Statistics 305: Introduction to Biostatistical Methods for Health Sciences

Chapters 2 and 3: Data presentations and summaries

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Data Presentation (Chapter 2)

Types of Variables

- Categorical versus quantitative variables
- Categorical variables: variable has categories or classes
  - Nominal data: unordered categories or classes (e.g., gender, cancer type).
  - Ordinal data: categories with a natural order (e.g., cancer stage, injury severity score)
- Quantitative variables: numbers represent measurable quantities
  - Discrete variables: Restricted values, e.g. integers. Some examples included number of days in hospital, parity.
  - Continuous data: No restriction on values (though in practice, the measuing device may impose restrictions). Some examples include blood pressure, height, weight.

Tables

- Tables can be used to display the frequency distribution of a categorical variable
- Example: Frequency distribution of gender among 21,737 bladder cancer patients. Data from Mungan et al. (2000)

```
## Gender
## Female   Male
##   5536  16201
```

Tables, cont.

- Joint frequency distribution of two categorical variables:

```
##          Cancer.Stage
## Gender       I    II   III    IV
##   Female  3926   402   356   852
##   Male   12418   995   883  1905
```

- More on analysis of two-way tables in Chapter 15.

Tabulating Quantitative Variables

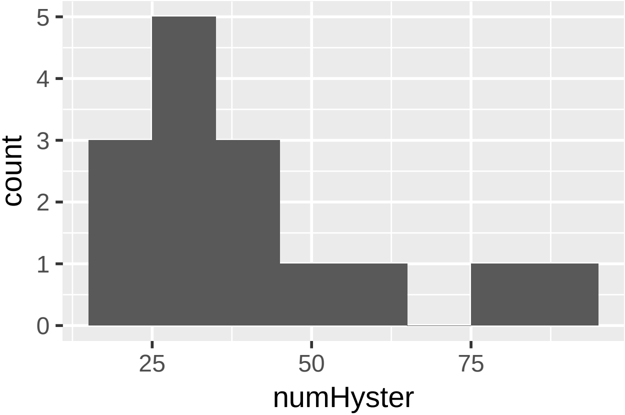
- Can tabulate quantitative variables after “binning”
- Divide the range of possible values into bins
    - For example, with age data ranging from 15 to 30 years, could create three 5-year bins for age
- Count the number of subjects in each bin
- Histograms are a graphical display of quantitative data that makes use of binning.
    - We will see an example histogram in two slides.

Graphs

- Bar plots to display categorical variables or discrete variables with a limited number of possible values
- Histograms to display discrete variables with many possible values and for continuous variables
- Bars above categories (or bins) indicate number of observations in that category (or bin)

Example Histogram

- Data on the numbers of hysterectomies performed by 15 male Swiss doctors:
  20 25 25 27 28 31 33 34 36 37 44 50 59 85 86



- Observations far from the others are called outliers

Notes on Histograms

- The purpose is a graphical representation of a distribution.
  - The details of how the picture are drawn are not that important.
  - But you may find yourself wondering . . .
- The bins in the previous example were of width 10.
  - It looks like they were set at 15 to 25, 25 to 35, etc.
- Which bin do the 25's go in?
  - The default is in the 15-25 bin. Bins don't include their left end-point, but do include their right end-point

Summary Statistics (Chapter 3)

Summary Statistics Overview

- For quantitative variables, numerical summaries are used to measure different aspects of a data distribution.
  - Mean and median measure centre (central tendancy) of the distribution
  - Inter-quartile range and standard deviation measure spread (dispersion)
- *Five-number summary* to summarize a distribution: min, max, median, 1st and 3rd quartiles. Graphed with a boxplot (more later).

Centre: The mean

- The sample mean is the ordinary arithmetic average of the observations in the sample.
  - Notation: Let $x_1, x_2, \ldots, x_n$ denote the observed values of a variable measured on n individuals. The sample mean, $\overline{x}$ is

$$\overline{x} = \frac{x_1 + x_2 + \ldots + x_n}{n} = \frac{1}{n}\sum_{i=1}^{n} x_i$$

- Hysterectomy example data:

  20 25 25 27 28 31 33 34 36 37 44 50 59 85 86

  has sample mean

$$\frac{20 + 25 + \ldots + 86}{n} = 41.3$$

Centre: The Median

- The sample median is the “middle value” of the variable

20, 25, 25, 27, 28, 31, 33, **34**, 36, 37, 44, 50, 59, 85, 86

- The centre observation is the median, $M = 34$.
- The median represents a “typical” observation.

Spread: The Standard Deviation (SD) and Variance

- The SD measures the spread about the mean.
- The sample variance, s^2, can be viewed as an average (almost) of the squared deviations about the sample mean
- The sample SD, s, is the square root of the sample variance.
    - Notation: $x_1, x_2, \ldots, x_n$ are observed measurements on n individuals with sample mean $\overline{x}$.

$$
\begin{aligned}
s^2 &= \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \overline{x})^2 \\
s &= \sqrt{s^2} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \overline{x})^2}
\end{aligned}
$$

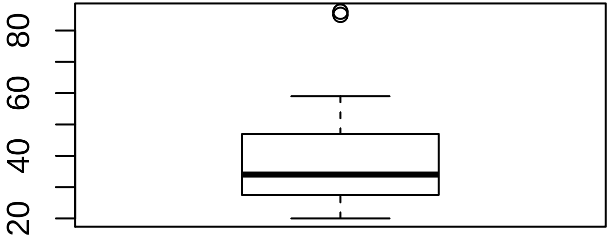
- Hysterectomy example: $s = 20.6$

Spread: The Inter-Quartile Range (IQR)

- The first and third quartiles mark the first and third quarters of the observations
  - These are also called the 25th and 75th percentile
- For the hysterectomy data, R calculates these quartiles to be 27.5 and 47, respectively.
  - Details of how R calculates quartiles are unimportant to us.
- The middle half of the data lies between.
- The range of the middle half, or IQR, is 47-27.5=19.5.

Boxplots

- The five-number summary is the minimum, maximum, median, 1st and 3rd quartiles; graphed with a boxplot:



- Box represents the IQR, thick horizontal line the median.
- Whiskers extend out to the min/max if these are within a certain distance from the box,
- However, **outliers** that are far from the box are plotted separately (as above)
- There are different ways to draw boxplots; details unimportant

Further Examples

- Summary statistics and graphics can be very powerful.
- See, for example, the late Hans Rosling's work

http://www.ted.com/talks/hans_rosling_shows_the_best_stats_you_ve_ever_seen.html