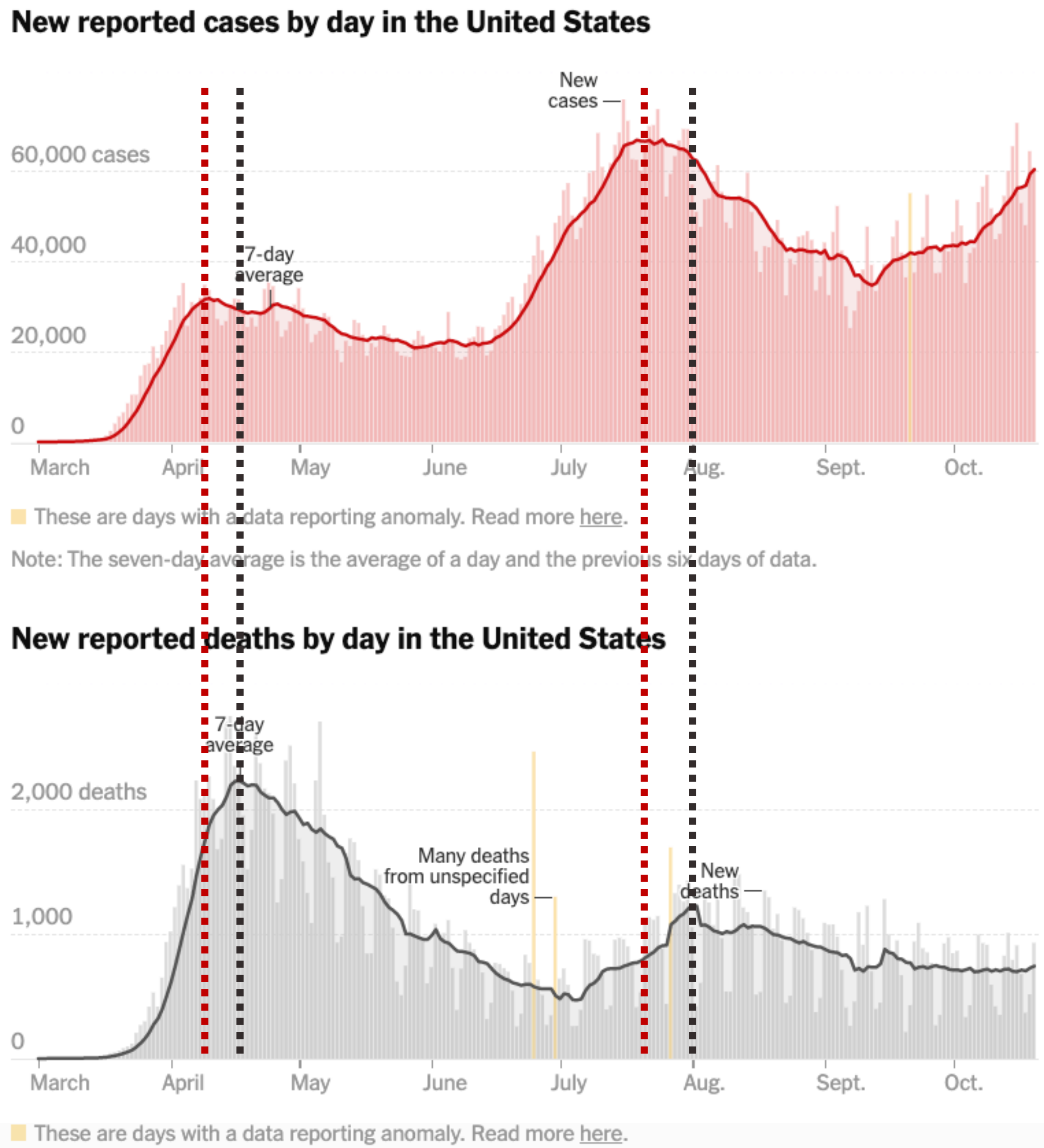
Our World in Data

Shown is the rolling 7-day average. Limited testing and challenges in the attribution of the cause of death means that the number of confirmed deaths may not be an accurate count of the true number of deaths from COVID-19.

Source: European CDC – Situation Update Worldwide – Last updated 20 October, 10:35 (London time)

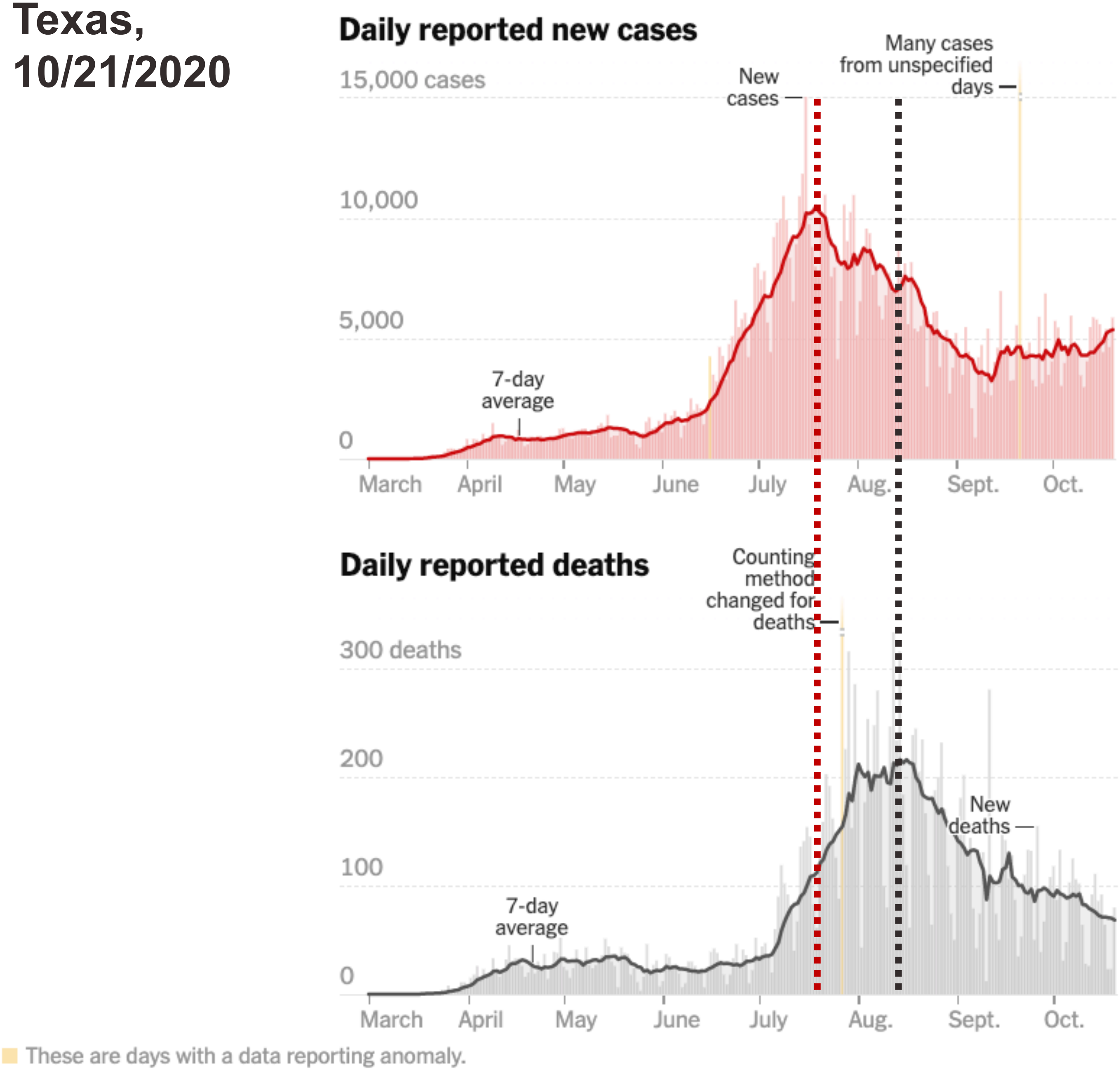
Source: https://ourworldindata.org/coronavirus.

10/21/2020



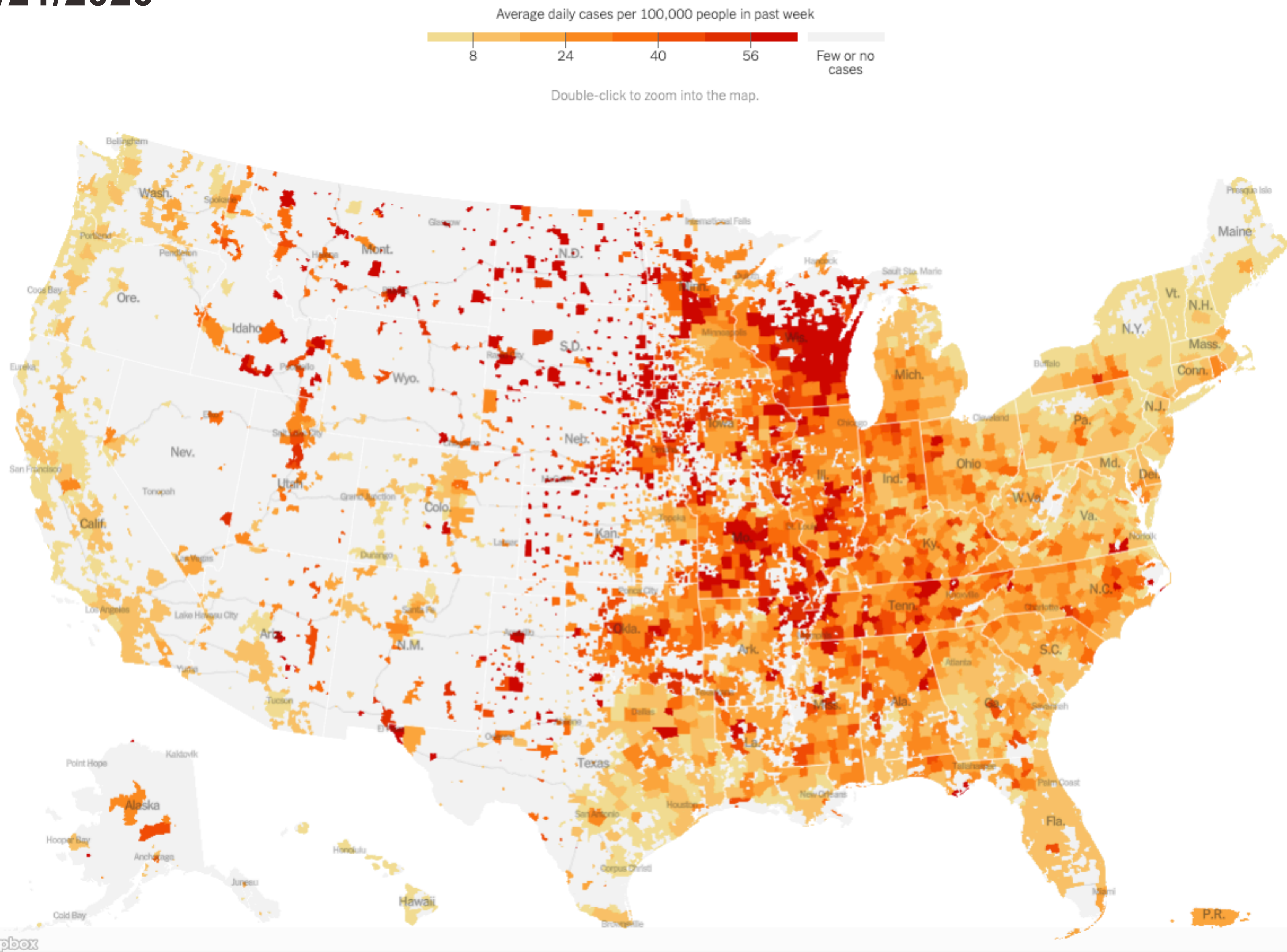
Source: https://www.nytimes.com/interactive/2020/us/coronavirus-us-cases.html.

Texas, 10/21/2020



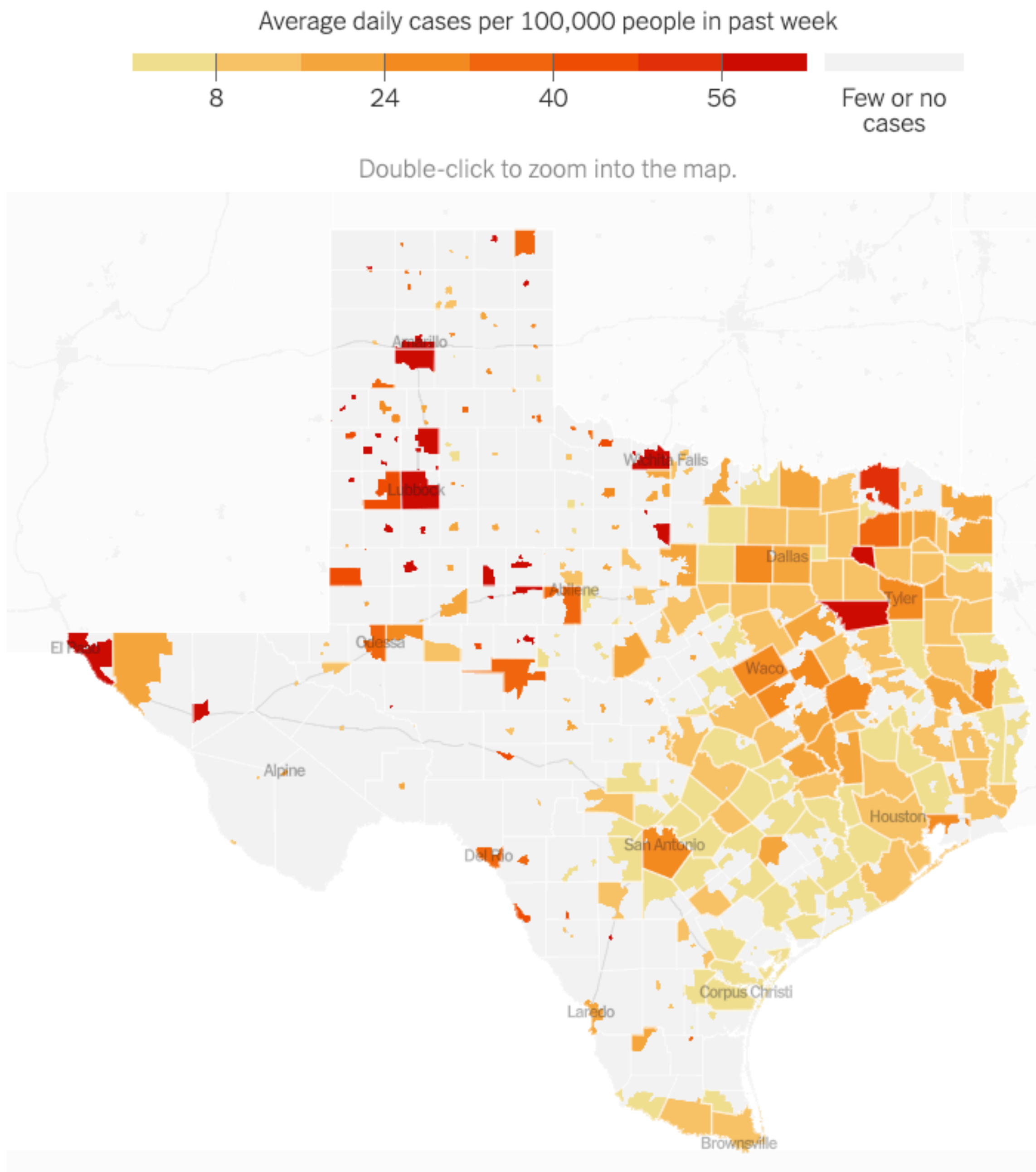
Source: https://www.nytimes.com/interactive/2020/us/texas-coronavirus-cases.html.

10/21/2020



Source: https://www.nytimes.com/interactive/2020/us/coronavirus-us-cases.html.

10/21/2020



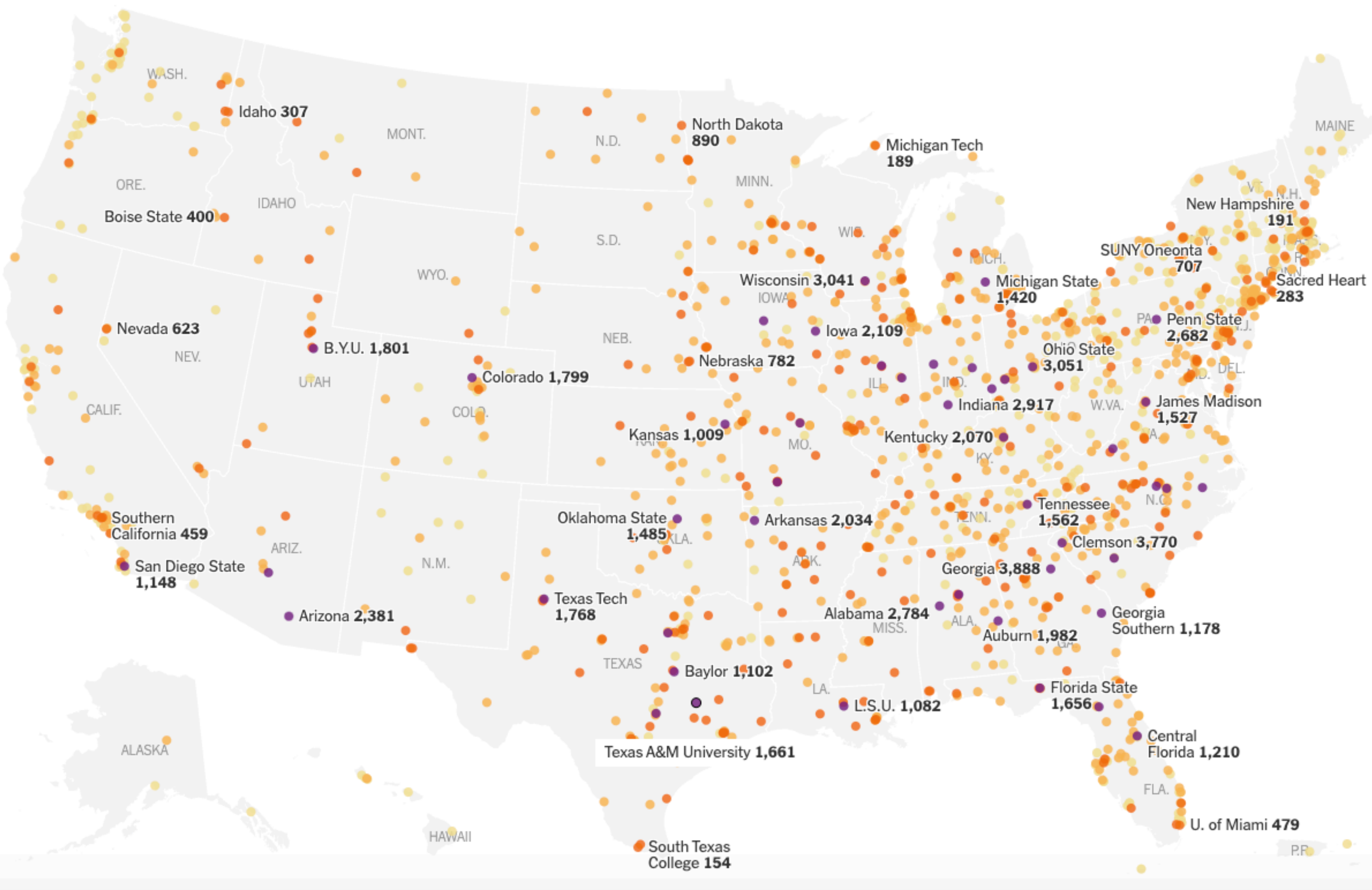
Source: https://www.nytimes.com/interactive/2020/us/texas-coronavirus-cases.html.

10/21/2020

Colleges with coronavirus cases since the pandemic began

● 1,000 or more cases ● 100-999 cases ● 10-99 cases ● Fewer than 10 cases

Double-click to zoom into the map. Drag to pan.



Coronavirus pandemic data

- **Coronavirus COVID-19 Global Cases**
  Center for Systems Science and Engineering (CSSE) at Johns Hopkins University (JHU)
  https://coronavirus.jhu.edu/map.html

- **COVID-19 Coronavirus Pandemic**
  Worldometer
  https://www.worldometers.info/coronavirus/

- **Coronavirus Pandemic (COVID-19)**
  Our World in Data
  https://ourworldindata.org/coronavirus

- **COVID Community Vulnerability Map**
  Jvion – Prescriptive Analytics for Preventable Harm
  https://covid19.jvion.com/

- **Coronavirus Deaths by U.S. State and Country Over Time: Daily Tracking**
  Josh Katz, Margot Sanger-Katz
  https://www.nytimes.com/interactive/2020/03/21/upshot/coronavirus-deaths-by-country.html?action=click&auth=login-email&login=email&module=Top%20Stories&pgtype=Homepage

Coronavirus and demography

- **Resources about demography and COVID-19**
  Population Europe
  https://population-europe.eu/news/demography-coronavirus

- **A demographer's view of the coronavirus pandemic**
  Isaac Chotiner
  March 13, 2020
  https://www.newyorker.com/news/q-and-a/a-demographers-view-of-the-coronavirus-pandemic

- **Coronavirus: Why it's so deadly in Italy**
  Andreas Backhaus
  March 13, 2020
  https://medium.com/@andreasbackhausab/coronavirus-why-its-so-deadly-in-italy-c4200a15a7bf

- **Demographic science aids in understanding the spread and fatality rates of COVID-19**
  Jennifer Beam Dowd, Valentina Rotondi, Liliana Andriano, David M. Brazel, Per Block, Xuejie Ding, Yan Liu, Melinda C. Mills
  March 14, 2020
  https://osf.io/fd4rh/?view_only=c2f00dfe3677493faa421fc2ea38e295&fbclid=IwAR15NPHaq_Ha9yK3uDDN0FhdAZmnfMLfdqgrHaL7qlIf3jBYu8CA_9gcEq

- **Students could be undercounted in the census as coronavirus closes colleges – here's why that matters**
  Dudley L. Poston, Jr.
  March 23, 2020
  https://theconversation.com/students-could-be-undercounted-in-the-census-as-coronavirus-closes-colleges-heres-why-that-matters-133889

Coronavirus and sex

- **Sex, gender and COVID-19**
Global Health 5050
http://globalhealth5050.org/covid19/

- **Sex, gender and COVID-19: Disaggregated data and health disparities**
BMJ Global Health Blogs
March 24, 2020
https://blogs.bmj.com/bmjgh/2020/03/24/sex-gender-and-covid-19-disaggregated-data-and-health-disparities/

- **Here's why the coronavirus may be killing more men than women. The US should take note**
Katie Polglase, Gianluca Mezzofiore, Max Foster
March 24, 2020
https://www.cnn.com/2020/03/24/health/coronavirus-gender-mortality-intl/index.html

Coronavirus and politics

- **The Real Pandemic Danger Is Social Collapse**
  Branko Milanovic
  March 19, 2020
  https://www.foreignaffairs.com/articles/2020-03-19/real-pandemic-danger-social-collapse?utm_medium=social&utm_source=twitter_cta&utm_campaign=cta_share_buttons

- **Coronavirus Could Overwhelm U.S. Without Urgent Action, Estimates Say**
  James Glanz, Lauren Leatherby, Matthew Bloch, Mitch Smith, Larry Buchanan, Jin Wu, Nicholas Bogel-Burroughs
  March 20, 2020
  https://www.nytimes.com/interactive/2020/03/20/us/coronavirus-model-us-outbreak.html?action=click&module=Spotlight&pgtype=Homepage

- **Before Virus Outbreak, a Cascade of Warnings Went Unheeded**
  David E. Sanger, Eric Lipton, Eileen Sullivan, Michael Crowley
  March 22, 2020
  https://www.nytimes.com/2020/03/19/us/politics/trump-coronavirus-outbreak.html

- **Sisi and Erdogan Are Accomplices of the Coronavirus**
  Steven A. Cook
  March 17, 2020
  https://foreignpolicy.com/2020/03/17/sisi-and-erdogan-are-partners-with-the-coronavirus/

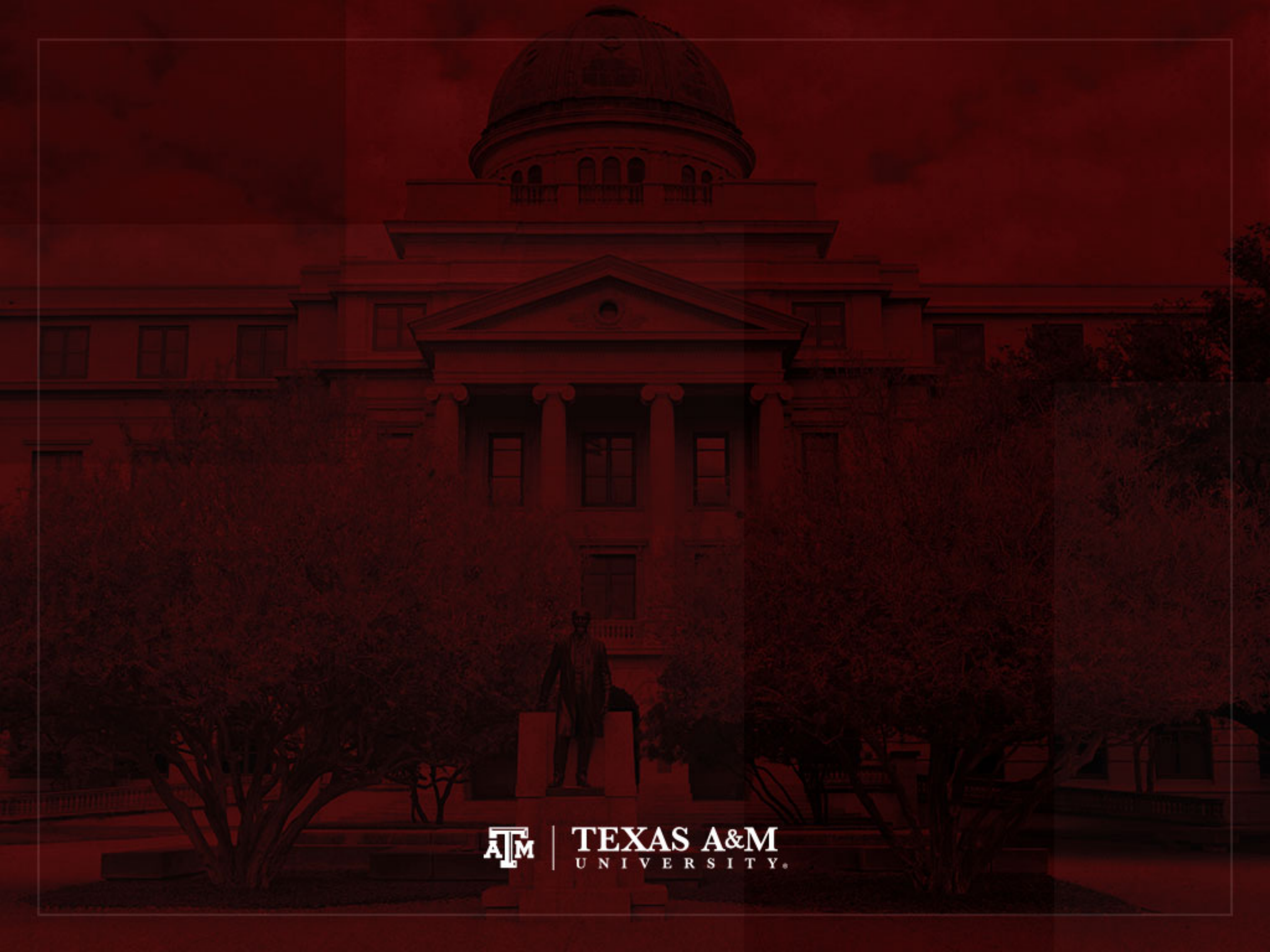
- **How South Korea Flattened the Curve**
  Max Fisher, Choe Sang-Hun
  March 23, 2020
  https://www.nytimes.com/2020/03/23/world/asia/coronavirus-south-korea-flatten-curve.html?action=click&module=Top%20Stories&pgtype=Homepage

References

Hviid A, Hansen JV, Frisch M, Melbye M. 2019. “Measles, mumps, rubella vaccination and autism: A nationwide cohort study.” Annals of Internal Medicine, March 5. (http://www.doi.org/10.7326/M18-2101)

Poston DL, Bouvier LF. 2017. Population and Society: An Introduction to Demography. New York: Cambridge University Press. 2nd edition. Chapter 7 (pp. 163–214).

Weeks JR. 2015. Population: An Introduction to Concepts and Issues. 12th edition. Boston: Cengage Learning. Chapter 5 (pp. 139–188).


TEXAS A&M
UNIVERSITY