The University of Hong Kong
School of Public Health

CMED6100/MMPH6002/CMED7100
Introduction to Biostatistics (Semester I)
Practical 3 Suggested solution

Part 1: Hypothesis tests

Describe and evaluate the association between breastfeeding status and SGA/AGA status, by using the Pearson's chi-square test.

We want to test whether there is an association between the breastfeeding status and SGA/AGA status using the Pearson's chi-square test.

a) State the null hypothesis.

H_0: There is no association between the breastfeeding status and SGA/AGA status

b) Construct a frequency table between breastfeeding status and SGA/AGA status. What is the expected frequency if breastfeeding status and SGA/AGA status are independent? Complete the tables.

Data -> Manage variables in active dataset -> Convert numeric variables to factors [Variables: feeddur; Factor Levels: Use numbers]
Statistics -> Contingency table -> Two-way table [Row variable: feeddur; Column variable: sga; Statistics: Compute Percentages: Column Percentages; Chi-square test of independence; Print expected frequencies]
Percentages of expected frequencies can be directly computed on R [e.g. type '314.1/572']

Observed breastfeeding status of the birth cohort, stratified by SGA/AGA status

Breastfeeding status*	**AGA (n=572)**	**SGA (n=282)**
Never breastfed	293 (51.2%)	176 (62.4%)
Partially breastfed	169 (29.5%)	64 (22.7%)
Exclusively breastfed ≤2m	66 (11.5%)	18 (6.4%)
Exclusively breastfed >2m	44 (7.7%)	24 (8.5%)

*Children with missing breastfeeding status were excluded

Expected breastfeeding status of the birth cohort, stratified by SGA/AGA status

Breastfeeding status*	**AGA (n=572)**	**SGA (n=282)**
Never breastfed	314.1 (54.9%)	154.9 (54.9%)
Partially breastfed	156.1 (27.3%)	76.9 (27.3%)
Exclusively breastfed ≤2m	56.3 (9.8%)	27.7 (9.8%)
Exclusively breastfed >2m	45.5 (8.0%)	22.5 (8.0%)

*Children with missing breastfeeding status were excluded

c) By using R Commander, what is the value of the Pearson's chi-square test statistic? How many degrees of freedom? What is the p-value?

From the output in b)

Chi-square value	Degree of freedom	p-value
12.8	3	0.005

d) How do the children classified as AGA differ from those classified as SGA in terms of breastfeeding status? By using a 0.05 level of significance, state your conclusion based on your above findings.

There was a higher proportion of children with SGA status who were never breastfed. At a 0.05 level of significance, we reject the null hypothesis and conclude that there are association between breastfeeding status and AGA/SGA status.

Part 2: Designing studies

(a) If two groups of equal size are compared at the 5% significance level, how large should each group be if there is to be 90% power to detect a change in mean skin fold of 0.5 mm? (Hints: you can apply "two sample t-test")

[Two-sample t-test; sigma1, sigma2 = 2.3, true difference = 0.5, alpha = 0.05, power = 0.9]

n1 = n2 = 446, a sample of 892 subjects is needed.

(b) How many would I need if the desired power were 80%?

[power = 0.8]

n1 = n2 = 334, a sample of 668 subjects is needed.

(c) Suppose I can recruit 300 patients only, what difference can I detect with 80% power?

[n1 = n2 = 150, change the difference until power = 0.8]

Difference = 0.747mm

(d) Suppose I decide that a change of 1 mm in mean skin-fold is of interest after all. How many patients do I need for a power of 80%?

[σ_1, σ_2 = 2.3, true difference = 1, alpha = 0.05, change n1/n2 until power = 0.8]

n1 = n2 = 85, a sample of 170 subjects is needed.

(e) There is some uncertainty about the standard deviation, and it may be as low as 2 mm or as high as 3 mm. Complete the following table for the sample size required for 80% power.

[σ_1, σ_2 = 2.3, 2 or 3, alpha = 0.05, change n1/n2 until power = 0.8]

Standard deviation	Sample size required
2 mm	128
2.3 mm	170
3 mm	286

Scenario 2: Dichotomous outcome, 2 groups

Two methods of the management of malignant low bile duct obstruction are surgical biliary bypass and endoscopic insertion of a stent. A randomized controlled trial was performed to compare these approaches.

The primary outcome of the trial will be the binary variable which shows the dichotomous responses (yes/no) to the question "Did the patient die within 30 days of the procedure?" The trial will be designed to test the null hypothesis at the 5% level of significance with 95% power. The trial should be able to detect a change in mortality rate from 20% to 5%. How large is the sample needed for the study? (Hints: you can use "test for comparing two proportions".)

[Test comparing two proportions; p2 = 0.2, p1 = 0.05, alpha = 0.05, change n1/n2 until power = 0.95**]**

Assumptions

Level of significance:	0.05
Statistical power of hypothesis test:	0.95

Sample size calculations

Sample size in each group:	137
Total sample size:	274

Scenario 3: Unbalanced design and resource constraints

Suppose you test H_0: OR = 1 at $\alpha = 0.05$ (two-sided) with 100 cases in a case-controlled study. The prevalence of exposure in the control population is assumed to be 25%. You aim to know the statistical power to detect odds ratios of 2.0.

(a) What is the statistical power of the test if you decide to use different case-to-control ratios?

p2= 0.25, odds ratio = 2.0 => p1 = 0.4

Case-to-control ratio =1: 2, 100 cases ➔ 200 controls

n1=100, n2=200 controls
n1=100, n2=400 controls
n1=100, n2=600 controls
n1=100, n2=800 controls

[Test comparing two proportions; p2 = 0.25, p1 = 0.4, alpha = 0.05, n2 = 200, 400, 600 and 800, n1 = 100**]**

Case-to-control ratio	Statistical power
1: 2	0.7131
1: 4	0.8015
1: 6	0.8316
1: 8	0.8466

You can request funding from a local agency, but the budget must be no higher than $120,000. The cost of recruiting a case is $400, while controls are easier to find and recruit and will only cost $200 each.

(b) If you recruit cases and control in the ratio 1:1, what sample size could you achieve with $120,000?

For 1:1, let **X** be the number of subjects in the control group, then the number of subjects in the case group is also **X** and we have:

$200**X** + $400**X** = $120,000

➔ $600**X** = $120,000

➔ **X** = 200

200 cases and 200 controls.

(c) Complete the following table for possible sample sizes with alternative ratios of cases to controls:

For 2:1, let **X** be the number of subjects in the control group, then the number of subjects in the case group is also 2**X** and we have:

$400(2**X**) + $200(**X**) = $120000

➔ $1000 **X** = $120000

➔ **X**=120

120 controls and 240 cases

Table. Total costs

Case-to-control ratio	2:1	1:1	1:2	1:4	1:8
Number of cases	240	200	150	100	60
Number of controls	120	200	300	400	480
Total costs	$120,000	$120,000	$120,000	$120,000	$120,000

(d) Complete the following table to describe the power of each possible study to detect odds ratios of 1.5, 1.8 and 2.0.

p2 = 0.25, odds ratio = 2, 1.8 and 1.5 => p1 = 0.4, 0.375 and 0.333, respectively

[Test comparing two proportions; p2 = 0.25, p1 = 0.4, 0.375 and 0.333, alpha = 0.05,
(n2, n1) = (120, 240)
(n2, n1) = (200, 200)
(n2, n1) = (300, 150)
(n2, n1) = (400, 100)
(n2, n1) = (480, 60) **]**

Table. Statistical power

Case-to-control ratio	2:1	1:1	1:2	1:4	1:8
OR = 2	0.781	0.875	0.879	0.802	0.630
OR = 1.8	0.620	0.737	0.746	0.653	0.484
OR = 1.5	0.314	0.404	0.416	0.349	0.247

(e) What is the optimal study design given the constraints listed above?

Design with case-to-control ratio 1:2. Its power is largest under the same budget constraint.