Applied Epidemiology I: Tables and interpreting results

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Acknowledgements

This course material is based on my learning from Anastasia Lam's teachings in last year's Applied Epidemiology I lab sessions, and readings from *Epidemiology* by Gordis [1], *A First Course in Probability and Statistics* by Goldsman and Goldsman [2], *Principles of Biostatistics* by Pagano and Gauvreau [3], and *Biostatistics I* by Gabriel and Frumento [4]. I especially want to thank Marlene Stratmann for reviewing the slides and Prof. Paul Dickman for providing me with suggestions to improving the teaching.

Outline

1. Tables
   - One-way tables
   - Two by two tables
   - Stata tool for Epidemiology
2. Basic Epidemiology terms
   - Rate vs. proportion
   - Risk, risk difference, risk ratio
   - Odds, odds ratio
3. Interpreting results
   - Principles
   - Ratio $>$ or $<$ 1
   - More examples
4. Calculate ratios using Stata
   - Risk ratio
   - Odds ratio
   - Incidence rate ratio
5. References

Tables: One-way tables

- We use cancer data still.

```
sysuse cancer, clear
keep if drug ==1 | drug == 2
```

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```

- One-way table of frequencies with mean and sd of age
```
. table died, contents(freq mean age sd age)

----------------------------------------------
1 if      |
patient   |
died      |      Freq.    mean(age)     sd(age)
----------+-----------------------------------
        0 |          9      55.1111    5.487359
        1 |         25        56.88    6.227091
----------------------------------------------
```

Tables: One-way tables

- One-way table of frequencies

```
. tabulate died

     1 if |
  patient |
     died |      Freq.     Percent        Cum.
------------+-----------------------------------
        0 |          9       26.47       26.47
        1 |         25       73.53      100.00
------------+-----------------------------------
    Total |         34      100.00
```

Tables: One-way tables

- One-way tables of frequencies each variable specified

```
. tab1 died drug
-> tabulation of died

     1 if |
  patient |
     died |      Freq.     Percent        Cum.
------------+-----------------------------------
        0 |          9       26.47       26.47
        1 |         25       73.53      100.00
------------+-----------------------------------
    Total |         34      100.00

-> tabulation of drug

  Drug type |
(1=placebo) |      Freq.     Percent        Cum.
------------+-----------------------------------
        0 |         14       41.18       41.18
        1 |         20       58.82      100.00
------------+-----------------------------------
    Total |         34      100.00
```

Tables: One-way tables

- Create table I of baseline characteristics using `table1_mc`
- This command is useful. Play it on your own!
- See `help table1_mc`

```
. ssc install table1_mc, replace
. table1_mc, vars(age conts)
  +----------------------------------------------+
  |                                 Total        |
  |----------------------------------------------|
  |                                 N=34         |
  |----------------------------------------------|
  | Patient's age at start of exp.   56 (51-61) |
  +----------------------------------------------+
Data are presented as median (IQR).
```

Tables: Two by two tables

- 2 by 2 table for drug and died with relative frequency by column or row

```
. tabulate died drug, col row

     1 if |
  patient | Drug type (1=placebo)
     died |         0          1 |     Total
-----------+----------------------+----------
        0 |         8          1 |         9
          |     88.89      11.11 |    100.00
          |     57.14       5.00 |     26.47
-----------+----------------------+----------
        1 |         6         19 |        25
          |     24.00      76.00 |    100.00
          |     42.86      95.00 |     73.53
-----------+----------------------+----------
    Total |        14         20 |        34
          |     41.18      58.82 |    100.00
          |    100.00     100.00 |    100.00
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Tables: Two by two tables

- 2 by 2 table with chi-square test and fisher's exact test

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. tabulate died drug, col row chi2 exact
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    Total |        14         20 |        34
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          Pearson chi2(1) =  11.5039   Pr = 0.001
           Fisher's exact =                 0.001
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- How to interpret the results?
- Chi-square test: testing the association between two binary variables.
- Using placebo has association with that the patients died or not.

Tables: Two by two tables

- 2 by 2 tables straitified by sex

```
. bysort sex: tab died drug, col row chi2

-> sex = 0

     1 if |
  patient | Drug type (1=placebo)
     died |         0          1 |     Total
-----------+----------------------+----------
        0 |         6          1 |         7
          |     85.71      14.29 |    100.00
          |     75.00       9.09 |     36.84
-----------+----------------------+----------
        1 |         2         10 |        12
          |     16.67      83.33 |    100.00
          |     25.00      90.91 |     63.16
-----------+----------------------+----------
    Total |         8         11 |        19
          |     42.11      57.89 |    100.00
          |    100.00     100.00 |    100.00

          Pearson chi2(1) =   8.6466   Pr = 0.003
```

```
-> sex = 1
     1 if |
  patient | Drug type (1=placebo)
     died |         0          1 |     Total
-----------+----------------------+----------
        0 |         2          0 |         2
          |    100.00       0.00 |    100.00
          |     33.33       0.00 |     13.33
-----------+----------------------+----------
        1 |         4          9 |        13
          |     30.77      69.23 |    100.00
          |     66.67     100.00 |     86.67
-----------+----------------------+----------
    Total |         6          9 |        15
          |     40.00      60.00 |    100.00
          |    100.00     100.00 |    100.00

          Pearson chi2(1) =   3.4615   Pr = 0.063
```

Tables: Stata tool for Epidemiology

- How to use Stata to generate risk ratios (relative risk) and odds ratios?

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- But before demonstrating how this works, a recapture on basic epi terms!

Basic Epidemiology terms: Rate vs. proportion

Rate

Proportion

Risk

Basic Epidemiology terms: Rate vs. proportion

Rate

- Incidence (rate): $\frac{\text{no. of diseased}}{\text{total person-time}}$

Proportion

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- Cumulative incidence: **over a time period**, $\frac{\text{no. of new cases of the disease}}{\text{no. of initially disease-free persons}}$

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- Point prevalence: **at a specified time**, $\frac{\text{no. of diseased}}{\text{no. of persons}}$
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$$\frac{\text{no. of alive persons (since diagnosis)}}{\text{no. of initially disease-free persons (since diagnosis)}}$$

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3. Is risk a rate or a proportion?

Basic Epidemiology terms: Risk, risk difference, risk ratio

Risk: the proportion (probability) of an event, e.g., death.

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Cumulative hazard = 1−Survival proportion = Cumulative probability of death

$$F(t) = 1 - S(t) = P(T \leq t)$$

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- Risk ratio: the ratio of the probabilities of an event between the exposed group and non-exposed group
- **Caution!** Relative risk could be either risk ratio or rate ratio!

Basic Epidemiology terms: Risk, risk difference, risk ratio

	Female (Exposed)	Male (Unexposed)	Total
shiba (Case)	2	2	4
guinea pig (Noncase)	2	1	3
Total	4	3	7

Epidemiologists love two by two tables!

Basic Epidemiology terms: Risk, risk difference, risk ratio

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- Risk difference between females having shiba and males having shiba $= \widehat{p_F} - \widehat{p_M} = 2/4 - 2/3 - = -0.16667$
- Interpretation: Females have 16.67 % lower risk of having shiba than males.

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- Risk ratio between females having shiba and males having shiba $= \widehat{p_F} \div \widehat{p_M} = 2/4 \div 2/3 = 0.75.$
- Interpretation: The RR of females having shiba is 0.75 times than males having shiba.

Basic Epidemiology terms: Odds, odds ratio

Odds: the ratio between those having and not having an outcome.

$$Odds = \frac{p}{1 - p}$$

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- E.g., the OR is 0.5, which indicates that there is a 50% decrease in the odds of having an outcome among the exposed compared to the unexposed.

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- E.g., the OR is 0.5, which indicates that there is a 50% decrease in the odds of having an outcome among the exposed compared to the unexposed.
- Why there is no odds difference?

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- The odds of having shiba among females is

$$\widehat{odds_F} = \frac{p(\text{having shiba}|\text{female})}{p(\text{having guinea pig}|\text{female})} = \frac{(2/4)}{(2/4)} = 1$$

- The odds of having shiba among males is 2 (calculation ignored).

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- OR of having shiba (females to males)
- OR $= \frac{Odds_f}{Odds_m} = \frac{1}{2}$

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- The odds of having shiba among males is 2 (calculation ignored).

- OR of having shiba (females to males)
- OR $= \frac{Odds_f}{Odds_m} = \frac{1}{2}$
- Interpretation: there is a 50% decrease in the odds of having shiba among females compared to males. Higher odds of shiba ownership among males than females!
- It seems that females instead love guinea pigs more.

Interpreting results: Principles

- When describing a ratio, it can ideally be illustrated by
    1. Exposed group
    2. Ratio (exact value, higher or lower percentage)
    3. Outcome
    4. Unexposed

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- Example:
  1. Females have a RR of 0.75 having shiba compared to males.

Interpreting results: Principles

- When describing a ratio, it can ideally be illustrated by
  1. Exposed group
  2. Ratio (exact value, higher or lower percentage)
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- Example:
  1. Females have a RR of 0.75 having shiba compared to males.
  2. Females have a 50% decrease in the odds of having shiba compared to males.

Interpreting results: Ratio $>$ or $<$ 1

Ratio

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Ratio

- As ratio < 1,
  - $(1 - \text{RR/OR}) \times 100\%$
  - E.g., $\text{RR} = 0.75$, $(1 - 0.75) \times 100\% = 25\%$
  - 25% lower risk

Ratio

- As ratio < 1,
  - $(1 - RR/OR) \times 100\%$
  - E.g., $RR = 0.75$, $(1 - 0.75) \times 100\% = 25\%$
  - 25% lower risk
- As ratio > 1,
  - $(RR/OR - 1) \times 100\%$
  - E.g., $OR = 2.05$, $(2.05 - 1) \times 100\% = 105\%$
  - The odds is 2 times higher.
  - Twice the odds

Interpreting results: More examples

Diabetes Is a Risk Factor for Pulmonary Tuberculosis: A Case-Control Study from Mwanza, Tanzania (Faurholt-Jepsen, 2011)

	OR (95% C.I.)	OR (95% C.I.)	OR (95% C.I.)
		Model 1	Model 2
	Unadjusted	Adjusted for age, sex, socio-demography [2]	Model 1 + AGP [3]
HIV negative (n = 770)			
Glucose intolerance status [1]			
normal glucose tolerance	ref.	ref.	ref.
IFG/IGT	2.26 (1.50;3.41)	2.34 (1.52;3.61)	2.65 (1.00;7.06)
diabetes	2.15 (1.35;3.42)	2.14 (1.32;3.46)	4.23 (1.54;11.57)

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1. People with diabetes had a higher odds of TB (OR 2.15, 95% CI: 1.35-3.42) relative to people without diabetes.

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diabetes	2.15 (1.35;3.42)	2.14 (1.32;3.46)	4.23 (1.54;11.57)

1. People with diabetes had a higher odds of TB (OR 2.15, 95% CI: 1.35-3.42) relative to people without diabetes.
2. Having diabetes was associated with more than a 2-fold increase (OR: 2.15, 95% CI: 1.35; 3.42) in the odds of TB compared to not having diabetes.

Bidirectional association between physical activity and symptoms of anxiety and depression: the Whitehall II study (Azevedo Da Silva, 2012)

Table 3 Cross-sectional associations between physical activity at recommended levels and anxiety and/or depression symptoms at phase 1 (1985–1988) (N = 9,309)

	OR (CI 95 %)	*P* value
Anxiety symptoms		
Model 1		
Physical activity		
Yes	0.71 (0.54, 0.91)	0.01
No	1 (reference)	
Model 2		
Physical activity		
Yes	0.71 (0.55, 0.93)	0.01
No	1 (reference)	
Depression symptoms		
Model 1		
Physical activity		
Yes	0.63 (0.48, 0.81)	<0.001
No	1 (reference)	
Model 2		
Physical activity		
Yes	0.63 (0.49, 0.82)	0.001
No	1 (reference)	

Interpreting results: More examples

Bidirectional association between physical activity and symptoms of anxiety and depression: the Whitehall II study (Azevedo Da Silva, 2012)

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1. Patients who conducted recommended levels of physical activity had a 29% lower odds of anxiety (OR: 0.71, 95% CI: 0.54-0.91) and a 37% lower odds of depression (OR: 0.63, 95% CI: 0.48-0.81) relative to those who did not.

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1. Patients who conducted recommended levels of physical activity had a 29% lower odds of anxiety (OR: 0.71, 95% CI: 0.54-0.91) and a 37% lower odds of depression (OR: 0.63, 95% CI: 0.48-0.81) relative to those who did not.
2. Our results showed that individuals who practiced recommended levels of physical activity were less likely to have anxiety (OR: 0.71, 95% CI: 0.54-0.91) and depression (OR: 0.63, 95% CI: 0.48-0.81) in comparison with those who did not.

Calculate ratios using Stata: Risk ratio

- Finally we come back to Stata again!

Calculate ratios using Stata: Risk ratio

- Finally we come back to Stata again!
- cs case exposed

```
. cs died drug

                 | Drug type [1=placebo]  |
                 |   Exposed   Unexposed  |      Total
-----------------+------------------------+-----------
           Cases |        19           6  |         25
        Noncases |         1           8  |          9
-----------------+------------------------+-----------
           Total |        20          14  |         34
                 |                        |
            Risk |       .95    .4285714  |   .7352941
                 |                        |
                 |      Point estimate    |    [95% Conf. Interval]
                 |------------------------+------------------------
 Risk difference |         .5214286       |    .245166    .7976911
      Risk ratio |         2.216667       |   1.200631    4.092525
 Attr. frac. ex. |         .5488722       |   .1671043    .7556521
 Attr. frac. pop |         .4171429       |
                 +-------------------------------------------------
                               chi2(1) =    11.50  Pr>chi2 = 0.0007
```

Calculate ratios using Stata: Odds ratio

- cs case exposed, or

```
. cs died drug, or

                 | Drug type [1=placebo]  |
                 |   Exposed   Unexposed  |      Total
-----------------+------------------------+------------
           Cases |        19           6  |         25
        Noncases |         1           8  |          9
-----------------+------------------------+------------
           Total |        20          14  |         34
                 |                        |
            Risk |       .95    .4285714  |   .7352941
                 |                        |
                 |      Point estimate    |    [95% Conf. Interval]
                 |------------------------+------------------------
 Risk difference |         .5214286       |     .245166    .7976911
      Risk ratio |         2.216667       |    1.200631    4.092525
 Attr. frac. ex. |         .5488722       |    .1671043    .7556521
 Attr. frac. pop |         .4171429       |
      Odds ratio |         25.33333       |    3.189793           . (Cornfield
                 +-------------------------------------------------
                               chi2(1) =    11.50  Pr>chi2 = 0.0007
```

Calculate ratios using Stata: Incidence rate ratio

- ir case exposed studytime

```
 . ir died drug studytime
Incidence-rate comparison
                 | Drug type [1=placebo]  |
                 |   Exposed   Unexposed |      Total
-----------------+------------------------+-----------
1 if patient die |        19           6 |         25
Months to death  |       180         209 |        389
-----------------+------------------------+-----------
                 |                        |
  Incidence rate |  .1055556    .0287081 |   .0642674
                 |                        |
                 |      Point estimate    |    [95% Conf. Interval]
                 |------------------------+------------------------
 Inc. rate diff. |         .0768474       |    .0241182    .1295766
 Inc. rate ratio |         3.676852       |    1.411772    11.24864 (exact)
 Attr. frac. ex. |         .7280282       |    .2916701    .9111003 (exact)
 Attr. frac. pop |         .5533014       |
                 +-------------------------------------------------
Mid p-values for tests of incidence-rate difference:
  Adj Pr(Exposed 1 if patient die <= 19) = 0.9985 (lower one-sided)
  Adj Pr(Exposed 1 if patient die >= 19) = 0.0015 (upper one-sided)
                       Two-sided p-value = 0.0031
```

References

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