2.1 A 3-year study was conducted to look at the effect of oral contraceptive (OC) use on heart disease in women 40–44 years of age. It is found that among 5000 OC users at baseline (i.e. the start of the study), 15 women develop a myocardial infarction (MI) during the 3-year period, while among 10,000 non-users at baseline, 10 developed an MI over the 3-year period.

i. Is this a designed experiment or an observational study?
ii. What are the experimental/study units?
iii. Is this a prospective study, retrospective study or a cross-sectional study?
iv. What are the response and explanatory variables?
v. All the women in the study are aged 40–44. Explain why this was done.
vi. Present the results using table and/or diagram. What conclusion can you draw?

2.2 A medical study of heart surgery investigates the effects of drugs called β-blockers on the pulse rate of the patient during surgery. The pulse rate will be measured at a specific point during the operation. After consultation with a statistician, the investigators decide to use as subjects 20 patients facing heart surgery who have consented to take part in the study. You have a list of these patients, numbered 1 to 20 in alphabetical order.

(a) Briefly outline a completely randomised experimental design for this study. Would your study be single-blind or double-blind?
(b) Carry out the randomisation required by your design and report your results, explaining in some detail the technique used.
(c) Simulate the results of your experiment as follows.
[To do this we ‘play God’ and pretend that we know everything.]
Suppose that without the β-blocker, the patients’ pulse rates would have been:
<table>
<thead>
<tr>
<th>id</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR</td>
<td>92</td>
<td>83</td>
<td>83</td>
<td>69</td>
<td>74</td>
<td>68</td>
<td>67</td>
<td>81</td>
<td>82</td>
<td>86</td>
<td>76</td>
<td>95</td>
<td>92</td>
<td>64</td>
<td>75</td>
<td>77</td>
<td>79</td>
<td>85</td>
<td>88</td>
<td>72</td>
</tr>
</tbody>
</table>

Suppose that the effect of the β-blocker is to reduce the pulse rate by 10. Generate observed pulse rates by subtracting 10 from the pulse rates of those patients to whom you gave the β-blocker.
[All we mortals get to see are the observed pulse rates.]
Compare the samples of treated and control.
[Later in the semester, we derive ways to test the significance of results like these.]
(d) * I just made these numbers up! See if you can find out what a plausible range of values for pulse rates in a heart operation should be.

Review questions

2.3 (a) What is the difference between:
   i. an experiment and an observational study?
   ii. cohort study and a case-control study?
   iii. placebo and control?
   iv. blind and double-blind studies?
   (b) In the context of experimental design:
       i. what is blocking? how does it relate to stratification?
       ii. what is confounding?
       iii. what is a lurking variable?
       iv. what is the point of randomisation? replication? balance?
   (c) i. What is the difference between matched and independent samples?
      ii. What is the advantage of matched samples?
Tutorial questions

2.4 The effect of exercise on the amount of lactic acid in the blood was examined in a study. Eight men and seven women who were attending a conference participated in the experiment. Blood lactate levels were measured before and after playing a set of tennis, and shown below.

<table>
<thead>
<tr>
<th>player</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>M7</th>
<th>M8</th>
<th>W1</th>
<th>W2</th>
<th>W3</th>
<th>W4</th>
<th>W5</th>
<th>W6</th>
<th>W7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>13</td>
<td>20</td>
<td>17</td>
<td>13</td>
<td>16</td>
<td>15</td>
<td>16</td>
<td>11</td>
<td>16</td>
<td>13</td>
<td>18</td>
<td>14</td>
<td>11</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>After</td>
<td>18</td>
<td>37</td>
<td>40</td>
<td>35</td>
<td>30</td>
<td>20</td>
<td>33</td>
<td>19</td>
<td>21</td>
<td>26</td>
<td>19</td>
<td>21</td>
<td>14</td>
<td>31</td>
<td>20</td>
</tr>
</tbody>
</table>

(a) What is the research question?
(b) Is this a designed experiment or an observational study?
(c) What are the experimental units?
(d) What is the response variable? What are the treatments?
(e) Upon further investigation, we find that nine of the sample are 20–29 years old, while the other six are 40–49 years old. What is the potential problem with the study?
(f) What is a confounding variable? Can you think of any potential confounding variables in this case?

2.5 A study claimed to show that meditation lowers anxiety proceeded as follows. The researcher interviewed the subjects and rated their level of anxiety. Then the subjects were randomly assigned to two groups. The researcher taught one group how to meditate and they meditated daily for one month. The other group was simply encouraged to relax more. At the end of the month, the researcher interviewed all the subjects again and rated their anxiety level. The meditation group were found to have less anxiety.

(a) What are the experimental units? What are the response variable and the explanatory variable?
(b) Is this a designed study or an observational study?
(c) Is this a blind study? What is the reason for designing a blind study?
(d) It was found that the control group had 70% men and the meditation group had 75% women. Is this a problem? Explain.

2.6 Explain why each of the following studies is not an experiment:

(a) The question of whether a radical mastectomy (removal of the breast, chest muscles and lymph nodes) is more effective than a simple mastectomy (removal of the breast only) in prolonging the life of women with breast cancer has been debated intensely. To study this question, a medical team examines the record of five large hospitals and compares the survival times after surgery of all women who have had either operation.

(b) It has been suggested that (given all else equal) general practitioners are more likely to prescribe psychoactive medication (e.g. valium) to women than to men. A researcher selects a large random sample of adults and asks them if they have been prescribed psychoactive medication in the last year (and their response is validated by checking with their doctor).

2.7 For the experimental situation described below, identify the experimental units, the explanatory variable(s), and the response variable.

**Can aspirin help heart attacks?** The Physicians’ Health Study, a large medical experiment involving 22,000 male physicians, attempted to answer this question. One group of 11,000 physicians took an aspirin every second day, while the rest took a placebo. After several years it was found that the subjects in the aspirin group had significantly fewer heart attacks than subjects in the placebo group.
Additional questions

2.8 (a) Placebos are useful in clinical trials: [classify each as true or false]
   i. when two apparently similar active treatments are to be compared;
   ii. to guarantee comparability in non-randomised trials;
   iii. because the fact of being treated may itself produce a response;
   iv. because they help to conceal the subject’s treatment from assessors;
   v. when an active treatment is to be compared with no treatment.

(b) In a double blind clinical trial: [classify each as true or false]
   i. the patients do not know what treatment they receive;
   ii. each patient receives a placebo;
   iii. the patients do not know they are in a trial;
   iv. each patient receives both treatments;
   v. the clinician making the assessment does not know which treatment the patient receives.

2.9 For the experimental situation described below, identify the experimental units, the explanatory variable(s), and the response variable.

New varieties of corn with altered amino acid patterns may have higher nutritive value than standard corn, which is low in the amino acid lysine. An experiment compares two new varieties, called opaque-2 and floury-2, with normal corn. Corn-soybean meal diets using each type of corn are prepared at three different protein levels: 12%, 16% and 20%. There are thus nine diets in all. Researchers assign 10 one-day-old male chicks to each diet and record their weight gain after 21 days. The weight gain of the chicks is a measure of the nutritive value of their diet.

2.10 As part of a study investigating the effect of smoking on infant birthweight a physician examines the records of 40 nonsmoking mothers, 40 light-smoking, and 40 heavy-smoking mothers. The mean birthweights (in kg) for the three groups are respectively 3.43, 3.29 and 3.21.

   (a) What are the independent and dependent variables? What are the experimental units.

   (b) Is this a designed experiment or an observational study? Explain your choice.

   (c) What are the potential confounding variables in this case? Explain how you would eliminate the effect of at least some of the variables.

2.11 A study was conducted to examine the efficacy of an intramuscular injection of cholecalciferol for vitamin D deficiency. A random sample of 50 sufferers of vitamin D deficiency were chosen and given the injection. Serum levels of 25-hydroxyvitamin $D_3$ ($250HD_3$) were measured at the start of the study and 4 months later. The difference was calculated (4 month reading – baseline reading).

   (a) Is this an observational study or a designed experiment? Briefly explain your choice.

   (b) Identify the experimental units.

   (c) Ten men and forty women participated in this study. Their results were analysed together. What is the potential problem with this?
2.12 Two new fertilizers (A and B) are being tested for their effectiveness on corn crop yields. An investigation is set up as follows: a field is divided into 9 plots; 3 of the plots are assigned a current fertilizer (C), 3 of the plots are assigned fertilizer A, and the remaining 3 plots are assigned fertilizer B. Each plot is planted with the corn crop and the yields are measured after a set period of time.

(a) What is the response variable? What is the explanatory variable?
(b) Briefly explain why the current fertilizer is included in the study.
(c) A fellow researcher claims that it is too expensive to maintain 9 plots. He thinks that 3 plots are sufficient; one with the current fertilizer, one with fertilizer A, and one with fertilizer B. Do you agree with him? Justify why or why not.
(d) The field looks like a 3 by 3 block of plots:

```
  A | B | C
  ___|___|___
  |   |   |
  |   |   |
  ___|___|___
```

Use an appropriate randomisation procedure to assign the three fertilizers (A, B, C) to the plots above.
(e) Another researcher points out that to the left of the field is a river, and consequently the soil moisture differs from left to right across the plots.
   i. Explain the statement “soil moisture is confounded with the fertilizers”.
   ii. Briefly describe a method for ensuring that this is not a problem.

2.13 Suppose that a sample of 8 non-pregnant, pre-menopausal, 35–39 year-old oral contraceptive (OC) users who work in a company are identified who have mean systolic blood pressure 132.9 mm Hg with standard deviation 15.3 mm Hg. A sample of 21 non-pregnant, pre-menopausal, 35–39 year-old non-OC users working for the same company are similarly identified, who have mean systolic blood pressure 127.2 mm Hg and sample standard deviation 18.2 mm Hg. We want to identify whether the blood pressures of the two underlying populations are different.

(a) What are the independent and dependent variables? What are the experimental units?
(b) Is this a designed experiment or an observational study?
(c) Suppose an analysis finds that there is significant evidence that the two groups have different mean blood pressures. Can we conclude that OC use affects blood pressure? Explain.
(d) The sampled women in both groups are 35–39 year-olds, non-pregnant and pre-menopausal. Explain why this is done.

2.14 A researcher interviews 30 women whom she judges to be successful. She would like to use the information obtained to isolate those variables that are good indicators of a woman’s success. (The researcher has not identified the independent variable(s) beforehand.)

(a) What is the dependent variable in this case?
(b) What are the experimental units?
(c) What essential element is missing in this study? Explain why the researcher’s efforts will be fruitless without this element.
(d) What steps could be taken to correct the problem?