Week 3 Video Lecture Notes

A. Learning Outcomes and Key Terms - for categorical data analysis (Part 1)

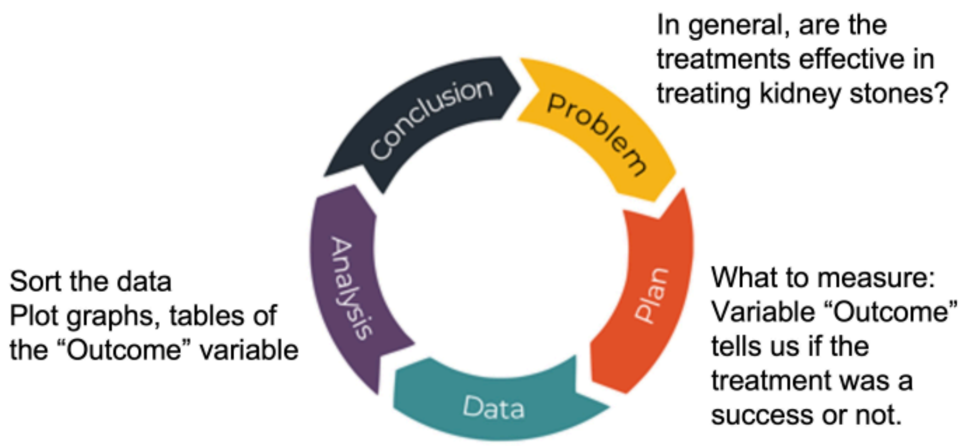
- EDA techniques and concepts for **categorical data**
- describe categorical variables using frequency and rates
- use and interpret contingency tables and bar graphs for categorical variables
- what is a conditional rate versus a joint rate?
- basic rule of rates, symmetry rule
- establish association between categorical variables

B. Understanding Rates

- using the kidney stones dataset `kidneystones.csv` throughout this chapter.
    - `Treatment` - nominal categorical (i.e. two categories $\implies$ X and Y)
    - `size` - ordinal categorical (i.e. small, large)
    - `Gender` - nominal categorical (i.e. two categories $\implies$ Male and Female)
    - `Outcome` - nominal categorical (i.e. two categories $\implies$ Success and Failure)
- When looking just at absolute numbers, there is a tendency to misinterpret the higher count to be better, even though the percentage of success for it may not be so.

Using PPDAC

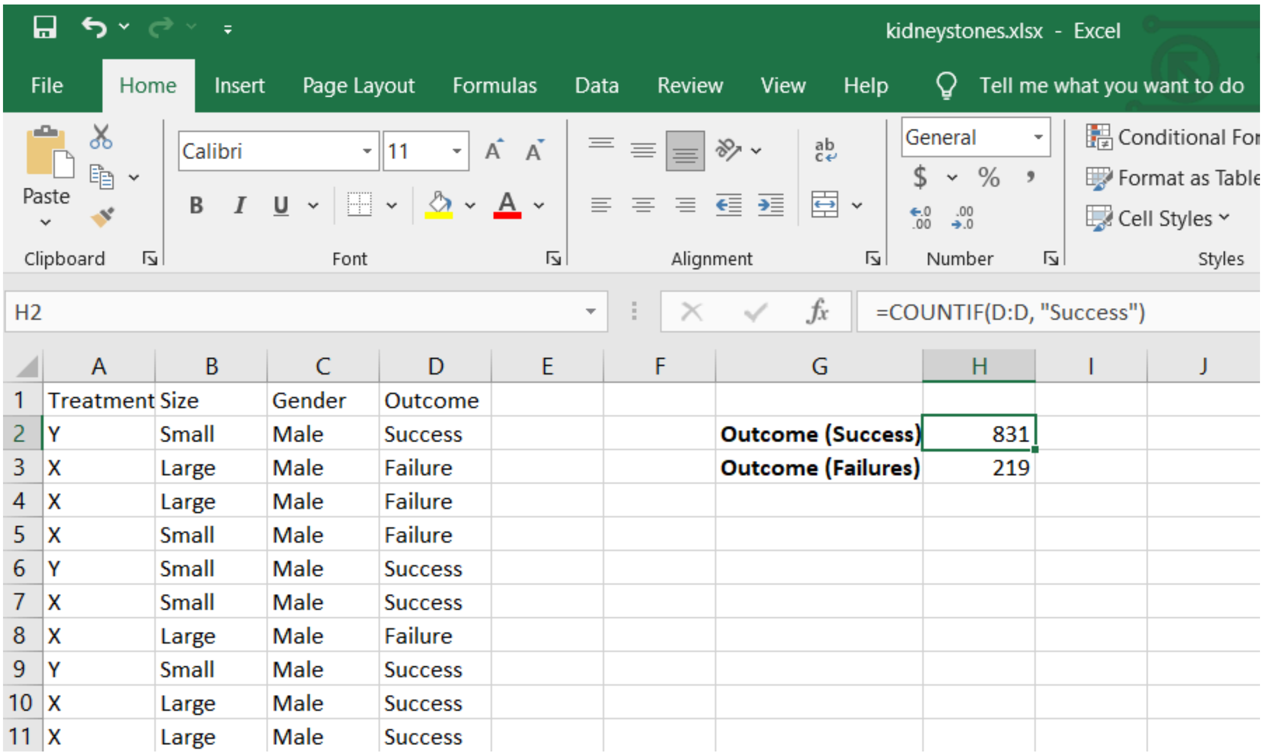
- Problem (may have more than one): *Do treatments provided to patients in general tend to be successful?*
- Plan (not conducting experiment, no need for measurement or quantification): Take a look at `outcome` **variable** to show us if the treatment was a success $\implies \because$ this is an observational study .
- Data (reveal interesting trends)
- Analysis: sorting the data, plot graphs etc.
- Conclusion:
    - preliminary types of conclusions may lead us to ask more questions



1. Categorical Variables

> *def* Rate: a quantity or amount that can be represented through a fraction, proportion or percentage (measured as compared to something else)

Using example dataset:



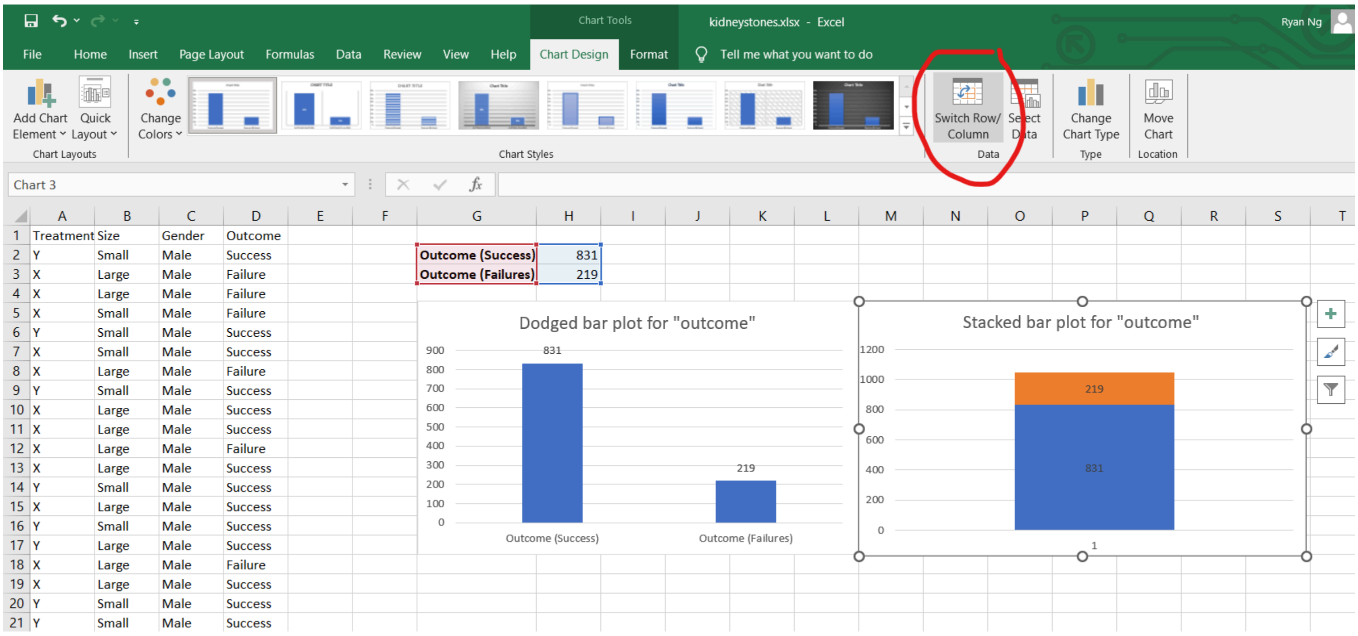
`Rate(Success)` = $\frac{831}{1050} = 0.791 \text{ or } 79.1\%$.

2. Tables and Plots

- allows us to visualize the data and come to the same conclusion

i. Single variable

- can use either a dodged bar plot or a stacked bar plot to measure the variable being explored.
- can normalize values as a percentage or fraction instead of just a count.



- can also use these plots for two variables
  - can normalize the y-axis to become 100% (transform to become a 100% bar plot)

ii. Two variables

using PPDAC chart to answer new question discovered

> *def:* A two-way contingency table is a cross-classification of observations by the levels of two discrete variables

- can make use of data to determine if treatment X or Y is better in giving a Successful outcome?
  - make use of a `2x2` data/contingency table (not to be confused with a *two-way relative frequency table*)
    - dependent variable (outcome) as the row headers of the table (horizontal)
    - independent variable as the column headers of the table (vertical)

3. Marginal, Conditional & Joint rates

Marginal Rate

> *def*: Marginal rate - how the numbers in the margin of the table relate to (change in respect with) categorical variables

- to calculate, take the **row or column total** (depending on the question) and divide it by the **grand total**.

> *Formulae:*
>
> - Row Marginal rate: $\frac{Row\ Total}{Grand\ Total}$
> - Column marginal rate: $\frac{Column\ Total}{Grand\ Total}$

Conditional Rate

> *def:* Conditional rate - consider one part of the population and "ignore" the others (provided based on a **given condition**)

> *Formulae*:
>
> - General: $rate(Y \mid X) = \frac{rate(Y \wedge X)}{rate(X)}$
> - $Conditional\ rate = \frac{Joint\ count\ of\ Y \wedge X}{Marginal\ Count\ of\ X}$

- total number of participants / size of EITHER control OR treatment group will function as the denominator of the conditional rate.
  - conditional rate because only certain margins or conditions are taken into account

Joint Rate

i.e. based on "filtering out" both the independent and dependent variables

- looking at **all observations** as the base / total (as the denominator)

> *Formulae:*
> $Joint\ rate = \frac{Joint\ count\ of\ X \wedge Y}{Grand\ Total}$

4. Normalization and Parity

- normalization makes it such that in an experiment (in this case) comparing two dependent variables, we can make it such that the **discrepancy in the sizes** of the treatment and control groups are addressed

- can be through the calculation of rates *instead of using absolute numbers* which might provide a false representation of the success of either treatment.

Workflow:

1. Compares the success rates of treatments X and Y
2. Given a treatment, what is the success rate? (calculate and normalize for both treatments in question, in this case X and Y).
3. Make a fair comparison (i.e. use some similar scale
    1. Treatment X, ~77 out of 100 patients found success
    2. Treatment Y, ~83 out of 100 patients found success (positively associated with the success of the treatment)
4. Conclusion

Calculate the percentages across all rows (limit focus to one row at a time)

Table with row percentages

Outcome / Treatment	Success (row %)	Failure (row %)	Row Total (row %)
X	542 (77.4%)	158 (22.6%)	$\boxed{700}$ (100%)
Y	289 (82.6%)	61 (17.4%)	350 (100%)
Column Total	831 (79.1%)	219 (20.9%)	1050 (100%)

C. Association

> *def* Association: there is a relationship between some variables -- the independent variable (i.e. the treatment type) and the dependent variable (i.e. the outcome of the treatment)

- how two variables are related to each other
- use of the term association when we don't know if the y variable is entirely based on the x variable.
    - use of rates to determine that one of the dependent `x` variables resulted in a better `y` variable or outcome.
- association is NOT causation!

Types of Conditional rates

Case	Remarks	
Rate(A | B) = Rate(A | NB)	*Not* Associated / Association is absent	
Rate(A | B) < Rate(A | NB)	Positive association	Presence of A, when B is present is stronger than when B is absent
Rate(A | B) > Rate(A | NB)	Negative Association	Presence of A when B is present is weather than when B is absent

Notes:

- `x | y` is read as "x given y"
- `A` and `B` represent the **first** dependent (outcome) and independent variables respectively.
- `NA` and `NB` represent the **second** dependent and independent variables respectively.

Misconceptions when establishing association

Exercise
`rate(A | B) < rate(A | NB)`

- x neg associated w success
- y pos associated w success

`rate(NA | B) < rate(NA | NB) ≡ rate(A | B) < rate(A | NB)`

- x pos associated w failure
- y neg associated w failure

Given x pos associated w failure ≡ x neg associated w success

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D. Rules that govern rates

1. Symmetry Rule

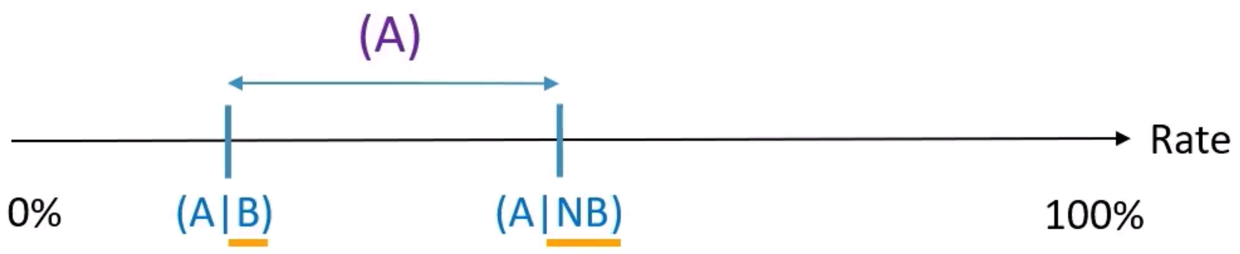
> Notation:
> $rate(X|Y) \ < trichotomy\_operator > \ rate(X|NY) \iff rate(B|A) < trichotomy\_operator > \ rate(B|NA)$

Consequences of the symmetry rule
checking for association (use either one)

1. $rate(A|B) \neq rate(A|NB)$
2. $rate(B|A) \neq rate(B|NA)$
   The above imply that the variables are either positively or negatively associated

2. Basic rule on rates

- The overall rate (`rate(A)`) will always lie between `rate(A|B)` and `rate(A|NB)`



Three Consequences of the basic rule on rates

> `rate(A | B) ≤ rate(A) ≤ rate(A | NB)` or vice versa

- As `rate(B)` approaches 100%, `rate(A)` gets closer and closer to `rate (A | B)` as compared to `rate(A | NB)` (should still fulfil the above criteria)

> $rate(B) = 50\% \implies rate(A) = \frac{[rate(A \mid B) + rate(A \mid NB)]}{2}$

- if the `rate(B)` is exactly 50%, then the `rate(A)` is exactly halfway between the boundaries of `rate(A | B)` and `rate(A | NB)`.

> $rate(A|B) = rate(A|NB) \implies rate(A) = rate(A|B) = rate(A|NB)$

- If there is equality between A given B and A given not B, then the overall rate of A would also be the same value