

Another expected value problem:

- An insurance company charges \$500 for a life insurance policy. Past experience shows that 1 in 10,000 policy holders will die, forcing the insurance company to payout \$1,000,000. Also, 1 in 5,000 will lose a limb, forcing a payout of \$100,000. On average, how much does the insurance company profit per policy?
- (a) \$380.00
 - (b) \$120.00
 - (c) \$175.00
 - (d) \$225.00
 - (e) \$425.00

6.4 Risk and Life Expectancy

- Trade-off between benefits and risks.
- How much of a risk are you willing to take if some of the possible outcomes are very beneficial?
 - e.g. Shorter time for traveling
 - Airplane vs. car
 - 55 mph vs. 80 mph
- How do we quantify 'risk'?

Risk

- Risk is often expressed as a rate.
 - 750 of 100,000 people are expected die next year.
 - That's 750 deaths *per* 100,000 people.
 - The probability that an 'average' individual dies in the next year is 0.00750.
- Does each person really have the same risk of dying?

Example: How risky is flying?

- The annual risk of being killed in a commercial plane crash for the **average American** is about 1 in 2 million.
- How did they come up with this rate?

$$\frac{\text{Total number of commercial airline deaths}}{\text{Total U.S. population}} = \frac{1}{2 \text{ million}}$$

How risky is flying?

- Would these people have the same risk?
 - A business woman who flies 25 times a year.
 - A grandmother who flies to see her grandkids each winter.
 - A person who never flies.
- Some people fly less, some people fly more. Shouldn't this come into play?
- This idea is related to an individual's **exposure** to an event (or accident).

How risky is flying?

- If you take the total number of people killed in commercial plane crashes and divide that by the total population, the result, the risk for the **average American**, may be a good general guide to whether the risk is big or small, but it's *not specific to your personal risk*.

$$\frac{\text{Total number of commercial airline deaths}}{\text{Total U.S. population}} = \frac{1}{2 \text{ million}}$$

How risky is flying?

- How about a **per flight** rate?
 - Accounts for people who fly more often.
- How about a **per air miles traveled** rate
 - Accounts for people who spend more time in the air.
- These are all rates that can be computed, but some are more relevant than others.



Type	Deaths Per Year	'Average American' Risk Per Year	Risk Based on Exposure (by miles traveled)
Motor vehicles	36,676	1 out of 7,700	1.3 deaths per 100 million vehicle miles
Motorcycles	3,112	1 out of 91,500	31.3 deaths per 100 million vehicle miles
Railroads	931	1 out of 306,000	1300 deaths per 100 million vehicle miles
Bicycles	695	1 out of 410,000	n/a
Air Carriers	138	1 out of 2,067,000	1.9 deaths per 100 million aircraft miles

(Based on years 1999-2003)

How risky is flying compared to cars?

- Consider the ‘average American’ rates:
(doesn’t consider exposure)
 - Airlines: 1 in 2 million
 - Motor vehicles: 1 in 7,700
- Consider the ‘*per miles traveled*’ rate:
(does consider exposure)
 - Airlines: 1.9 deaths per 100 million miles
 - Motor vehicles: 1.3 deaths per 100 million miles

How risky is flying compared to cars?

- Consider the '*per miles traveled*' rate:
 - (does consider exposure)
 - Airlines: 1.9 deaths per 100 million miles
 - Motor vehicles: 1.3 deaths per 100 million miles

- Aligning **exposure** in this manner can make for a more straight-forward comparison.

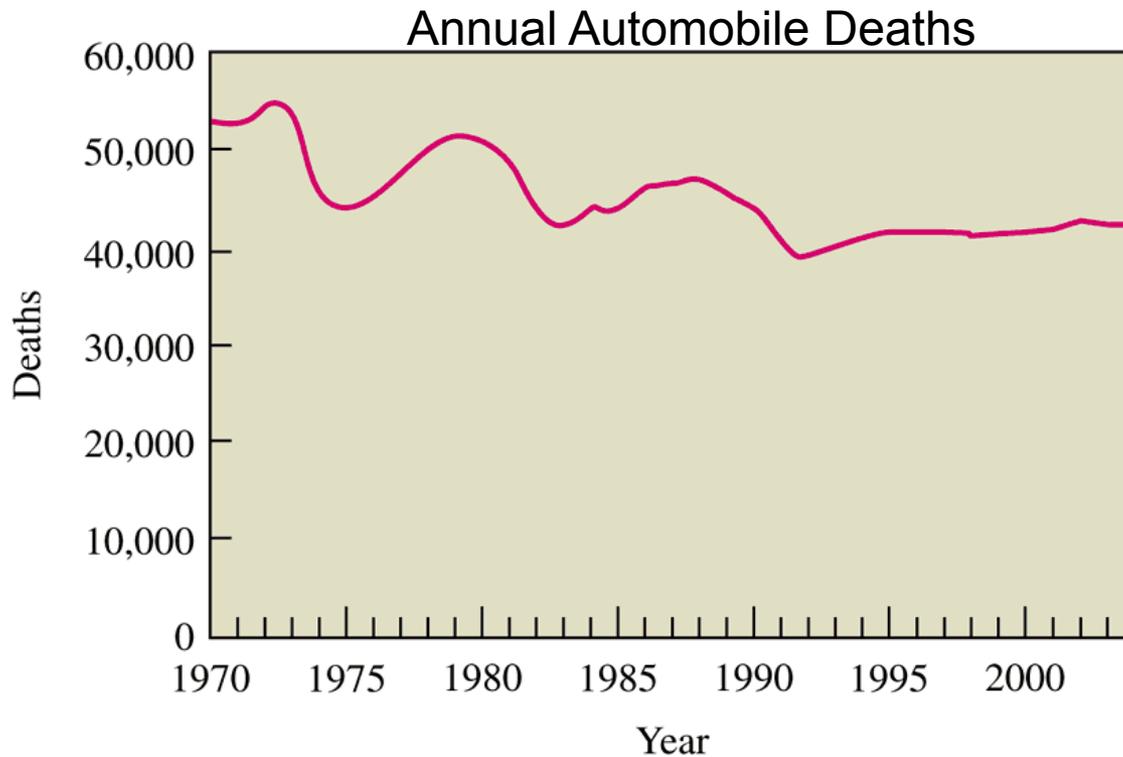
Computing '*per miles traveled*' rates

Suppose passengers travel a total of 7 billion air miles in a year, and there are 98 deaths.

$$\frac{98 \text{ deaths}}{7 \times 10^9 \text{ miles}} \approx 1.4 \times 10^{-8} \text{ deaths per mile}$$

- As a side note, because each flight (or trip) logs quite a few miles, we know that the '*per trip*' rate will be higher.

Is Driving Getting Safer?



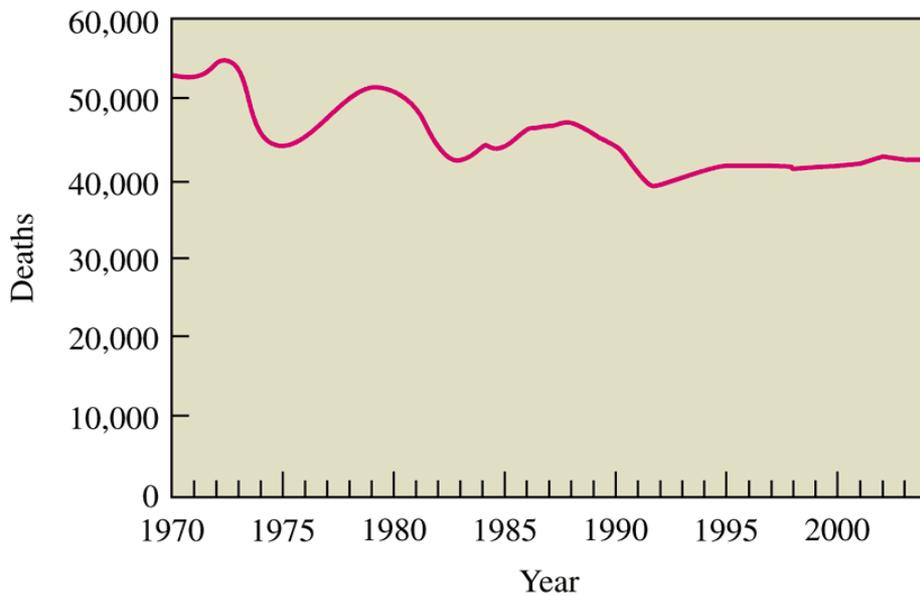
(a)

Though the overall number of deaths has decreased, is this enough to say that drivers are driving more safely?

What if more people are taking the bus? Or bicycling or walking?

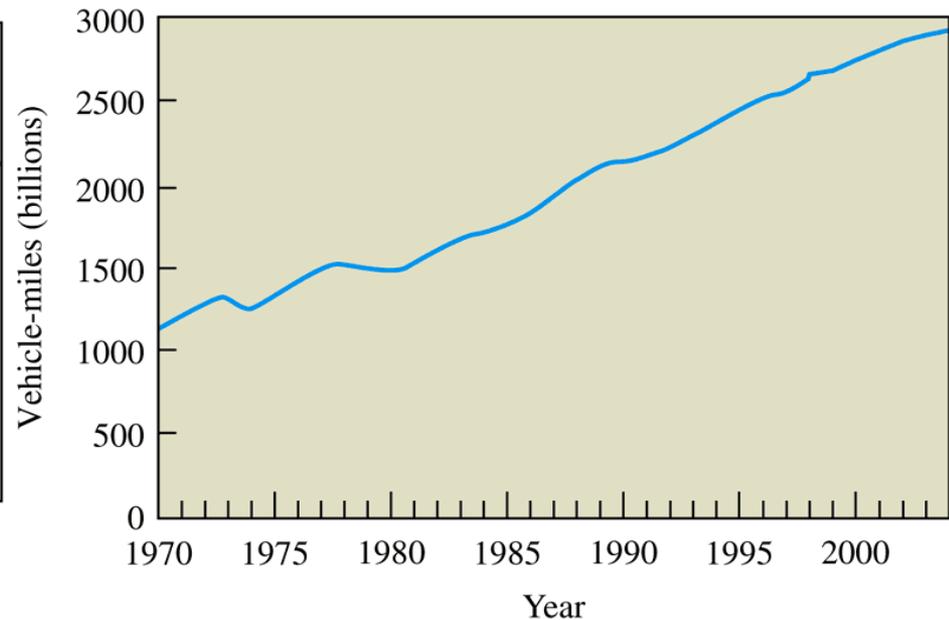
Is Driving Getting Safer?

Annual Automobile Deaths



(a)

Total Miles Driven Annually



(b)

Knowing that people are logging MORE miles in their vehicles as time goes by (and still seeing a reduction in deaths) does give us evidence that driving is getting safer.

Is Driving Getting Safer?

$$1970: \quad \frac{52,000 \text{ deaths}}{1 \times 10^{12} \text{ miles}} \approx 5.2 \times 10^{-8} \text{ death per mile}$$

$$2004: \quad \frac{43,000 \text{ deaths}}{2.9 \times 10^{12} \text{ miles}} \approx 1.5 \times 10^{-8} \text{ death per mile}$$

Again, this brings in the idea of **exposure**.

You're only *exposed to* the chance of getting killed in a car if you're actually **IN** a car.

Is Mom or Dad the safer caregiver?

- I have a 10 month old nephew.
- He's learning to walk and taking plenty of spills.
- I recently received the following photo in a text message from my brother-in-law...



The text read:
“The scoreboard
says who the
better parent is ;)”

What do you think
about his
statement?



Vital Statistics

- Data concerning births and deaths of citizens, often called *vital statistics*, are very important to understanding risk-benefit tradeoffs.
- Demographers use birth and death rates to predict future population trends.

Vital Statistics

- One important set of vital statistics, shown as a table below, concerns causes of death

Table 6.8 Leading Causes of Death in the United States (in a single recent year)

Cause	Deaths	Cause	Deaths
Heart disease	684,462	Diabetes	73,249
Cancer	554,643	Pneumonia/Influenza	65,681
Stroke	157,803	Alzheimer's disease	63,343
Pulmonary disease	126,128	Kidney disease	42,536
Accidents	105,695	Septicemia (blood poisoning)	34,243

Source: Centers for Disease Control.

Vital Statistics

- We can use the data in the table to compute risk, assuming a U.S. population size of 300,000,000.

We find the *risk per person* by dividing the number of deaths by the total population of 300 million:

$$\text{Pneumonia /influenza: } \frac{65,681 \text{ deaths}}{300,000,000 \text{ people}} \approx 0.00022 \text{ deaths per person}$$

$$\text{Cancer: } \frac{554,643 \text{ deaths}}{300,000,000 \text{ people}} \approx 0.00180 \text{ death per person}$$

Vital Statistics

Pneumonia /influenza: $\frac{65,681 \text{ deaths}}{300,000,000 \text{ people}} \approx 0.00022 \text{ deaths per person}$

Cancer: $\frac{554,643 \text{ deaths}}{300,000,000 \text{ people}} \approx 0.00180 \text{ deaths per person}$

Death by cancer is about 8 times more likely than death by pneumonia/influenza.

$$\frac{0.00180}{0.00022} \approx 8.18$$

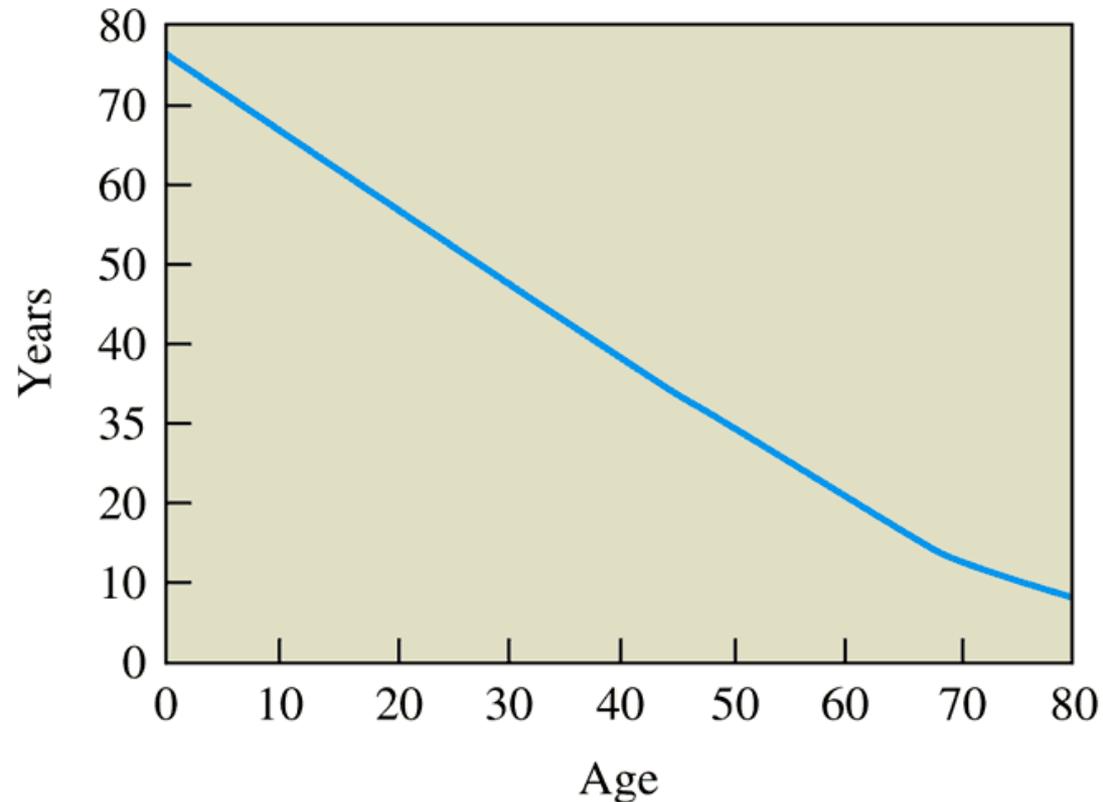
Life Expectancy

- Life Expectancy is the number of years a person with a given age today can expect to live, on average.
- A 20-year old person may have a life expectancy of 60 years (so, they'll probably live to be 80).

Life Expectancy

- How long is a 30-year old expected to live?
 - About 50 years.
- How long is a 70-year old expected to live?
 - About 13 years.
- Life expectancy decreases as you get older.
- Right now, at birth, life expectancy is about 78 years.

U.S. Life Expectancy by Age

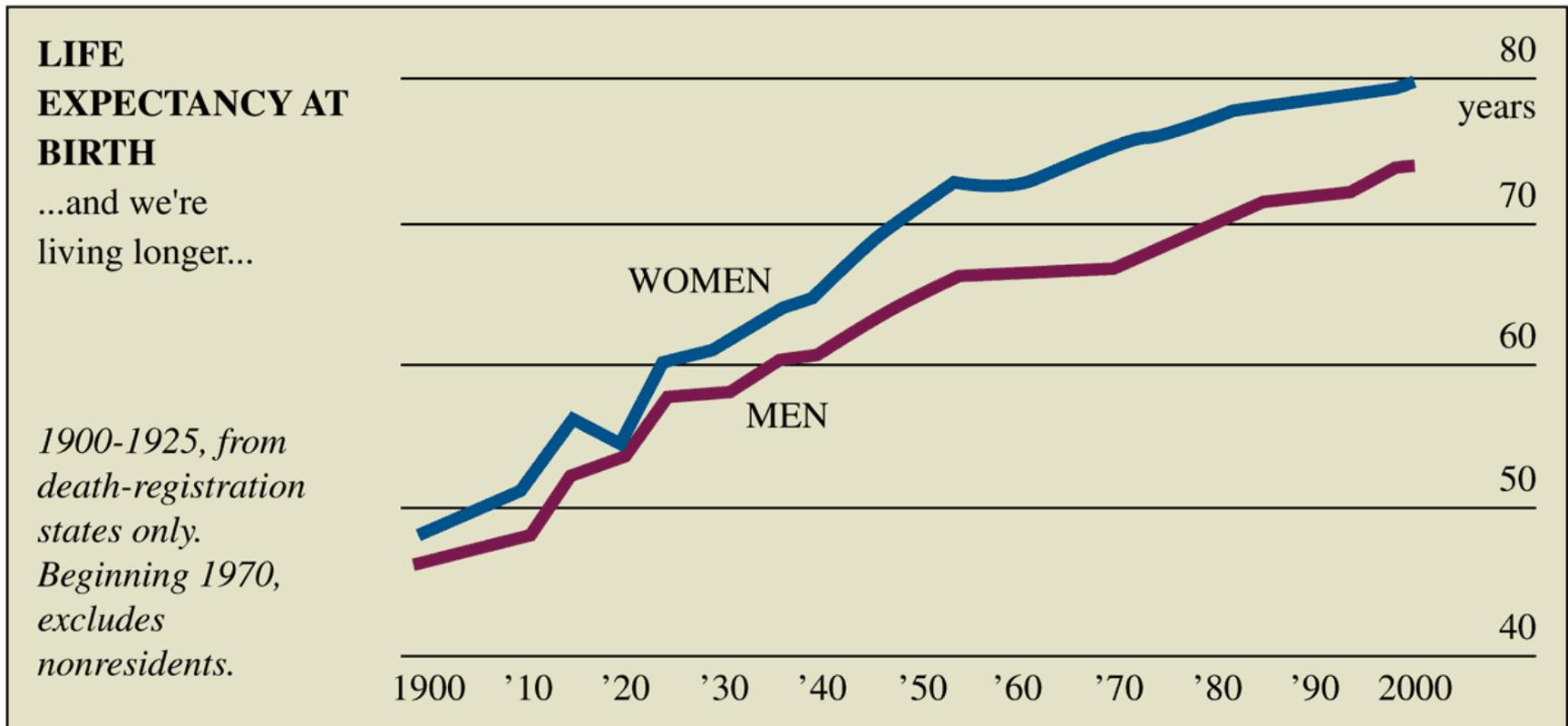


Source: U.S. National Center for Health Statistics

(b)

Life Expectancy

- As we progress through time (from 1900's to 2000's), we have seen life expectancy at birth continue to climb.

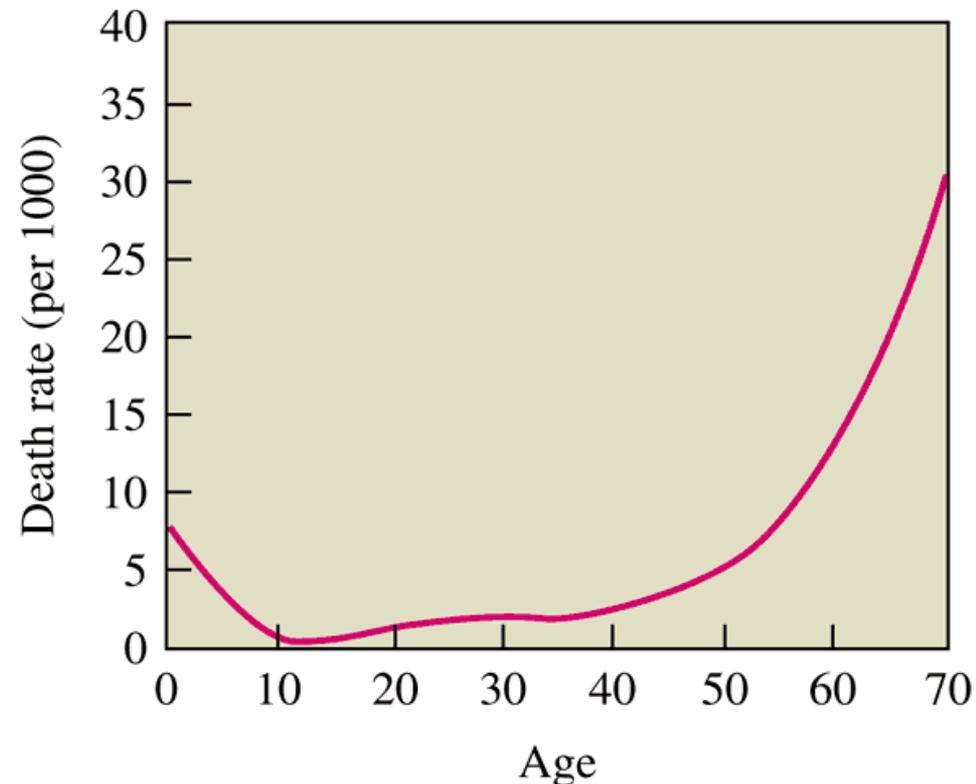


Source: New York Times and National Center for Health Science Statistics.

Life Expectancy

- Life expectancy at a given age is related to the chance of dying (at that age).
- Life expectancy matters for:
 - Social Security
 - Insurance
 - Retirement planning

U.S. Death Rate by Age



(a)