

Department of Statistics
First Year Statistics
Mid-Semester Test: Summer Semester, 2014

VERSION 1
ANSWERS ON PAGE 16

Instructions:

- All questions have a single correct answer.
- All questions carry the same mark value.
- If you do not know the answer, then take a guess.
- Incorrect answers are not penalised.
- Multiple answers to a question will ALL be marked wrong.

There are 20 questions.

Formulae are provided (appended to the back of the test paper).

Answer ALL questions on the ANSWER SHEET provided (attached to the front of the test paper).

- Hand in your answer sheet **only**.
- Keep a personal record of your answers on the test paper — answers will be announced on Cecil tomorrow.

References

- Bloom, H. L., Shukrullah, I., Cuellar, J. R., Lloyd, M. S., Jr., S. C. D., and Zafari, A. M. (2007). Long-term survival after successful in-hospital cardiac arrest resuscitation. *American Heart Journal*, **153**(5), 831 – 836.
- Lyle, R. M., Melby, C. L., Hyner, G. C., Edmondson, J. W., Miller, J. Z., and Weinberger, M. H. (1987). Blood pressure and metabolic effects of calcium supplementation in normotensive white and black men. *JAMA*, **257**(13), 1772–1776.
- Mitchell, J. A., Rodriguez, D., Schmitz, K. H., and Audrain-McGovern, J. (2013). Sleep duration and adolescent obesity. *Pediatrics*, **131**(5), e1428–e1434.
- Morris, B. H., Oh, W., Tyson, J. E., Stevenson, D. K., Phelps, D. L., O'Shea, T. M., McDavid, G. E., Perritt, R. L., Van Meurs, K. P., Vohr, B. R., Grisby, C., Yao, Q., Pedroza, C., Das, A., Poole, W. K., Carlo, W. A., Duara, S., Laptook, A. R., Salhab, W. A., Shankaran, S., Poindexter, B. B., Fanaroff, A. A., Walsh, M. C., Rasmussen, M. R., Stoll, B. J., Cotten, C. M., Donovan, E. F., Ehrenkranz, R. A., Guillet, R., and Higgins, R. D. (2008). Aggressive vs. conservative phototherapy for infants with extremely low birth weight. *New England Journal of Medicine*, **359**(18), 1885–1896. PMID: 18971491.

Questions 1 and 2 refer to the following information.

Data on all of Air New Zealand's operating aircraft, as at 28 February 2013, were collected for a large number of variables. Table 1 shows data on some of these variables.

Aircraft type	Number	Cruising speed (km/h)	Length (m)	Wing span (m)
Airbus A320	17	850	37.6	34.1
ATR72	13	518	27.2	27.1
Boeing 737	12	790	32.2	28.9
Boeing 747	2	920	70.6	64.4
Boeing 767	5	870	54.9	47.6
Boeing 777	13	910	63.7	60.9
Bombardier Q300	23	520	25.7	27.4
Beech 1900D	18	510	17.6	17.7
Total	103			

Table 1: Air New Zealand operating fleet, 28 February 2013

1. Which **one** of the following is the **most** appropriate plot to display the number of each aircraft type in Air New Zealand's operating fleet as at 28 February 2013?
 - (1) A pie chart with 8 sectors, each representing the number of each aircraft type and with each sector having a label identifying the aircraft type.
 - (2) A stem-and-leaf plot with stems of 0, 1 and 2 (representing 0, 10 and 20 aircraft) and a leaf unit of 1 aircraft.
 - (3) A box plot on a scale from 0 to 25, with the lower whisker ending at 2 and the upper whisker ending at 23.
 - (4) A bar graph with 8 bars, each representing the number of each aircraft type and with each bar having a label identifying the aircraft type.
 - (5) A histogram with a scale from 0 to 25 and with interval widths of 5 units.

2. Figure 1 shows a scatter plot of takeoff speed against length for the eight types of aircraft in the operating fleet.

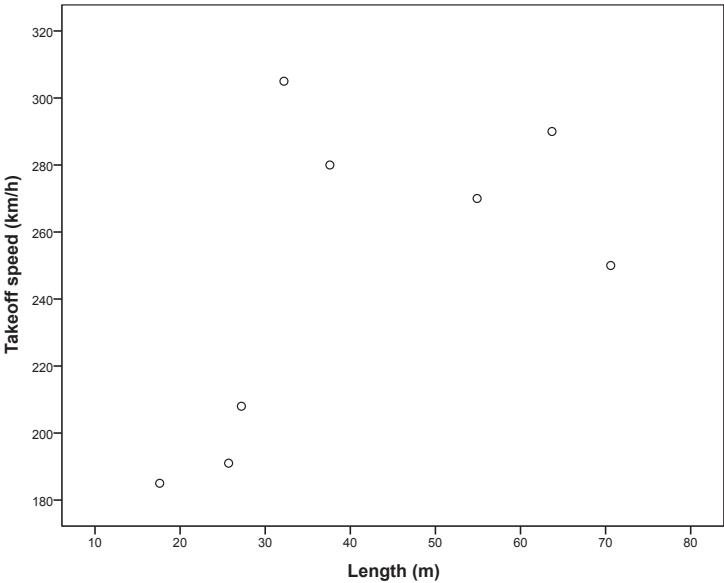


Figure 1: Air New Zealand operating fleet

Based on Figure 1, which **one** of the following statements is **false**?

- (1) For the aircraft that are longer than 30 m, the longer the aircraft the faster the takeoff speed.
- (2) There are two groups of aircraft types; those that have relatively slow takeoff speeds and those that have relatively fast ones.
- (3) All of the aircraft types that have a takeoff speed slower than 220 km/h are shorter than 30 m.
- (4) Both of the aircraft types that are longer than 60 m have a takeoff speed faster than 240 km/h.
- (5) The shortest aircraft has the slowest takeoff speed.

Questions 3 and 4 refer to the following information.

Table 2 has been constructed using information published by Statistics New Zealand in February 2013 about overseas visitors arriving in New Zealand during 2012.

Country	Age group (years)							Total
	Under 15	15 – 24	25 – 34	35 – 44	45 – 54	55 – 64	Over 64	
Australia	122 352	130 304	240 144	205 904	210 960	165 888	80 240	1 155 792
China	9024	11 664	30 736	40 064	49 792	41 792	13 952	197 024
UK	10 880	19 920	39 808	22 304	23 440	37 152	36 144	189 648
USA	8368	22 928	30 336	21 504	27 472	34 192	32 880	177 680
Japan	5200	17 296	9808	9696	8304	12 224	9552	72 080
Germany	1968	16 944	16 128	7344	10 496	6416	4480	63 776
South Korea	5760	5376	6768	7344	11 344	12 288	4016	52 896
Canada	2432	6528	7744	5104	7072	9536	8032	46 448
Singapore	4976	3376	8080	8256	7008	3488	1216	36 400
India	2096	3584	7216	4048	4416	5680	2816	29 856
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Total	220 156	315 851	517 135	418 758	450 431	405 860	236 427	2 564 618

Table 2: Overseas visitors to New Zealand, 2012

3. In 2012, what percentage of overseas visitors to New Zealand were from the UK and over 64 years old (to 1 decimal place)?
- (1) 15.2%
 - (2) 19.1%
 - (3) 16.6%
 - (4) 15.3%
 - (5) 1.4%
4. Of the overseas visitors to New Zealand in 2012 who were under 25 years old, what proportion were from Australia (to 3 decimal places)?
- (1) 0.484
 - (2) 0.099
 - (3) 0.968
 - (4) 0.219
 - (5) 0.471

Questions 5 to 8 refer to the following information.

Mussels are a shellfish commonly found around the coast of New Zealand. Horse mussels (*Atrina zelandica*) are a species of large mussels. A random sample of 30 horse mussels was selected from each of two sites in the Marlborough Sounds.

Questions 5 and 6 refer to Figure 2, which shows the lengths of the mussels.

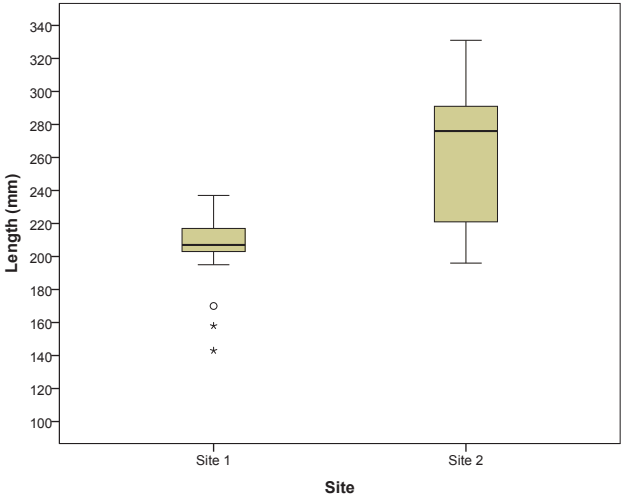


Figure 2: Lengths of horse mussels

5. Which **one** of the following statements is **false**?
- (1) **This option is no longer examinable.**
 - (2) At least 50% of the mussels from Site 2 are longer than all of the mussels from Site 1.
 - (3) The standard deviation of the lengths in the Site 1 sample is less than the standard deviation of the lengths in the Site 2 sample.
 - (4) At least 75% of the mussels from Site 1 are longer than 200 mm.
 - (5) The mussels from Site 2 are longer, on average, and more variable in length than those from Site 1.
6. Only **one** of the following values is a reasonable estimate of the sample standard deviation of the lengths of the mussels from Site 1. Which **one** is it?
- (1) 100
 - (2) 2
 - (3) 80
 - (4) 40
 - (5) 20

Questions 7 and 8 refer to the following additional information.

Using the Site 2 data, a bootstrap confidence interval for a median was constructed. The three plots (Sample, Re-sample and Bootstrap distribution) from iNZightVIT are shown in Figure 3.

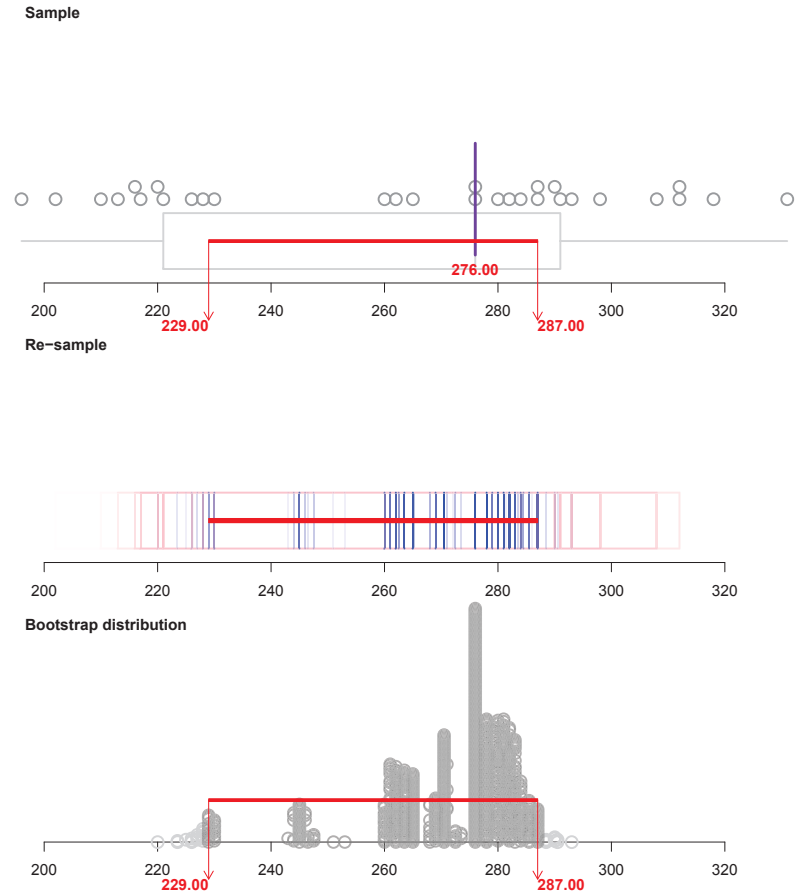


Figure 3: Bootstrap confidence interval output

7. Which **one** of the following statements is **false**?
- (1) The bootstrap distribution shows the extent of the variation of the medians of 1000 random re-samples taken with replacement from the original sample.
 - (2) Even though the shortest mussel (196 cm long) occurs once in the original sample, it would not be surprising if it occurred twice in some re-samples.
 - (3) The bootstrap distribution is used to estimate the distribution of the length of mussels from the Site 2 population.
 - (4) The bootstrap distribution estimates the extent of the variation in the sample median length, allowing the limits of the bootstrap confidence interval to be determined.
 - (5) Each vertical line in the 'Re-sample' plot represents the median of a re-sample obtained by randomly re-sampling with replacement from the original sample of 30 mussels.

8. Which **one** of the following statements is the **best** interpretation of the bootstrap confidence interval?

It is a fairly safe bet that:

- (1) the distribution of the median length of the sample of 30 mussels from Site 2 is somewhere between 229 mm and 287 mm.
- (2) the median length of mussels at Site 2 is somewhere between 229 mm and 287 mm.
- (3) the distribution of the lengths of mussels at Site 2 is somewhere between 229 mm and 287 mm.
- (4) the length of each mussel at Site 2 is somewhere between 229 mm and 287 mm.
- (5) the median length of the sample of 30 mussels from Site 2 is somewhere between 229 mm and 287 mm.

Questions 9 and 10 refer to the following information.

An experiment conducted by a group of researchers in Indiana investigated the effect of calcium on blood pressure in African-American men (Lyle *et al.*, 1987). A treatment group of 10 men received a calcium supplement for 12 weeks and a control group of 11 men received a placebo during the same period. All subjects, while seated, had their blood pressure tested before and after the 12-week period. The decrease in systolic blood pressure (before – after) was recorded.

A plot of the data, together with the difference in the group means, is shown in Figure 4.

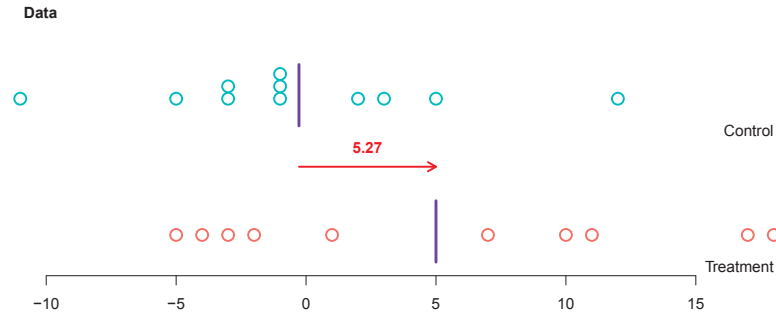


Figure 4: Decrease in systolic blood pressure

A randomisation test was carried out on the data and the resulting output is shown in Figure 5.

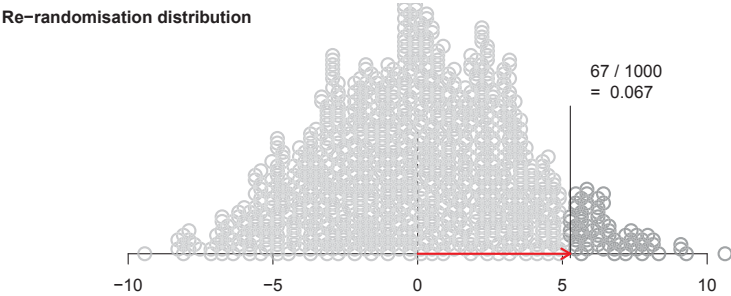


Figure 5: Randomisation test output

9. Which **one** of the following statements is **true**?

The re-randomisation plot has come about by:

- (1) repeatedly (1000 times) taking a different 21 subjects, randomly allocating them to a group (treatment or control) and plotting the difference of the group means.
- (2) conducting 1000 experiments with 21 different subjects each time, then randomly allocating them to a group (treatment or control) and plotting the difference between the two group means.
- (3) taking 1000 re-samples of size 21 from the original 21 subjects, with replacement, and plotting the differences between the two group means.
- (4) re-allocating (1000 times) the decrease in blood pressure of each of the 21 subjects, at random, to a group (treatment or control) and plotting the difference between the two group means.
- (5) conducting 1000 experiments with the same 21 subjects, randomly allocating them to a group (treatment or control) and plotting the differences between the two group means.

10. When considering the output in Figure 5 on the previous page, which **one** of the following conclusions is **false**?

- (1) We may claim that the observed difference between the two group means is partially due to chance and partially due to one group having a calcium supplement and the other group having a placebo.
- (2) We may claim that giving a calcium supplement to one group and a placebo to the other group has caused those in the treatment group to have a greater decrease in blood pressure, on average, than those in the control group.
- (3) Chance is acting alone cannot be ruled out as a plausible explanation for the observed difference between the group means.
- (4) We have evidence against chance acting alone as a plausible explanation for the observed difference between the group means.
- (5) Under chance acting alone it is unusual to get a difference between the group means (Treatment – Control) of 5.27 percentage points or more.

Questions 11 to 13 refer to the following information.

In 2011 Universities New Zealand – Te Pokai Tara, the body that represents New Zealand's eight universities, started a study called the Graduate Longitudinal Study New Zealand. A random selection of about 13 000 of the 40 000 students completing their studies at New Zealand universities during 2011 were invited to participate. The online survey was conducted during the period August to December 2011. About 8700 students responded and these students will be followed up three times; 2, 5 and 10 years after graduation.

11. Which **one** of the following non-sampling errors is **not** a potential source of bias?

- (1) Behavioural considerations
- (2) Self-selection
- (3) Non-response
- (4) Survey-format effects
- (5) Question effects

Questions 12 and 13 refer to the following additional information.

One group of questions in the survey asked about experiences at university during the 2011 academic year. Two of the questions were:

Question 1: *About how often have you used library resources online?*

Question 2: *About how often have you used email or an online learning forum to communicate with teaching staff?*

The response options for each question were:

Never, Sometimes, Often, Very often, Not applicable

Results are shown in Table 3.

Question	Response					Total
	Never	Sometimes	Often	Very often	Not applicable	
1	244	1168	2101	5169	35	8717
2	358	2022	2501	3740	96	8717

Table 3: Responses to two questions

Let:

p_1 be the true proportion of graduates from New Zealand universities in 2011 who very often used library resources online

and

p_2 be the true proportion of graduates from New Zealand universities in 2011 who very often used email or an online learning forum to communicate with teaching staff.

12. The sampling situation associated with $se(\hat{p}_1 - \hat{p}_2)$ is best described as:

- (1) one sample of size 8909 (5169 + 3740), many yes/no items.
- (2) one sample of size 8717, several response categories.
- (3) two independent samples, each of size 8717.
- (4) one sample of size 8717, many yes/no items.
- (5) two independent samples, of sizes 5169 and 3740.

13. A 95% confidence interval for $p_1 - p_2$ is (0.1435, 0.1844).

Based on this confidence interval, four of the following statements are **definitely true**.

Which **one** of the following statements **may not be true**?

For graduates from New Zealand universities in 2011:

- (1) it is not plausible that the true proportion who very often used library resources online is the same as the true proportion who very often used email or an online learning forum to communicate with teaching staff.
- (2) a claim that the true proportion who very often used library resources online is greater than the true proportion who very often used email or an online learning forum to communicate with teaching staff by 0.15 would not be rejected.
- (3) the difference between the true proportion who very often used library resources online and the true proportion who very often used email or an online learning forum to communicate with teaching staff is in the 95% confidence interval.
- (4) with 95% confidence we estimate that the true proportion who very often used library resources online is somewhere between 0.144 and 0.184 greater than the true proportion who very often used email or an online learning forum to communicate with teaching staff.
- (5) with 95% confidence we estimate that the true proportion who very often used library resources online is about 0.164 greater than the true proportion who very often used email or an online learning forum to communicate with teaching staff, with a margin of error of about 0.02.

14. A study (Mitchell *et al.*, 2013) examined the sleep habits of about 1400 adolescents from Pennsylvania. The adolescents were recruited for the study at age 14 and they were followed up every six months for four years. Each subject's height, weight and sleep habits were recorded. Each subject's height and weight were used to calculate their body mass index (BMI). Researchers concluded that additional sleep was associated with a reduction in BMI.

Which **one** of the following statements is **true**?

It is **incorrect** to use this study to conclude that increasing the amount of sleep in adolescents will result, on average, in a decrease in BMI **mainly** because:

- (1) the sleep habits of the adolescents in the study were not controlled by the researchers.
- (2) it is too difficult to correctly classify the sleep habits of adolescents.
- (3) the number of subjects (about 1400) was not large enough relative to the number of 14 to 18 year olds in Pennsylvania (about 800 000).
- (4) the BMI of the adolescents in the study was not controlled by the researchers.
- (5) the direction of the cause and effect should have been reversed; that is, a decrease in BMI will result, on average, in additional sleep.

15. Table 4 gives information about shareholders of ordinary shares in Auckland International Airport Limited as at 15 August 2012.

Size of shareholding	Number of shareholders	Percentage of shareholders	Number of shares	Percentage of shares
1 – 1000	3442	6.95%	1 953 865	0.15%
1001 – 5000	32 106	64.85%	68 669 411	5.19%
5001 – 10 000	6414	12.96%	45 860 180	3.47%
10 001 – 100 000	7255	14.65%	168 008 744	12.70%
100 001 and over	291	0.59%	1 038 072 289	78.49%
Total	49 508	100.00%	1 322 564 489	100.00%

Table 4: Auckland International Airport Limited shareholder information

Which **one** of the following statements is **false**?

- (1) Most of the shareholders hold, in total, a small proportion of the ordinary shares.
- (2) The mean number of ordinary shares held by the shareholders is about 26 700.
- (3) A small proportion of the shareholders hold, in total, a large proportion of the ordinary shares.
- (4) Most of the shareholders each hold more than 100 000 ordinary shares.
- (5) The median number of ordinary shares held by the shareholders is more than 1000 but no more than 5000.

16. Many patients who have a cardiac arrest in hospital and are resuscitated do not live for long. A study (Bloom *et al.*, 2007) of patients who had a heart attack in a hospital in Virginia, USA, looked at the effect on survival rates of implanting an internal cardioverter-defibrillator (ICD). Over a ten-year period, 49 of the 732 patients who had a cardiac arrest in hospital survived to be discharged.

Consider only the 49 discharged patients. Nine of these had an ICD implanted and, of the 49 discharged, 29 survived for three years or less. Of those who did not have an ICD implanted, 13 survived for more than three years.

For the patients who were discharged, how many times more likely is it that a patient who had an ICD implanted survived for more than three years compared to a patient who did not have an ICD implanted?

- (1) About 1.9 times more likely.
- (2) About 0.5 times more likely.
- (3) About 4.4 times more likely.
- (4) About 2.4 times more likely.
- (5) About 0.2 times more likely.

Questions 17 to 20 refer to the following information.

Bilirubin is a yellowish pigment found in bile, a fluid made by the liver. Large amounts of bilirubin in the blood can lead to jaundice, a yellow colour in the skin, mucus membranes or eyes. Phototherapy is a process which uses light to reduce bilirubin levels because high levels of bilirubin in the blood can be harmful to a baby.

A study (Morris *et al.*, 2008) compared the effect of two forms of phototherapy, aggressive and conservative, on the incidence of death or neurodevelopmental impairment among infants with extremely low birth weight (1000g or less). Many other outcomes were measured including the time for an infant to regain its birth weight and whether an infant's weight at 22 months was below the 5th percentile for this age. Study outcomes were determined by investigators who were unaware of the assignment to phototherapy groups.

Prior to being assigned to phototherapy groups the 1972 infants were sorted into two groups based on birth weight; 501g to 750g and 751g to 1000g. Infants in each birth-weight group were then randomly assigned to a phototherapy group. For infants in the aggressive group, phototherapy was carried out when the bilirubin level reached 5 mg/dL whereas in the conservative group, phototherapy was carried out when the bilirubin level reached 8mg/dL. Phototherapy was never given to 1 infant in the aggressive group and to 215 infants in the conservative group.

Some of the variables recorded were:

BirthWt	The infant's weight at birth (grams)
Death	Whether the infant died by age 22 months: — Yes, No
Ethnicity	The infant's ethnicity: — Black, Hispanic, White, Other
Impairment	Whether the infant had neurodevelopmental impairment by age 22 months: — Yes, No
Peak	Peak bilirubin level in blood from day 1 to day 14 after birth (mg/dL)
Phototherapy	The phototherapy group to which the infant was assigned: — Aggressive, Conservative
Regain	The time to regain birth weight (days)
Weight5th	Whether the infant's weight at 22 months is below the 5th percentile for this age: — Yes, No

17. Which one of the following statements about the variables defined above is true?

- (1) **Ethnicity** is discrete, **Weight5th** is numeric and **Regain** is discrete.
- (2) **Ethnicity** is categorical and both **Weight5th** and **Regain** are numeric.
- (3) **Ethnicity** and **Weight5th** are discrete and **Regain** is numeric.
- (4) **Ethnicity** is discrete and both **Weight5th** and **Regain** are numeric.
- (5) **Ethnicity** and **Weight5th** are categorical and **Regain** is numeric.

18. Which **one** of the following statements about this study is **false**?
- (1) This study used a randomised block design with the phototherapy group (conservative or aggressive) serving as the block.
 - (2) In this study **Death** and **Impairment** are response variables.
 - (3) We would expect the distribution of **BirthWt** for the infants in the conservative group to be similar to that for the infants in the aggressive group.
 - (4) This study is an experiment because of the way the infants were assigned to the treatment groups.
 - (5) Blinding has been used in this study because the investigators who determined the study outcomes were unaware of the groups to which the infants were assigned.

Questions 19 and 20 refer to the following additional information.

Assume the 1972 infants in this study are a random sample from some population of low birth weight infants.

Let:

μ_C be the population mean peak bilirubin level in blood from day 1 to day 14 after birth for low birth weight infants assigned to a conservative phototherapy group

and

μ_A be the population mean peak bilirubin level in blood from day 1 to day 14 after birth for low birth weight infants assigned to an aggressive phototherapy group.

Summary statistics for the peak bilirubin level in blood from day 1 to day 14 after birth for the two groups are shown in Table 5.

Phototherapy	Peak bilirubin level (mg/dL)		Group size
	Mean	Std. dev.	
Conservative	$\bar{x}_C = 9.8$	$s_C = 2.1$	$n_C = 982$
Aggressive	$\bar{x}_A = 7.0$	$s_A = 1.8$	$n_A = 990$

Table 5: Summary statistics

19. **No longer examinable.**

20. Suppose that the group sizes were 245 for the conservative group and 247 for the aggressive group (that is, about $\frac{1}{4}$ the size of the groups in the actual study) and that the summary statistics were very similar to those stated in Table 5, page 15. Also suppose that a new 95% confidence interval for $\mu_C - \mu_A$ will be constructed using these smaller group sizes.

When comparing the new 95% confidence interval with the 95% confidence interval from the actual study, which **one** of the following statements is **true**?

- (1) The new interval will be about half the width of the interval from the actual study.
- (2) The new interval will be about four times the width of the interval from the actual study.
- (3) The new interval will be about twice the width of the interval from the actual study.
- (4) The new interval will be about quarter the width of the interval from the actual study.
- (5) The new interval will be about the same width as the interval from the actual study.

ANSWERS

- | | | | | |
|---------|---------|---------|---------|---------|
| 1. (4) | 2. (1) | 3. (5) | 4. (5) | 5. (1) |
| 6. (5) | 7. (3) | 8. (2) | 9. (4) | 10. (3) |
| 11. (2) | 12. (4) | 13. (3) | 14. (1) | 15. (4) |
| 16. (4) | 17. (5) | 18. (1) | 19. (1) | 20. (3) |
-