Pharmaceutical Statistics

Lecture 2

Types of Data

&

Graphical Presentation of Data

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Types of Data

Qualitative (Categorical) which is divided into:

a- Nominal (e.g. hair colour, sex….) unordered categories

b- Ordinal (e.g. Grade of malignancy, degree of pain) ordered categories

Quantitative data which is divided into:

a- Continuous e.g. (LDH, Cholesterol, BP….)

· There are no gaps between possible values, fractions are accepted

b- Discrete e.g. (number of absent students, number of crimes)

There are gaps between possible values, fractions are not accepted

Types of Data

- Nominal data
  - Values represent unordered categories
  - Example (simplest case-2 categories “binary”)

0 -- male

1 -- female

Types of Data

- Nominal data
  - Example 2: Race

    0 -- did not answer

    1 -- black

    2 -- white

    3 -- Asian

    4 -- other

Types of Data

- Ordinal Data
  - Values represent ordered categories
  - Example – toxicity grades

0 -- none

1 -- mild

2 -- moderate

3 -- severe

4 -- life-threatening

Types of Data

- Note that there is a natural ordering for the ordinal data
- No natural ordering for nominal data

Types of Data

- Discrete data
  - Numbers represent measurable quantities
  - Can take on only specified values that differ by fixed amounts
  - Often count data (e.g., number of hospitalizations)

Types of Data

- Discrete data
- Example – number of risk factors

  0 -- no risk factors

  1 -- one risk factor

  2 -- two risk factors

  3 -- three risk factors

  4 -- four risk factors

Types of Data

- Continuous data
  - Represents measurable quantities
  - Not restricted to specified values
  - Fractional values possible

Types of Data

- Continuous data examples:
  - Temperature
  - Time
  - Weight
  - Cholesterol level
  - Concentration of fluoride in drinking water

New York Heart Association Functional Class

- Measures extent of heart failure
  - 1: no symptoms or limitations
  - 2: mild symptoms, slight limitations
  - 3: marked limitation in activities due to symptoms
  - 4: severe limitations, symptoms even at rest

Poll

- What type of scale is the NYHA functional class?
  - Nominal
  - **Ordinal**
  - Discrete
  - Continuous

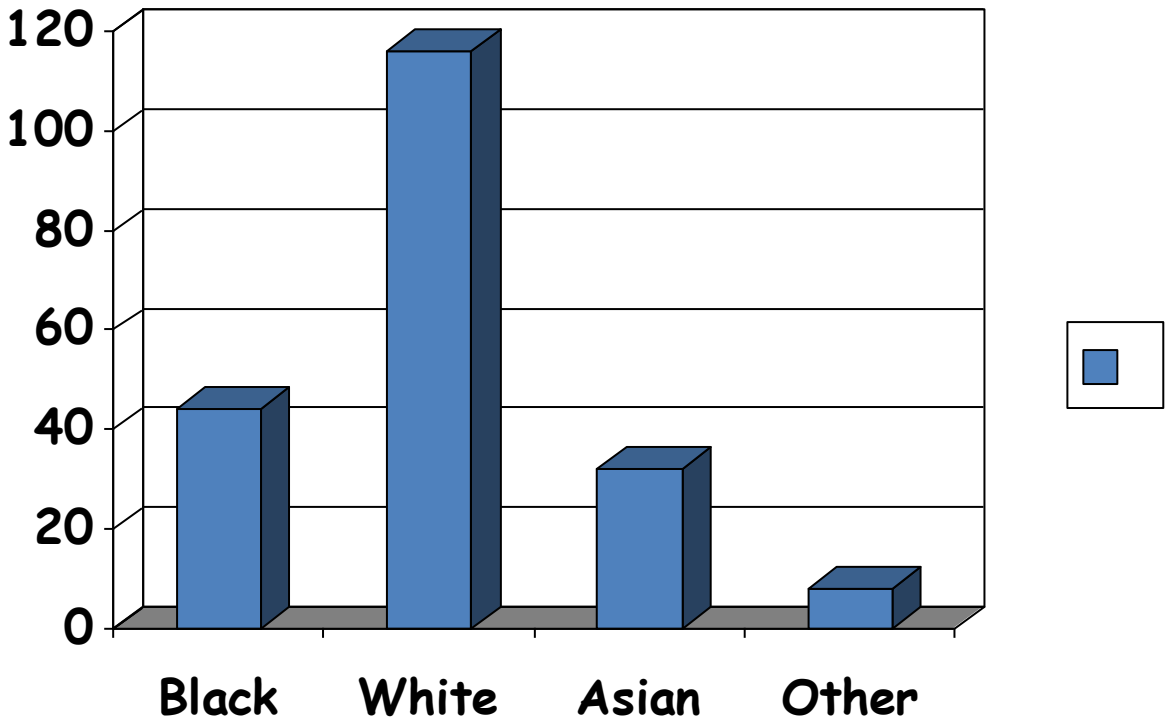
Data Presentation

- Nominal data
  - Limited options for presenting data
    - Counts in each category
    - Histograms
    - Relative frequencies
    - Relative frequency diagram
    - Pie chart

Nominal Data

Race	N
Black	44
White	116
Asian	32
Other	8

Histogram



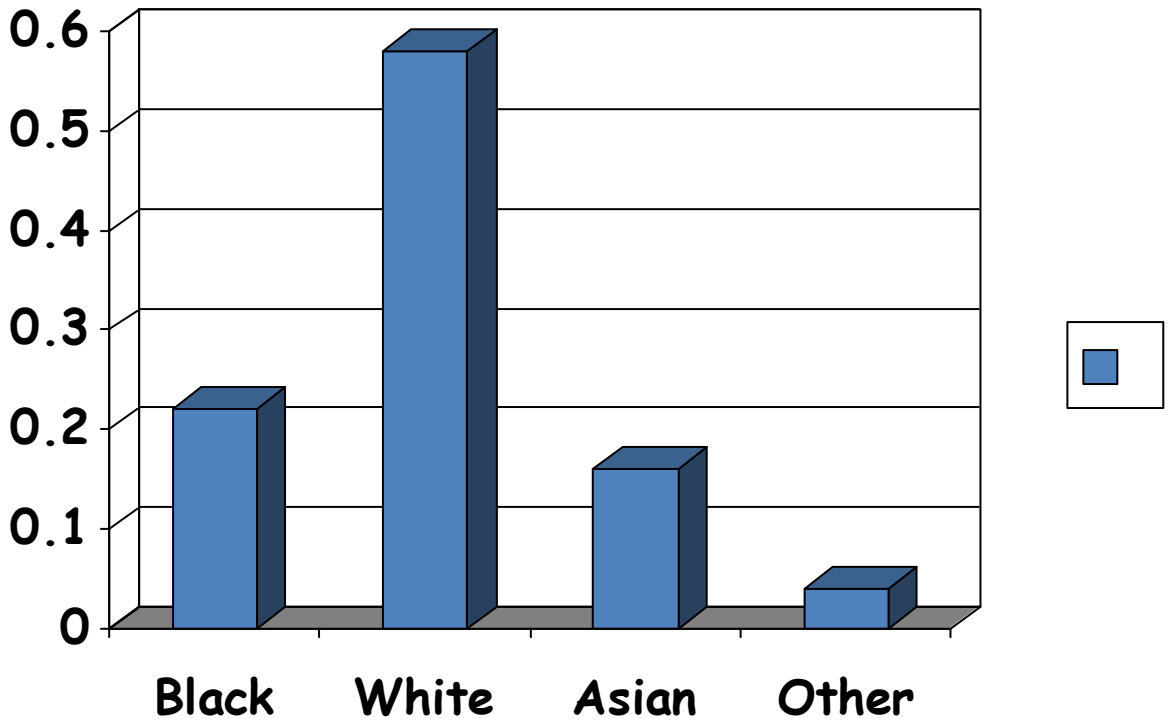
Nominal Data

Race	N	Relative frequency
Black	44	
White	116	
Asian	32	
Other	8	
Total	200	

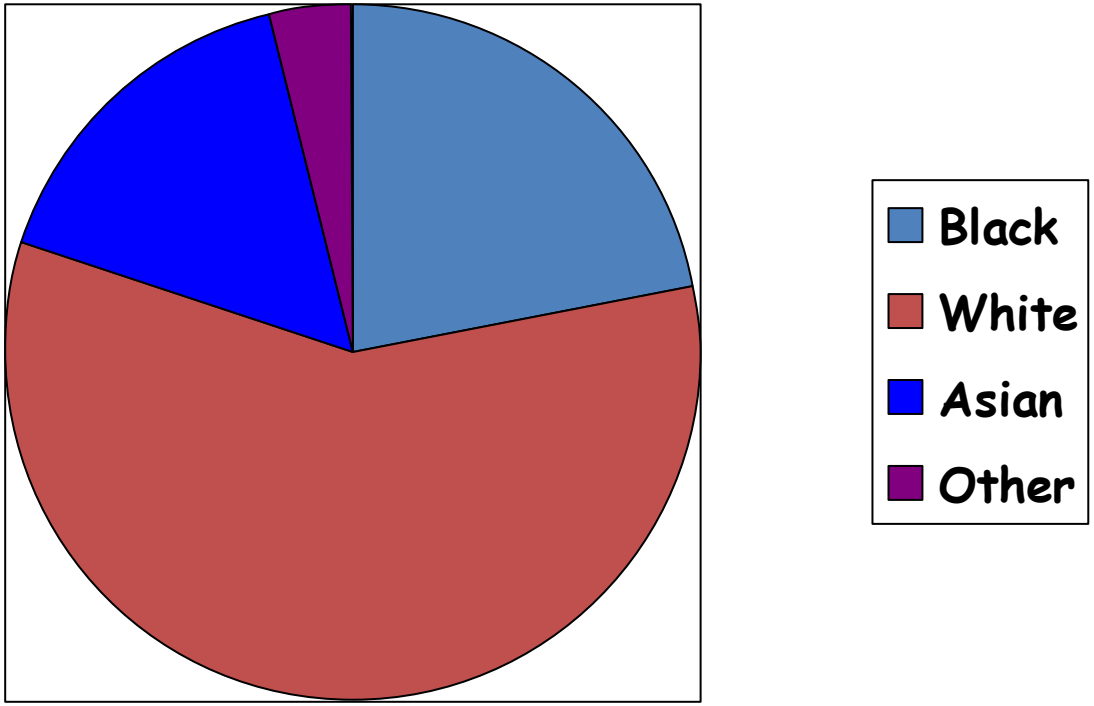
Nominal Data

Race	N	Relative frequency
Black	44	.22
White	116	.58
Asian	32	.16
Other	8	.04
Total	200	1.00

Relative Frequency Diagram



Pie Chart



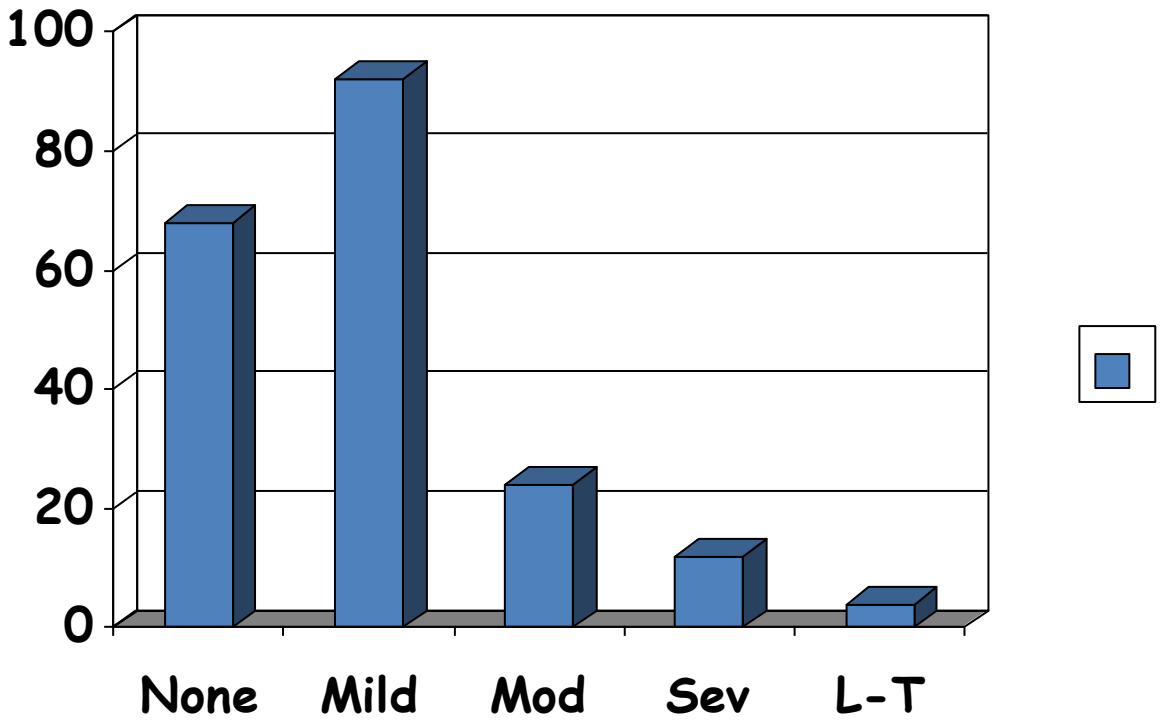
Data Presentation

- Ordinal data
  - All the tools for nominal data
  - Additional options for presenting data
    - Cumulative frequencies
    - Cumulative frequency polygons
    - Percentiles

Ordinal Data

Toxicity	N
None	68
Mild	92
Moderate	24
Severe	12
Life-threatening	4

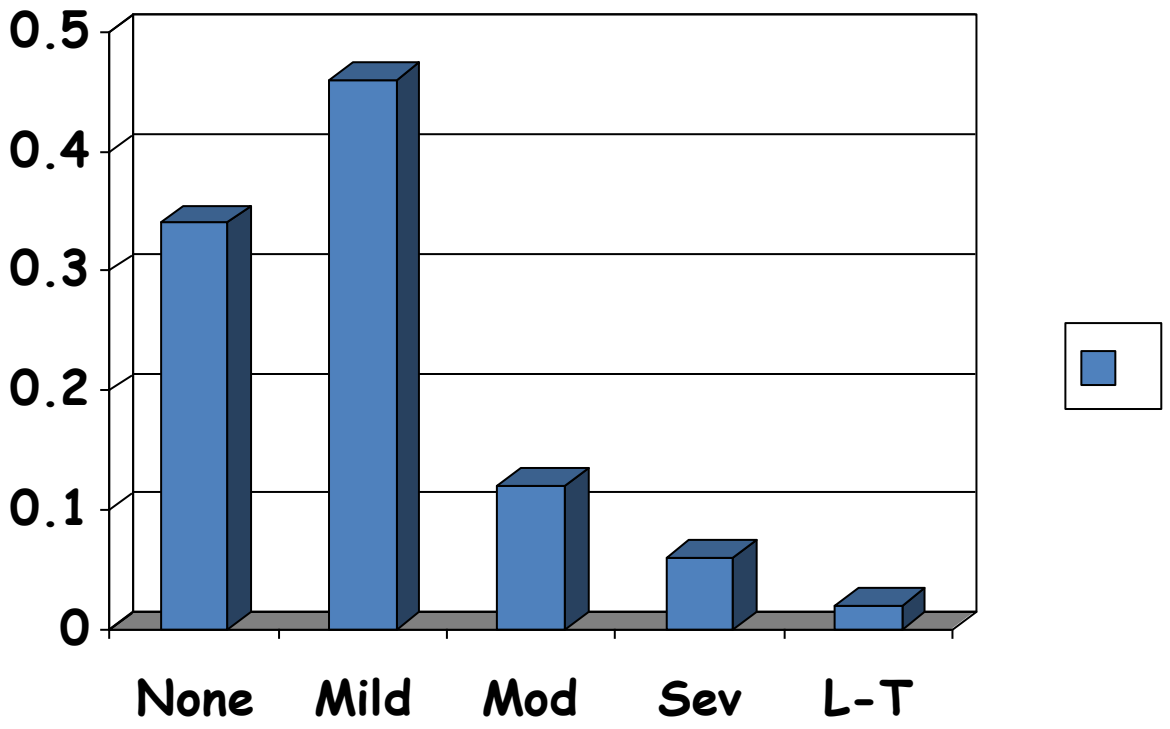
Histogram



Ordinal Data

Toxicity	N	Relative Freq
None	68	.34
Mild	92	.46
Moderate	24	.12
Severe	12	.06
Life-threatening	4	.02

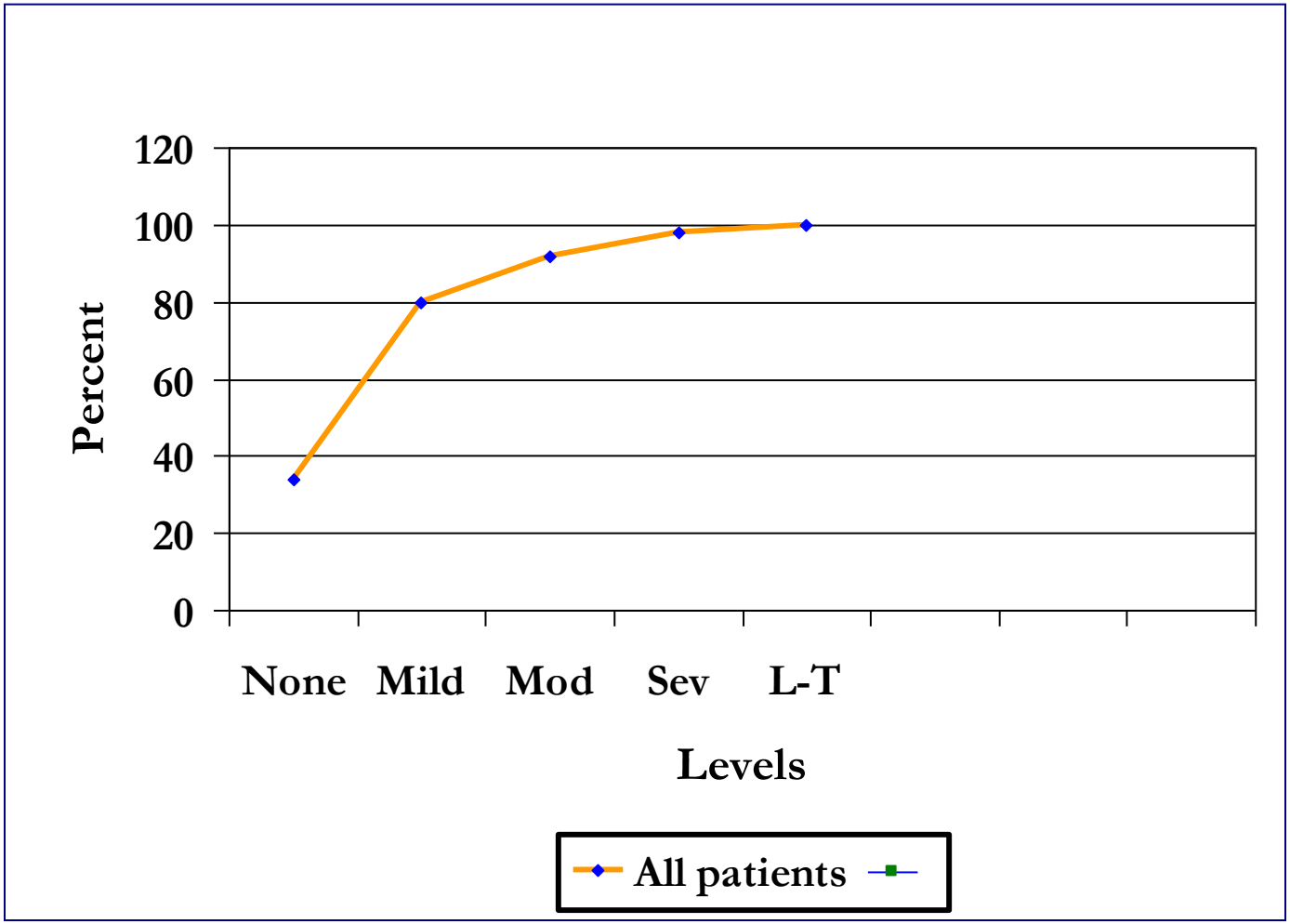
Relative Frequency Diagram



Ordinal Data

Toxicity	N	Relative Freq	Cumulative Freq
None	68	.34	.34
Mild	92	.46	.80
Moderate	24	.12	.92
Severe	12	.06	.98
Life-threatening	4	.02	1.00

Cumulative Frequency Polygon



Ordinal Data

- Since the data are ordered, we can also use percentiles
- Percentiles divide a distribution into equal or ordered parts
- The ***median*** (50^{th} percentile) divides a population into 2 equal-size parts (more on medians in a couple minutes)

Data Presentation

- Discrete data
  - All the tools for ordinal data
  - Values of the measure have numerical meaning
  - Additional options for presenting data
    - means

Discrete Data

Number of Risk Factors	N
0	62
1	86
2	32
3	14
4	6

Discrete Data

- The values of the observations now represent actual numeric values
- We can calculate a mean (simple arithmetic average)
- Mean = sum of observations / N

Discrete Data

- In our example,

Mean = [(0 x 62) + (1 x 86) + (2 x 32)
+ (3 x 14) + (4 x 6)] / 200

= [0 + 86 + 64 + 42 + 24] / 200

= 216 / 200

= 1.08 risk factors

Data Presentation

- Continuous data
  - Wide variety of options
    - numerical
    - graphical
  - Important to consider both central tendency and dispersion
  - Examining the distribution is important
  - Divided into (interval & ratio)

Continuous Data

- Data on fluoride levels (1st 15 values)

0.079	0.146	0.112
0.071	1.335	0.072
0.224	0.553	0.071
0.159	0.415	0.119
2.467	0.288	0.154

Measures of Central Tendency

- We can calculate the sample mean as before, i.e., add all the observations together and divide by N, the number of observations
  - Mean = 0.697

Measures of Central Tendency

- To calculate the median, we order observations from smallest to largest.
- If N is odd, define j=(N+1)/2. The jth ordered observation is the median
- If N is even, j=N/2. The median is the average of ordered observations j and j+1.

Measures of Central Tendency

- Suppose we have 9 observations:

  2.60, 2.75, 2.89, 4.05, 2.25,

  2.68, 3.00, 4.02, 2.85

- The mean is 27.09 / 9 = 3.01
- The median is 2.85

Measures of Central Tendency

- Suppose the 8th observation were 40.02 instead of 4.02

  2.60, 2.75, 2.89, 4.05, 2.25,

  2.68, 3.00, 40.02, 2.85

- The mean is now 63.09 / 9 = 7.01
- The median is 2.85

Measures of Dispersion

- It is also important to know something about the variability of the data
- Common measures include:
  - Range: difference between the largest and smallest observations
  - Interquartile range: difference between the 25^{th} and 75^{th} percentiles
  - Standard deviation: square root of the variance

Standard Deviation

x	x - mean
2.60	-0.41
2.75	-0.26
2.89	-0.12
4.05	1.04
2.25	-0.76
2.68	-0.33
3.00	-0.01
4.02	1.01
2.85	-0.16
total	0.00

Standard Deviation

x	x - mean	$(x - \text{mean})^2$
2.60	-0.41	0.1681
2.75	-0.26	0.0676
2.89	-0.12	0.0144
4.05	1.04	1.0816
2.25	-0.76	0.5776
2.68	-0.33	0.1089
3.00	-0.01	0.0001
4.02	1.01	1.0201
2.85	-0.16	0.0256
total	0.00	3.0640

Standard Deviation

- Variance is the sum of the squared deviations divided by (N-1)
  - Variance = 3.0640 / 8 = 0.383
- Standard deviation is the square root of the variance
  - s.d. = 0.619

Data Presentation Methods

- Presenting only the mean does not inform the reader of the diversity in the set of values from the sample. Thus, standard deviation (SD) is calculated.
- SD is presented with the mean value of the sample (e.g., 145 mg/dL ±15, where the former number is the mean and the latter number is the SD).

Data Organization

- **Measurements that have not been organized, summarized or otherwise manipulated are called raw data.**
- **Unless the number of observations is extremely small, it will be unlikely that these raw data will impart much information until they have been put into some kind of order.**
- **Always it is easier to analyze organized Data**

Table 1: Raw data of cholesterol lowering effect of a drug given to 156 subjects

17	-12	25	-37	-29	-39
-22	0	-22	-63	34	-31
-64	-12	-49	5	-8	33
-50	-7	16	-11	-38	-17
0	-9	-21	1	2	-30
-32	-34	-14	-18	5	6
24	-6	14	10	-41	-66
-25	-12	14	10	-41	-66
-31	35	21	-19	-27	17
-6	-17	-6	1	-28	40
-31	17	-54	-27	-16	16
-44	10	-3	-3	5	6
-19	9	-10	-20	-9	-8
-10	-11	11	-39	19	-32
4	-15	-18	35	6	20
26	24	-27	-19	6	-60
27	23	-22	-1	12	-27
-13	-39	39	-34	-97	-26
38	14	-47	8	26	-15
-62	12	-53	11	21	-47
-54	-11	-5	0	55	34
-69	-11	-44	20	-50	19
0	-25	-24	-4	14	2
-34	26	-23	-71	-58	9
9	2	-2	-58	13	14
17	-13	-22	-3	-17	1

Ordered Array

- **The preparation of the ordered array is the first step in organizing data.**

- **An ordered array is a listing of the values of a collection (either population or sample) from the smallest value to the largest value.**

- **The ordered array enables one to determine quickly the value of the smallest measurement, the value of the largest measurement and the general trends in the data.**

Table 2. Ordered array of data reported in Table 1.

-97	-38	-21	-9	5	17
-71	-37	-20	-8	5	17
-69	-34	-19	-8	6	17
-66	-34	-19	-7	6	19
-66	-34	-19	-6	6	19
-64	-32	-18	-6	6	20
-63	-32	-18	-6	8	20
-62	-31	-17	-5	9	21
-60	-31	-17	-4	9	21
-58	-31	-17	-3	9	23
-58	-30	-16	-3	10	24
-54	-29	-15	-3	10	24
-54	-28	-15	-2	10	25
-53	-27	-14	-1	11	26
-50	-27	-13	0	11	26
-50	-27	-13	0	12	26
-49	-27	-12	0	12	27
-47	-26	-12	0	13	33
-47	-25	-12	1	14	34
-44	-25	-11	1	14	34
-44	-24	-11	1	14	35
-41	-23	-11	2	14	35
-41	-22	-11	2	14	38
-39	-22	-10	2	16	39
-39	-22	-10	4	16	40
-39	-22	-9	5	17	55

Grouped Data
The frequency distribution

- Although a set of observation can be made more comprehensible and meaningful by means of an ordered array, further useful summarization may be achieved by grouping the data.

- To group a set of observations, we select a set of non-overlapping **intervals** such that each value in the data set of observations can be placed in one, and only one, interval.

- These intervals are usually referred to as **Class Intervals**.

- Usually class intervals are ordered from smallest to largest.
- Interval width=19-10+1=10 or 20-10=10
- Total range=69-10+1=60 or 10*6=60

Class Interval	Frequency
10-19	4
20-29	66
30-39	47
40-49	36
50-59	12
60-69	4
Total	169

Grouped data
The relative frequency distribution

- It may be useful sometimes to know the proportion rather than the number, of values falling between a particular class interval.
- We obtain this information by dividing the number of values in the particular class interval by the total number of values.
- We refer to the proportion of values falling within a class interval as the relative frequency of values in that interval.
- We may sum (cumulate) the frequencies and relative frequencies to facilitate obtaining information regarding frequency or relative frequency of values within two or more contiguous class intervals.

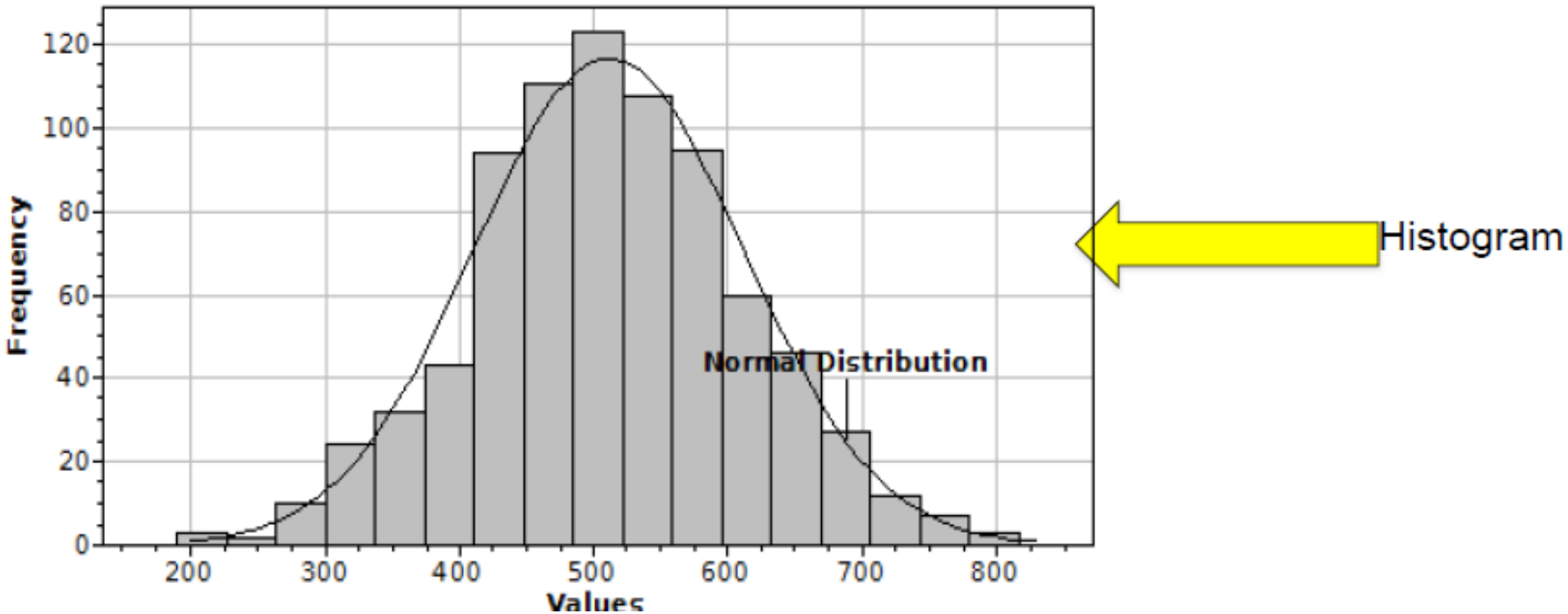
Total # of values higher than 10 and lower than 19, inclusive

Class Interval	Frequency	Relative Frequency	Cumulative Frequency	Cumulative Relative Frequency
10-19	4	0.0237	4	0.0237
20-29	66	0.3905	70	0.4142
30-39	47	0.2781	117	0.6923
40-49	36	0.2130	153	0.9053
50-59	12	0.0710	165	0.9763
60-69	4	0.0237	169	1.0000
Total	**169**	**1.0000**		

the ratio of the frequency of a particular event in a statistical experiment to the total frequency.

Histogram

- We may display a frequency distribution (or a relative frequency distribution) graphically in the form of a histogram, which is a special type of bar graphs.
- When we construct a histogram, the variable under consideration are represented by the horizontal (x) axis, while the the frequency (or relative frequency) of occurrence is the (y) axis.



Construction of Frequency Distribution Table

- How many class intervals to employ?
- Sturges's rule:

$k = 1 + 3.322 (\log_{10} n)$

K: Number of intervals

n = number of observations

Interval width = Range/K

- The rule is just used as guidance and should not be applied strictly

- For data in Table 1
- $K = 1 + 3.322 \times (\log 156)$

  ≈ 8
- Width = (55-(-97))/8

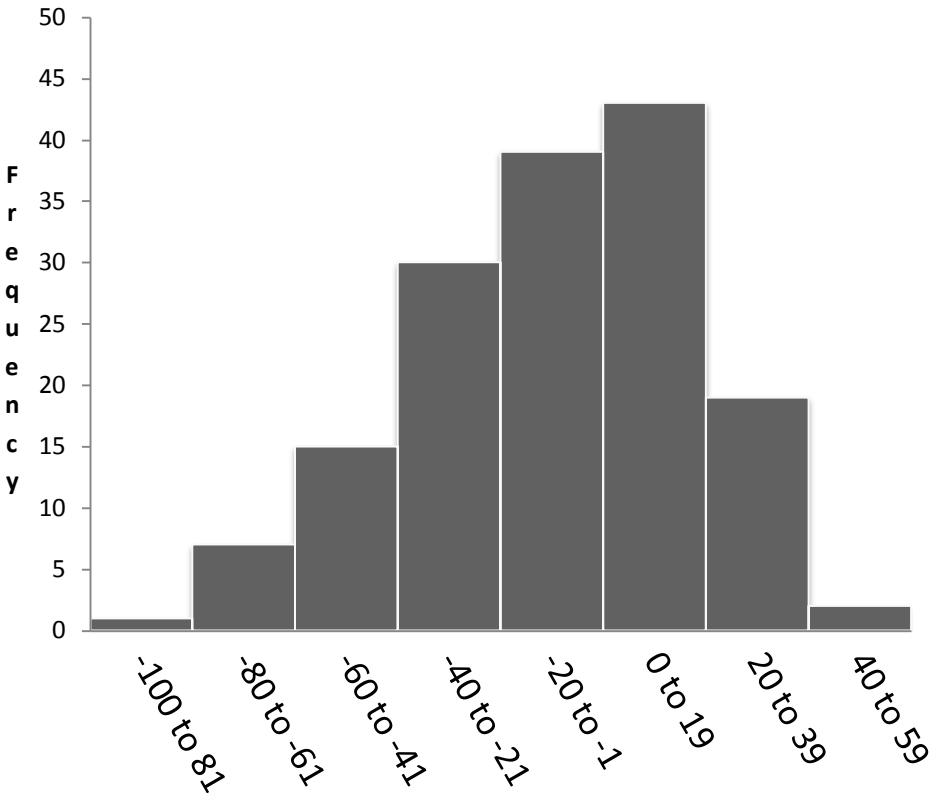
  = 19
- Width of twenty is fair choice
- Since the lowest and highest values are -97 and 55, the lowest and highest limits could be set as -100 and 40, respectively.

Construction of Frequency Distribution Table

According to the previous slide,

Data in Table 1 can be put into frequency distribution table as follows

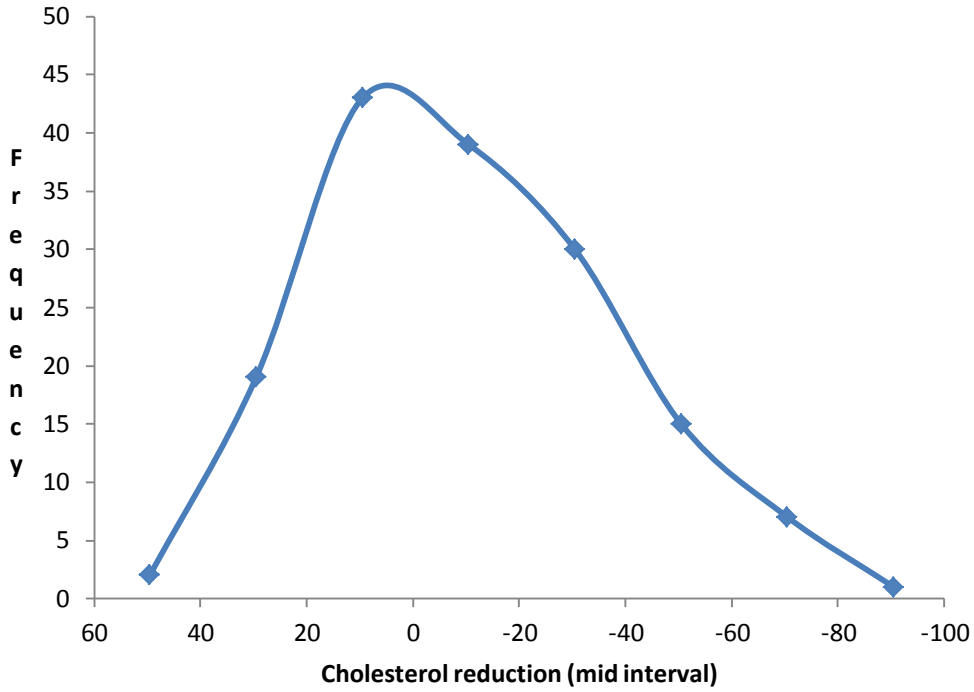
Interval	Frequancy
-100 to -81	1
-80 to -61	7
-60 to -41	15
-40 to -21	30
-20 to -1	39
0 to 19	43
20 to 39	19
40 to 59	2



Frequency Distribution Curve

A plot of frequency versus mid interval size taken as the average of upper and lower limits for each interval. For the data in Table 1 the following Table is plotted

Mid interval	Frequancy
-90.5	1
-70.5	7
-50.5	15
-30.5	30
-10.5	39
9.5	43
29.5	19
49.5	2



Review

Measures of central tendency

- **Mean:** average of the data points

e.g. Values are (2,4,6,10,12,16)→ Mean = ((2+4+6+10+12+14)/6)=8

- **Mode:** is most frequently occurring data point

e.g. values are (3,6,6,8,6,5) → mode = 6

Measures of central tendency

- **Median:** midpoint of the data (point at which the data lie 50% above and below)

e.g1. (5,6,10,15,14,16,3) → Ascending order

(3,5,6,10,14,15,16)

No. of values (n) = 7 (odd of number)

Median = (n+1/2) = (7+1)/2=4th value = 10

Measures of central tendency

- **e.g2. (5,6,10,15,14,16,3,2) → Ascending order (2,3,5,6,10,14,15,16)**

No. of values (n) = 8 (even of number)

Median = Average of (n/2 value and ((n/2) +1)value)

Median = Average of the 4^{th} value and the 5^{th} value

= Average of 6 & 10 = 8

Measures of Dispersion

- **Range:** usually described by listing the smallest and largest data points (e.g., "The range is from 5 to 9")
- **Standard Deviation (SD):** degree in which individual data points deviate from the mean value of the data set.
- **Variance:** = $(SD)^2$

Data Presentation Methods

Type of Data	Mode	Median	Mean	Range	SD
Nominal	X				
Ordinal	X	X		X	
Interval and Ratio	X	X	X	X	X