**JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**SCHOOL OF HEALTH SCIENCES**

**UNIVERSITY EXAMINATION FOR DEGREE OF MASTER PUBLIC HEALTH**

**1ST YEAR 2ND SEMESTER 2023/2024 ACADEMIC YEAR**

**KISUMU LEARNING CENTRE**

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**COURSE CODE:** **HMP 5136/HES 5122**

**COURSE TITLE:** **STATISTICAL METHODS IN EPIDEMIOLOGY**

**EXAM VENUE:** **STREAM:**

**DATE:** **EXAM SESSION:**

**TIME:** **3.00 HOURS**

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**Instructions:**

1. **Answer any four Questions (Question One is Compulsary)**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room.**

## SECTION A

### Answer question one(Compulsary)

**1. Question one (10 marks).**

Sixty-four pregnant women at high risk of pregnancy-induced hypertension participated in a randomized controlled clinical trial comparing 100mg of aspirin daily and a matching placebo during the 3rd trimester of pregnancy. The observed numbers with hypertension are shown in the following table.

| | Hypertension | | |
|---|---|---|---|
| | yes | No | Total |
| Aspirin | 5 | 29 | 34 |
| Placebo | 10 | 20 | 30 |
| Group Total | 15 | 49 | 64 |

i. Give the **estimate** and **approximate 90% confidence interval** for the following of hypertension between aspirin and placebo treated women
   a. Difference in risk (2 marks)
   b. Risk ratio (3 marks)
   c. Odds ratio (3 marks)

ii. Suppose a new study is planned. What sample size is approximately needed in order to have a power of 80% if the risk of hypertension is 0.05 lower in aspirin treated women ($\alpha = 0.05$)? (2 marks)

## SECTION B

### Answer any three Questions

**2. Question three (20 marks).**

Human beta-endorphin (HBE) is a hormone secreted by the pituitary gland under the condition of stress. An exercise physiologist measured the resting (unstressed) blood concentration of HBE in three groups of men: 15 who had just entered a physical fitness program, 11 who had been jogging regularly for some time, and 10 sedentary people. The mean and standard deviations of the HBE levels (pg/ml) are shown in the table below.

| | Fitness program entrants | Joggers | Sedentary |
|---|---|---|---|
| Mean | 38.7 | 35.7 | 42.5 |
| SD | 16.1 | 13.4 | 12.8 |
| N | 15 | 11 | 10 |

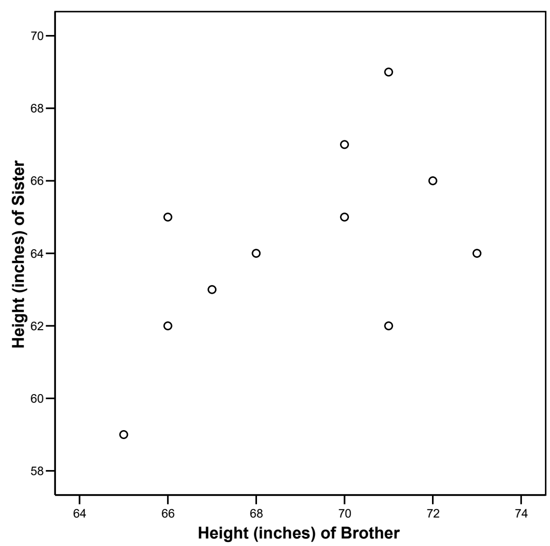
a. Make and complete the ANOVA table (12 marks)
b. Test the null hypothesis that there is no difference in mean HBE levels between the three groups (3 marks)
c. What is the pooled standard deviation (5 marks)

**3. Question two (20 marks).**

The table below contains an historic dataset on the height (in inches) of brother and sister, published in the second volume of Biometrika by Karl Pearson (indeed the man of the correlation coefficient) (Pearson K, Lee A. On the laws of inheritance in man. Biometrika 1902; 2:p357. In this case, we look at: - the correlation between the height of brother and si ster; how to predict height of the brother based on height of the sister or vice versa; - the difference in mean height between brothers and sisters.

| family | Height of brother | Height of sister | difference |
|---|---|---|---|
| **1** | 71 | 69 | 2 |
| **2** | 68 | 64 | 4 |
| **3** | 66 | 65 | 1 |
| **4** | 67 | 63 | 4 |
| **5** | 70 | 67 | 3 |
| **6** | 71 | 62 | 9 |
| **7** | 70 | 65 | 5 |
| **8** | 73 | 64 | 9 |
| **9** | 72 | 66 | 6 |
| **10** | 65 | 59 | 6 |
| **11** | 66 | 62 | 4 |

Study the SPSS output given below (the SPSS names of variables are: BROTHER, SISTER)




**Descriptive Statistics**

| | Mean | Std. Deviation | N |
|---|---|---|---|
| Brother | 69.00 | 2.720 | 11 |
| Sister | 64.18 | 2.714 | 11 |

**Correlations**

| | | Brother | Sister |
|---|---|---|---|
| Brother | Pearson Correlation | 1 | .555 |
| | Sig. (2-tailed) | . | ??? |
| | Sum of Squares and Cross-products | 74.000 | 41.000 |
| | Covariance | 7.400 | 4.100 |
| | N | 11 | 11 |
| Sister | Pearson Correlation | .555 | 1 |
| | Sig. (2-tailed) | ??? | . |
| | Sum of Squares and Cross-products | 41.000 | 73.636 |
| | Covariance | 4.100 | 7.364 |
| | N | 11 | 11 |

a. Is Pearson's correlation between height of sister and brother significantly different from zero? Answer this question by solving the following questions (i-iii).
   i. Give bounds for the p-value (3mark)
   ii. Compute also an approximate 90% confidence interval (3 marks)
   iii. Comment on the appropriateness of these assumptions for these data(1mark)

b. Compute the Spearman's correlation coefficient. (3 marks)
   i. Is it statistically different from zero? (1mark)
   ii. Give the upper bound for the p-value (1mark)

Compute the regression line of height of the brother on the height of the sister. (Hint: do not use the original observations, but use the relationship between the correlation coefficient and the slope of a regression line i.e. $r = \frac{s_x}{s_y} b$ or equivalent: $b = \frac{s_y}{s_x} r$ )

   iii. What is the best prediction of the height of a brother of a sister with height 70 inches? (3 marks)
   iv. What is the estimated amount of variability in height of brother explained by height of sister? (1mark)

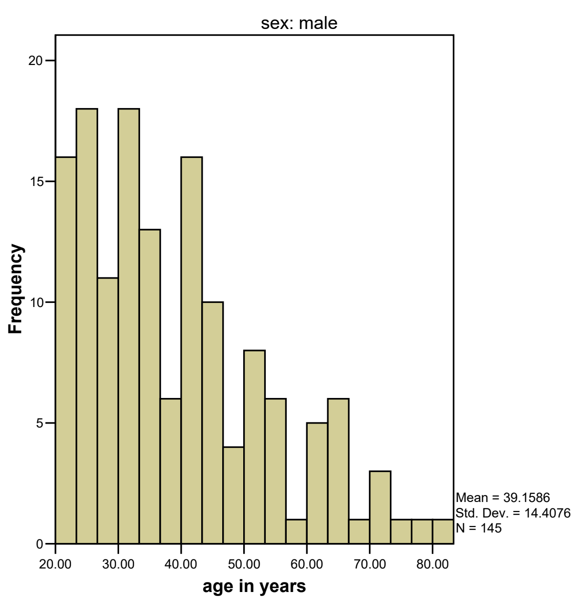
c. Test with a parametric method the hypothesis that the mean height of brother and sister is equal (2marks)
   i. Give the upper bound for the p-value (1mark)
   ii. Give the 95% confidence interval for the mean difference (1mark)

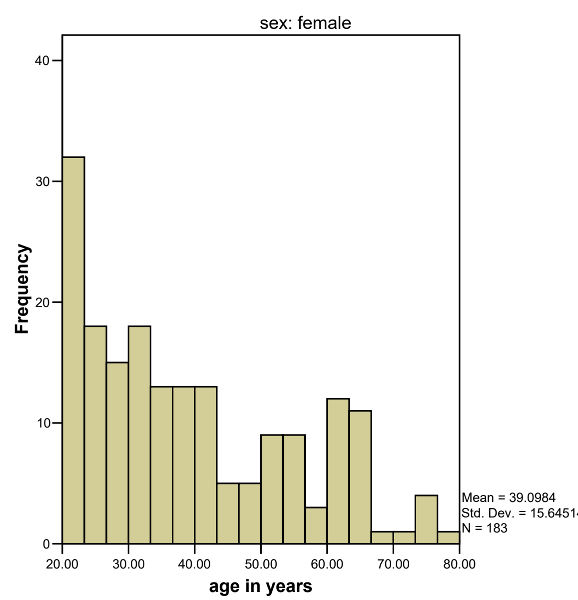
4. **Question four (20 marks).**

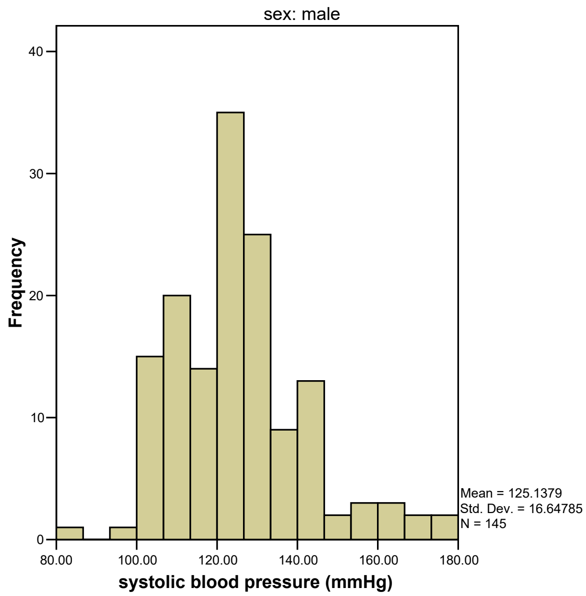
A medical investigator selected from the population of some rural villages in a certain developing country 328 people for his study. Among other variables, systolic and diastolic blood pressure, body weight and pulse frequency were measured. Age and sex were also registered. In the accompanying SPSS output you will find some descriptive statistics and the results of the simple regression analyses of systolic blood pressure on age for males (sex=1, n=145) and females (sex=2, n=183) separately. Use this SPSS output to answer the following questions. First study the results of the analysis for the females. Questions (a) to (f) refer to this analysis.

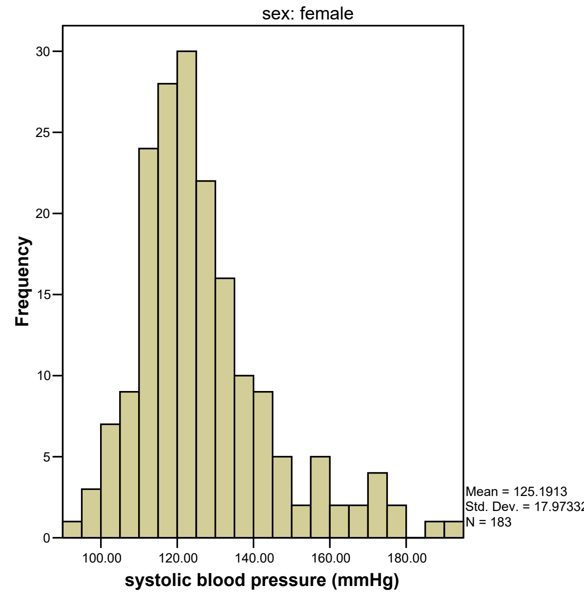
**Descriptive Statistics**

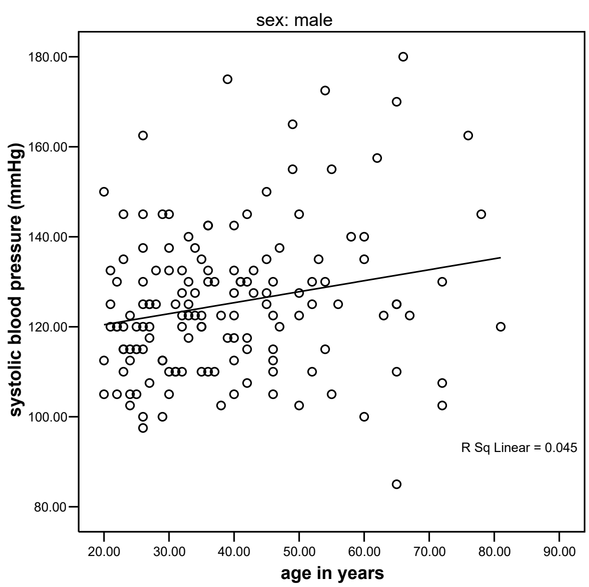
| Sex | | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|---|
| Male | age in years | 145 | 20.00 | 81.00 | 39.1586 | 14.40760 |
| | systolic blood pressure (mmHg) | 145 | 85.00 | 180.00 | 125.1379 | 16.64785 |
| | Valid N (listwise) | 145 | | | | |
| female | age in years | 183 | 20.00 | 80.00 | 39.0984 | 15.64514 |
| | systolic blood pressure (mmHg) | 183 | 92.50 | 195.00 | 125.1913 | 17.97332 |
| | Valid N (listwise) | 183 | | | | |

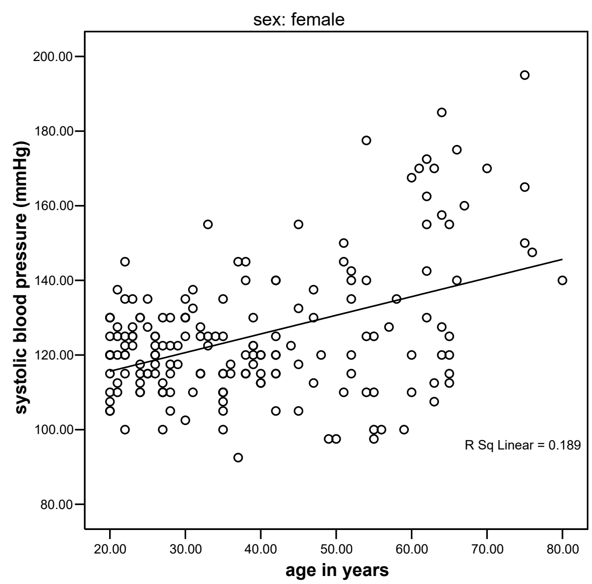





**Model Summary**

| Sex | Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|---|
| Male | 1 | .211(a) | .045 | .038 | 16.32811 |
| female | 1 | .435(a) | .189 | .185 | 16.22763 |

a Predictors: (Constant), age in years

**Coefficients(a)**

| sex | Model | | Unstandardized Coefficients B | Unstandardized Coefficients Std. Error | Standardized Coefficients Beta | t | Sig. |
|---|---|---|---|---|---|---|---|
| Male | 1 | (Constant) | 115.569 | 3.939 | | 29.340 | .000 |
| | | age in years | .244 | .094 | .211 | 2.587 | .011 |
| female | 1 | (Constant) | 105.649 | 3.237 | | 32.642 | .000 |
| | | age in years | .500 | .077 | .435 | 6.501 | .000 |

a Dependent Variable: systolic blood pressure (mmHg)

a. Give the estimate for the mean systolic blood pressure of sixty year old women (2marks)

b. Give an estimate of the mean increase per age **decade** for the systolic blood pressure. (1mark)

   i. Give 95% confidence interval for it. (2marks)

c. Give the 90% confidence interval for the mean systolic blood pressure of 30 year old women. (4marks)

d. From the histogram of the systolic blood pressure one can conclude that the distribution is not normal (the distribution is somewhat skewed to the right). Does this imply that the normality assumption underlying linear regression analysis is not fulfilled in this case? (1mark)

Now study also the results of the regression analysis for the male, and answer the following questions.

e. It will strike you that the correlation coefficient between age and systolic blood pressure is lower for males than for females. Is the difference statistically significant? (2marks)

f. Test whether the difference in mean **yearly** increase of the systolic blood pressure is significantly different between men and women. (the numbers are large, so use a simple and straightforward test). (3marks)

g. The difference in systolic blood pressure between men and women could be studied with the following multiple regression model.

$$systolic\,blood\,pressure = \beta_0 + \beta_1 age + \beta_2 Sex + \beta_3 Sex * age + residual$$

   Using the accompanying regression analyses for men and women, give estimates of the β's in this model and their interpretations. Will age play the role of a confounder or effect modifier? (5marks)

**Coefficients[a]**

| Model | | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. | 95.0% Confidence Interval for B | |
|---|---|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | | | Lower Bound | Upper Bound |
| 1 | (Constant) | 115.569 | 3.925 | | 29.441 | .000 | 107.846 | 123.292 |
| | age in years | .244 | .094 | .212 | 2.596 | .010 | .059 | .430 |
| | sex | -9.920 | 5.093 | -.284 | -1.948 | .052 | -19.940 | .100 |
| | Age*Sex | .255 | .122 | .334 | 2.100 | .037 | .016 | .495 |

a. Dependent Variable: systolic blood pressure (mmHg)

**5. Question five (20 marks).**

The data in the table were collected in Bradford, England, between 1968 and 1977, and relate to 13,384 women giving birth to their first child. The women were classified according to social class (five categories on the Registrar General's scale I-V) and according to the number of cigarettes smoked per day during pregnancy (on a three level categorization: 1 means no smoking, 2 means 1-19 cigarettes per day, and 3 means 20 or more cigarettes per day). The data for each category consist of counts of women showing toxaemic signs (hypertension and/or proteinuria) during pregnancy. The question of interest is how the toxaemic signs vary with smoking status, adjusted for social class. Some SPSS output is given below.

| Social Class | Smoking category | No. of women with toxaemic signs | No. of women without toxaemic signs |
|---|---|---|---|
| **1** | 1 | 131 | 286 |
| **1** | 2 | 34 | 71 |
| **1** | 3 | 4 | 13 |
| **2** | 1 | 350 | 785 |
| **2** | 2 | 122 | 284 |
| **2** | 3 | 18 | 34 |
| **3** | 1 | 1543 | 3160 |
| **3** | 2 | 754 | 2300 |
| **3** | 3 | 140 | 383 |
| **4** | 1 | 328 | 656 |
| **4** | 2 | 210 | 649 |
| **4** | 3 | 59 | 163 |
| **5** | 1 | 121 | 245 |
| **5** | 2 | 130 | 321 |
| **5** | 3 | 25 | 65 |

| | | Smoking category | | | | | | Group Total | |
|---|---|---|---|---|---|---|---|---|---|
| | | non smoking | | 1-19 cigarettes | | 20 or more cigarettes | | | |
| | | Count | Col % | Count | Col % | Count | Col % | Count | Col % |
| Toxaemic category | No | 5132 | 67.5% | 3625 | 74.4% | 658 | 72.8% | 9415 | 70.3% |
| | Yes | 2473 | 32.5% | 1250 | 25.6% | 246 | 27.2% | 3969 | 29.7% |
| Group Total | | 7605 | 100.0% | 4875 | 100.0% | 904 | 100.0% | 13384 | 100.0% |

| | | Social class | | | | | | | | | | Group Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | | 2 | | 3 | | 4 | | 5 | | | |
| | | Count | Col % | Count | Col % | Count | Col % | Count | Col % | Count | Col % | Count | Col % |
| Smoking category | non smoking | 417 | 77.4% | 1135 | 71.2% | 4703 | 56.8% | 984 | 47.7% | 366 | 40.4% | 7605 | 56.8% |
| | 1-19 cigarettes | 105 | 19.5% | 406 | 25.5% | 3054 | 36.9% | 859 | 41.6% | 451 | 49.7% | 4875 | 36.4% |
| | 20 or more cigarettes | 17 | 3.2% | 52 | 3.3% | 523 | 6.3% | 222 | 10.8% | 90 | 9.9% | 904 | 6.8% |
| Group Total | | 539 | 100.0% | 1593 | 100.0% | 8280 | 100.0% | 2065 | 100.0% | 907 | 100.0% | 13384 | 100.0% |

| | | | | Toxaemic category | | Group Total |
|---|---|---|---|---|---|---|
| | | | | no | Yes | |
| | | | | Count | Count | Count |
| Social class | 1 | smoking | non-smoking | 286 | 131 | 417 |
| | | | smoking | 84 | 38 | 122 |
| | | Group Total | | 370 | 169 | 539 |
| | 2 | smoking | non-smoking | 785 | 350 | 1135 |
| | | | smoking | 318 | 140 | 458 |
| | | Group Total | | 1103 | 490 | 1593 |
| | 3 | smoking | non-smoking | 3160 | 1543 | 4703 |
| | | | smoking | 2683 | 894 | 3577 |
| | | Group Total | | 5843 | 2437 | 8280 |
| | 4 | smoking | non-smoking | 656 | 328 | 984 |
| | | | smoking | 812 | 269 | 1081 |
| | | Group Total | | 1468 | 597 | 2065 |
| | 5 | smoking | non-smoking | 245 | 121 | 366 |
| | | | smoking | 386 | 155 | 541 |
| | | Group Total | | 631 | 276 | 907 |

**Risk Estimate**

| Social class | | Value | 95% Confidence Interval | |
|---|---|---|---|---|
| | | | Lower | Upper |
| 1 | Odds Ratio for Smoking (non-smoking / smoking) | .988 | .639 | 1.526 |
| | For cohort Toxaemic category = no | .996 | .870 | 1.141 |
| | For cohort Toxaemic category = Yes | 1.009 | .748 | 1.361 |
| | N of Valid Cases | 539 | | |
| 2 | Odds Ratio for Smoking (non-smoking / smoking) | .987 | .780 | 1.249 |
| | For cohort Toxaemic category = no | .996 | .927 | 1.071 |
| | For cohort Toxaemic category = Yes | 1.009 | .857 | 1.188 |
| | N of Valid Cases | 1593 | | |
| 3 | Odds Ratio for Smoking (non-smoking / smoking) | .682 | .619 | .752 |
| | For cohort Toxaemic category = no | .896 | .871 | .921 |
| | For cohort Toxaemic category = Yes | 1.313 | 1.224 | 1.408 |
| | N of Valid Cases | 8280 | | |
| 4 | Odds Ratio for Smoking (non-smoking / smoking) | .663 | .547 | .802 |
| | For cohort Toxaemic category = no | .888 | .839 | .939 |
| | For cohort Toxaemic category = Yes | 1.340 | 1.169 | 1.535 |
| | N of Valid Cases | 2065 | | |
| 5 | Odds Ratio for Smoking (non-smoking / smoking) | .813 | .610 | 1.083 |
| | For cohort Toxaemic category = no | .938 | .858 | 1.026 |
| | For cohort Toxaemic category = Yes | 1.154 | .947 | 1.406 |
| | N of Valid Cases | 907 | | |

**Tests of Homogeneity of the Odds Ratio**

| | Chi-Squared | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Breslow-Day | 11.551 | 4 | .021 |
| Tarone's | 11.550 | 4 | .021 |

**Mantel-Haenszel Common Odds Ratio Estimate**

| | | | |
|---|---|---|---|
| Estimate | | | .724 |
| ln(Estimate) | | | -.324 |
| Std. Error of ln(Estimate) | | | .039 |
| Asymp. Sig. (2-sided) | | | ??? |
| Asymp. 95% Confidence Interval | Common Odds Ratio | Lower Bound | ??? |
| | | Upper Bound | ??? |
| | ln(Common Odds Ratio) | Lower Bound | ??? |
| | | Upper Bound | ??? |

a. First look at the cross table of toxaemic signs against smoking category. What test would you choose for the null hypothesis that there is no association between smoking and toxaemic signs?
   i. What are the estimated risks of toxaemic signs for the three smoking categories? (1mark)
   ii. Give for the first smoking category also the corresponding standard error and 95% confidence interval. (1mark)
b. Compute the odds ratio of toxaemic signs of the combined second and third smoking category relative to the non-smokers. (1mark)
   i. Give also a 95% confidence interval (1mark)
c. Study the cross table of smoking category against social class. Do you think that smoking and social class are associated? (2marks)
d. To correct for possible confounding by social class, a stratified analysis was carried out using SPSS. Since the stratified analysis in SPSS cannot handle larger than 2X2-tables, the smoking categories were combined. Study the output and answer the following questions.
   i. Give the odds ratio per class and compare them with the overall unadjusted one. (2marks)
   ii. What is the most appropriate test for testing the hypothesis that there is no association between toxaemic signs and smoking, adjusted for social class? Give the value of the test statistic and p-value. (2marks)
   iii. Does possible heterogeneity of odds ratio across strata invalidate this test? (1mark)
   iv. Is there statistical evidence for the odds ratios being not homogeneous across strata? (1mark)
   v. Give the results of the tests and comment on it. (1mark)
   vi. What is the Mantel-Haenzel estimated odds ratio? (1mark)
   vii. What is its interpretation in this case? (1mark)
   viii. Fill in the question marks in the last table. (5 marks)