Lecture 3
Quantitative Variables

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DATASCI 112

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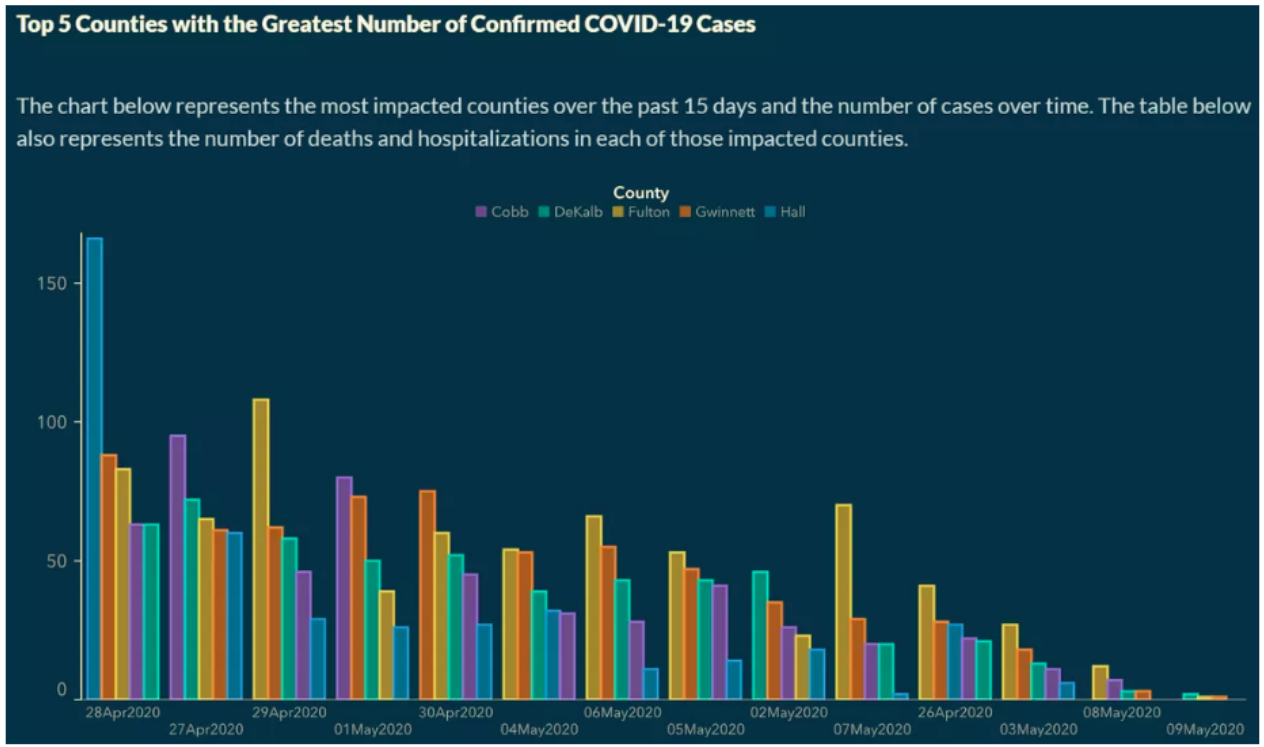


Quantitative Variables

We have analyzed a quantitative variable already. Where?

In the Colombia COVID data!

```
df_CO = pd.read_csv(url + "colombia_2020-05-28.csv")
df_CO
```

	Departamento	Edad	Sexo	Tipo	Ubicación	Estado	Fecha de inicio de síntomas
0	Bogotá D.C.	19	F	Importado	Recuperado	Leve	2020-02-27
1	Valle del Cauca	34	M	Importado	Recuperado	Leve	2020-03-04
2	Antioquia	50	F	Importado	Recuperado	Leve	2020-02-29
3	Antioquia	55	M	Relacionado	Recuperado	Leve	2020-03-06
4	Antioquia	25	M	Relacionado	Recuperado	Leve	2020-03-08
...	...	...	...	...	...	...	...
25361	Buenaventura D.E.	48	M	En estudio	Hospital	Moderado	2020-05-12
25362	Valle del Cauca	55	F	En estudio	Casa	Leve	2020-05-21
25363	Buenaventura D.E.	39	F	En estudio	Casa	Leve	2020-05-23
25364	Valle del Cauca	13	F	En estudio	Casa	Leve	2020-05-13
25365	Córdoba	0	F	En estudio	Hospital	Moderado	2020-05-11

25366 rows × 10 columns

This example will motivate our discussion of quantitative variables today!

1. Visualizing One Quantitative Variable

2. Summarizing One Quantitative Variable

3. Recap

1 Visualizing One Quantitative Variable

2 Summarizing One Quantitative Variable

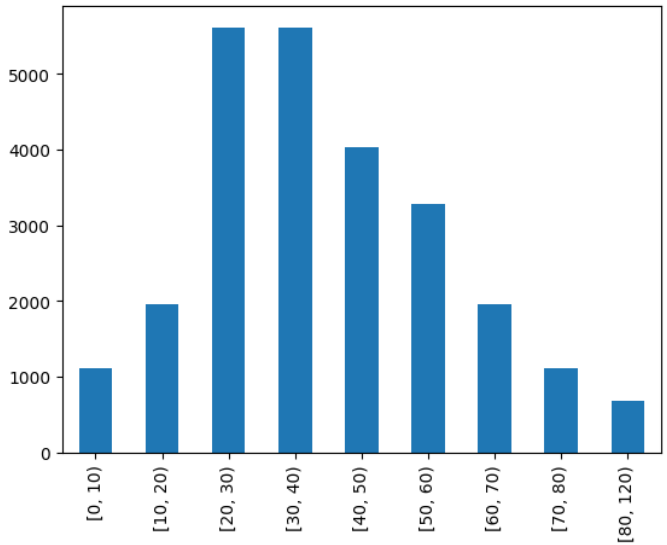
3 Recap

Visualizing One Quantitative Variable

To visualize the age variable, we did the following:

quantitative variable → (binning) → categorical variable → make a "bar plot"

```
df_CO["age"] = pd.cut(
    df_CO["Edad"],
    bins=[0, 10, 20, 30, 40, 50, 60, 70, 80, 120],
    labels=["0-9", "10-19", "20-29", "30-39", "40-49", "50-59", "60-69"
    right=False)
df_CO["age"].value_counts(sort=False).plot.bar()
```

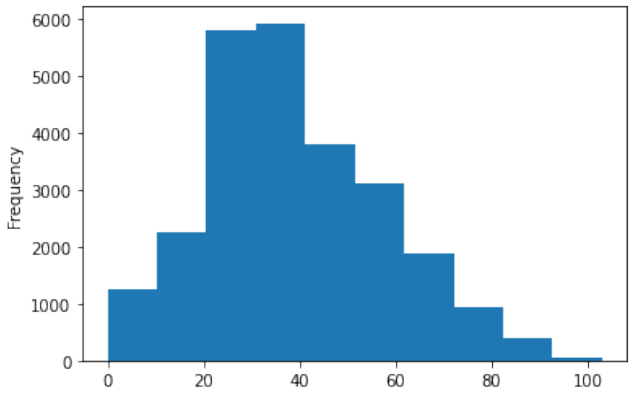


This is the idea behind a visualization called the **histogram**.

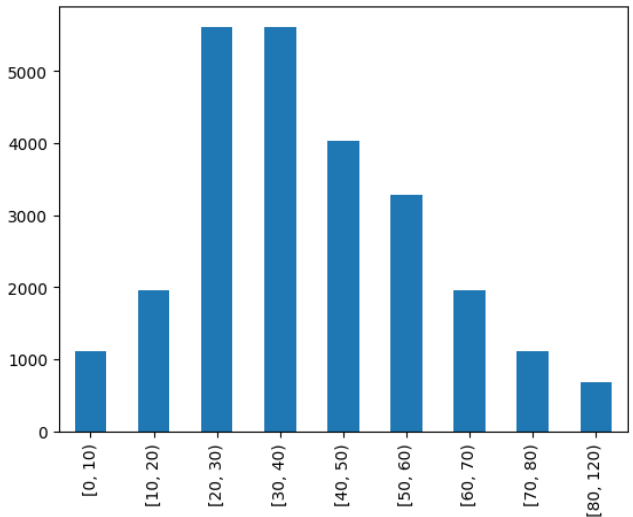
Histograms

Pandas provides a built-in method for constructing histograms: `Series.plot.hist()`.

```
df_CO["Edad"].plot.hist()
```



How does this differ from the manual histogram from earlier?



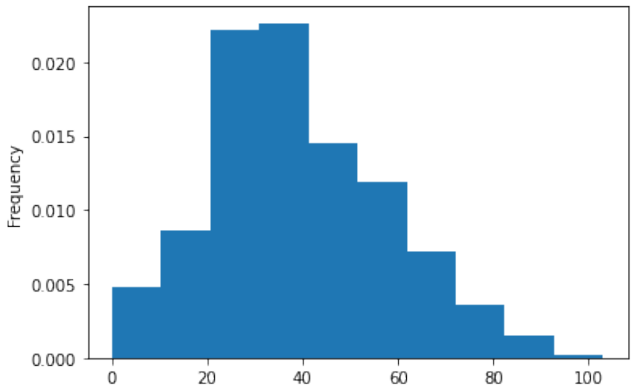
- There are no spaces between the bars.
- The x-axis is just numbers, rather than bins.

Distributions

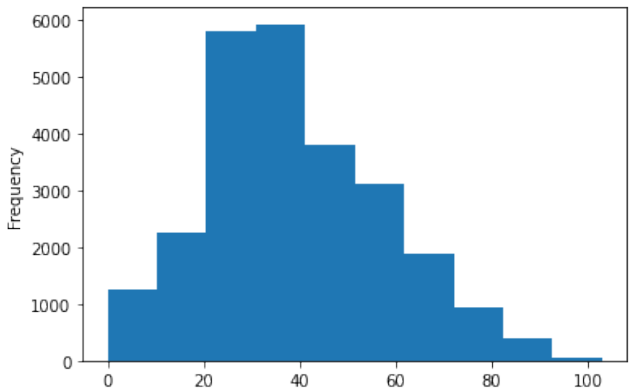
Recall the distribution of a categorical variable.

The **distribution** of a quantitative variable is similar. The counts are scaled so that the total *area* is 1.0 (or 100%).

```
df_CO["Edad"].plot.hist(density=True)
```



How does this differ from the (counts) histogram from earlier?



- Only the y-axis changes.
- The shape is the same!

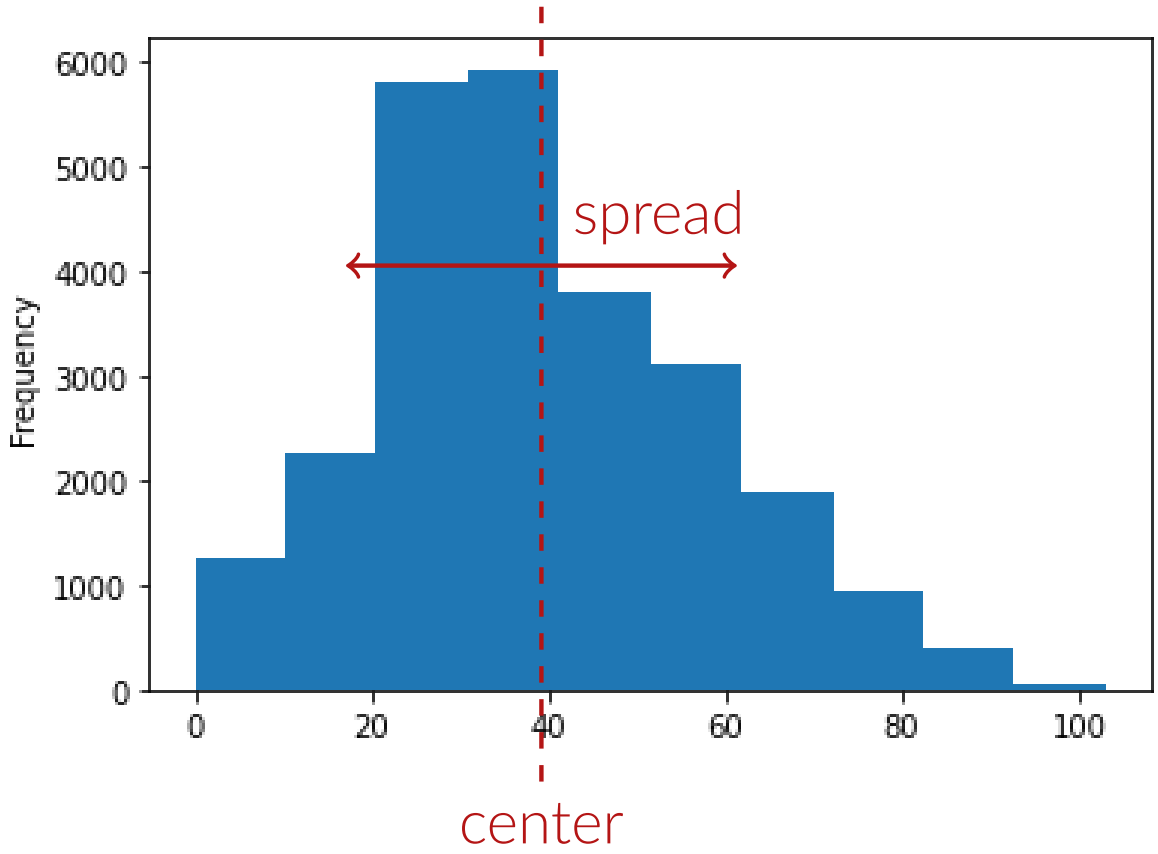
1 Visualizing One Quantitative Variable

2 Summarizing One Quantitative Variable

3 Recap

Summarizing a Quantitative Variable

If you had to summarize this data using a single number, what number would you pick?



If you had to summarize this data using two numbers, what number would you pick second?

Summaries of Center: Mean

One summary of the center of a quantitative variable is the **mean**.

To calculate the mean of a quantitative variable $\mathbf{x}$ with values $x_1, x_2, x_3, ..., x_n$, we use the formula:

$$\overline{\mathbf{x}} = \text{mean}(\mathbf{x}) = \frac{\sum_{i=1}^{n} x_i}{n}$$

You can calculate it manually...

```
df_CO["Edad"].sum() / len(df_CO)
```

```
39.04742568792872
```

...or using a built-in Python function.

```
df_CO["Edad"].mean()
```

```
39.04742568792872
```

Summaries of Center: Mean

Don't be fooled by the humble mean,

$$\overline{\mathbf{x}} = \text{mean}(\mathbf{x}) = \frac{\sum_{i=1}^{n} x_i}{n}.$$

It is not entirely obvious that this formula should give a summary of center!

Let's investigate one reason in Colab.


IF I HAVE SEEN FURTHER
IT IS BY STANDING ON THE
SHOULDERS OF GIANTS.

Summaries of Center: Median

Another summary of center is the **median**, which is the "middle" of the *sorted* values.

To calculate the median of a quantitative variable $\mathbf{x}$ with values $x_1, x_2, x_3, ..., x_n$, we do the following steps:

1. Sort the values from smallest to largest:

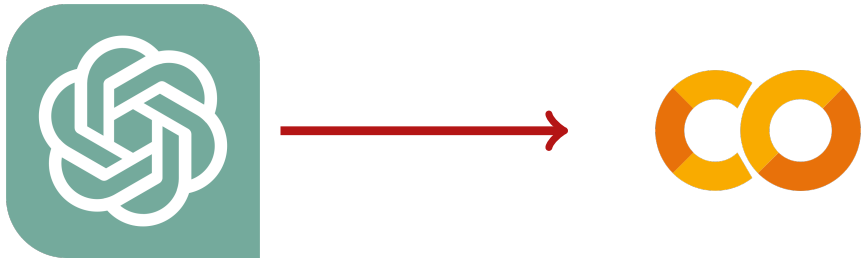
$$x_{(1)}, x_{(2)}, x_{(3)}, ..., x_{(n)}.$$

   Statisticians call the sorted values the **order statistics**.

2. The "middle" value depends on whether we have an odd or an even number of observations.
   - If n is odd, then the middle value is $x_{(\frac{n+1}{2})}$.
   - If n is even, then there are two middle values, $x_{(\frac{n}{2})}$ and $x_{(\frac{n}{2}+1)}$. It is conventional to report the mean of the two values (but you can actually pick any value between them).

Summaries of Center: Median

We can implement these steps in Python code manually. I asked ChatGPT, and it generated this code:



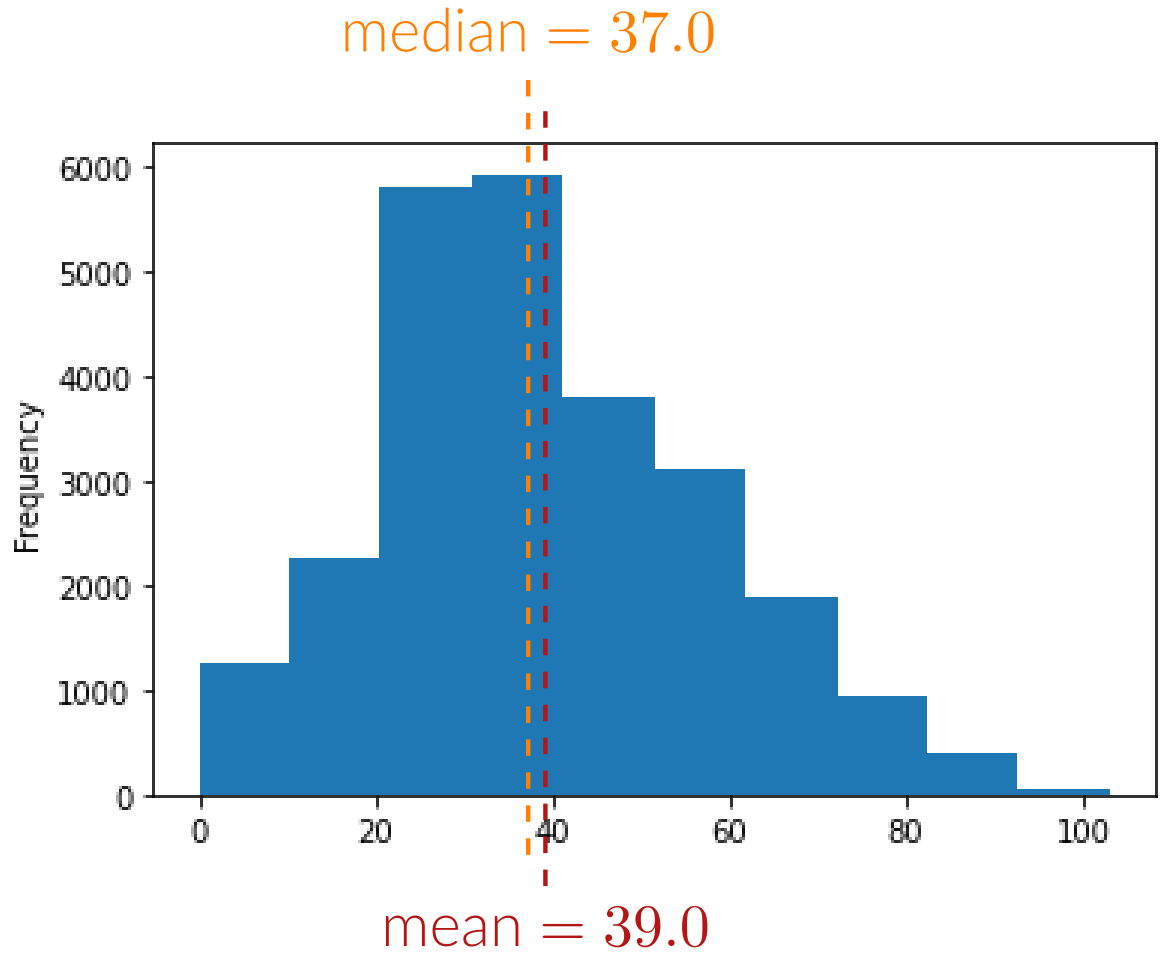
But it's easier to use the built-in Python function.

```
df_CO["Edad"].median()
```

```
37.0
```

Summaries of Center: Mean vs. Median

We now have two summaries of center. How do they compare?



How would we summarize spread now?

Summaries of Spread: Variance

One measure of spread is the **variance**.

The variance of a variable $\mathbf{x}$ whose values are $x_1, x_2, x_3, ..., x_n$ is calculated using the formula

$$\text{var}(\mathbf{x}) = \frac{\sum_{i=1}^{n}(x_i - \overline{\mathbf{x}})^2}{n-1}$$

You can implement this formula manually...

```
(((df_CO["Edad"] - df_CO["Edad"].mean()) ** 2).sum() /
 (len(df_CO) - 1))
```

```
348.0870469898451
```

...or using a built-in Python function.

```
df_CO["Edad"].var()
```

```
348.0870469898451
```

What are the units? years^2

Summaries of Spread: Standard Deviation

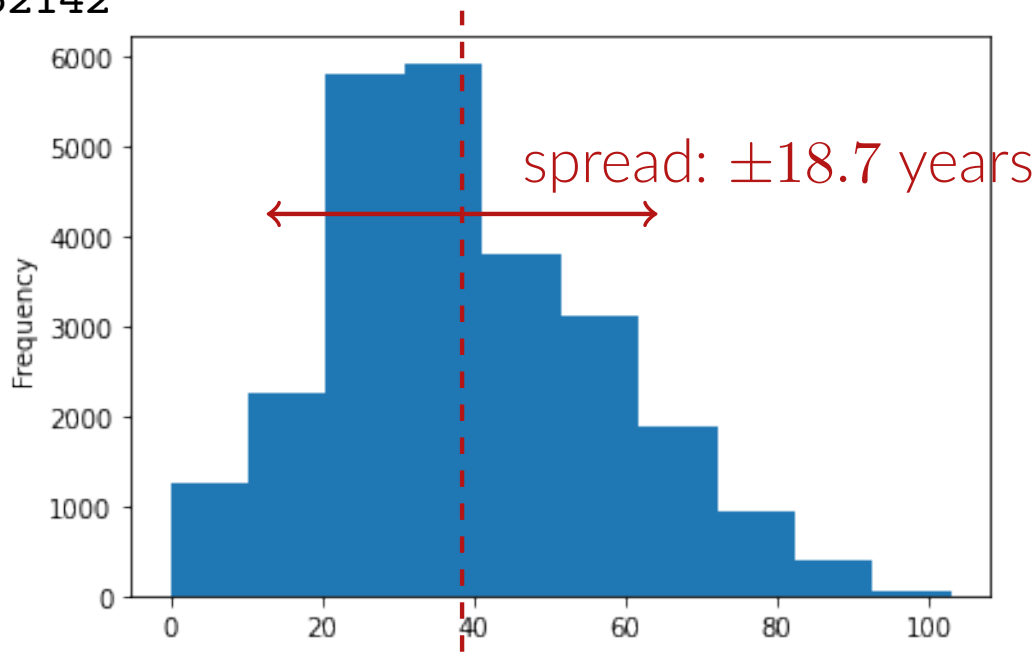
To fix the units, we take the square root to get the **standard deviation**:

$$\underset{\text{years}}{\text{sd}(\mathbf{x})} = \sqrt{\underset{\text{years}^2}{\text{var}(\mathbf{x})}}$$

We can calculate it using the built-in Pandas method `Series.std`:

```
df_CO["Edad"].std()
```

```
18.65709106452142
```



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What We Learned Today

- visualizing a quantitative variable using a histogram
  - We've now seen several plots that can be made within Pandas: `.plot.bar()`, `.plot.hist()`, and `.plot.line()`.
- summarizing a quantitative variable
  - summarizing the center By the mean or median
  - summarizing the spread By the standard deviation
- some new Python tricks