# Section Check In – Statistics: Hypothesis Testing

## Questions

1. A supermarket typically has 60% of inhabitants of a town who shop there. The manager wants to see if the new advertising campaign has increased the number of customers.

State the null and alternative hypothesis for this test.

2. A random sample of size *n* is taken from a binomial distribution. If carry out a hypothesis test given the null and alternative hypotheses. Test at the 3% significance level.

3.\* A random sample of size *n* is taken from a Normally distributed population with a given standard deviation. If  carry out a hypothesis test given the null and alternative hypotheses. Test at the 1% significance level.

4.\* A random sample of size *n* is taken from a Normally distributed population with a given standard deviation. If carry out a hypothesis test given the null and alternative hypotheses. Test at the 10% significance level.

5. A television programme called “Cook-off” changes three of its presenters. The programme was viewed by 20% of a population of 50 million. The producers want to determine if this change has affected viewing figures. From a random sample of 100 from the population, 28 said they watched the programme.

Carry out a suitable hypothesis test at the 5% significance level (stating the null and alternative hypotheses) to determine whether there is sufficient evidence to suggest viewing figures have changed.

6.\* The lifetimes of a particular type of light bulb has been Normally distributed with mean 4500 hours and standard deviation 500 hours. A quality control manager suspects that changes in production methods have led to lower mean lifetime but no change in the standard deviation. A random sample of 8 light bulbs will be used to test the quality control manager’s suspicion. The mean lifetime for the sample will be used as the test statistic.

(i) State suitable null and alternative hypotheses for the test.

(ii) Find the critical region for the test at the 3% significance level.

7. Harry is taking a multiple choice test with 40 questions. Each question has 4 answers to choose from. Harry gets 2 questions right; he says he guessed them all. Harry’s teacher says that his mark is worse than someone who is just guessing. Carry out a hypothesis test with a 5% level of significance to see if there is evidence to support the teacher’s claim.

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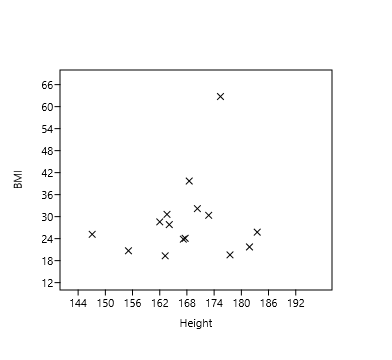
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8.\* An athlete’s times for running 400 m are Normally distributed with mean 55 seconds and standard deviation 3 seconds. A manufacturer of a new trainer claims that it improves running times. The athlete asks to trial it to see if it improves his times. He times a random sample of 10 runs of 400m each and his mean time was 53 seconds. Carry out a suitable hypothesis test (stating the null and alternative hypotheses) to investigate the manufacturer’s claim at the 3% significance level. Assume that there is no change in the standard deviation.

9.\* The scatter diagram below shows BMI against height in cm for a random sample of 15 adults.



(i) Write down suitable hypotheses for a test of whether there is any correlation between BMI and height.

(ii) For the sample shown above, the correlation coefficient is 0.1833 and the *p*-value is 0.5132. Does this provide evidence of correlation between BMI and height at the 5% level?

10.\* Packets of biscuits are labelled as having a mean weight of 500 grams. An inspector records the weights, *x* grams, of a random sample of 50 packets of biscuits.  .

(i) Calculate the sample mean.

(ii) Calculate the sample standard deviation.

(iii) Conduct a suitable hypothesis test of the claim that the mean weight of packets of biscuits is different to 500 grams. Use a 5% significance level.

**Extension**

Use a spreadsheet to generate 100 random samples of size 15 from , the standard Normal distribution.

(i) Calculate the sample mean for each sample.

(ii) Calculate the critical region for the sample mean at the 5% significance level for the following hypotheses.

 where *μ* is the population mean.

Assume that the standard deviation is 1.

(iii) How many of your 100 samples would result in the rejection of the null hypothesis? Is this what you expected?

## Worked solutions

1. Let  be the proportion of inhabitants that shop at the supermarket.



2. 



If the null hypothesis is true,

This is a one-tail test, 

Therefore, as the *p*-value is greater than the significance level, we do not reject which means there is insufficient evidence against the null hypothesis.

3. 



If the null hypothesis is true, for samples of size 10, 

The observed value of 140 for the sample mean would be in the lower tail.



This is a two-tail test, 0.0175 > 0.005

Therefore we do not reject  which means there is insufficient evidence against the null hypothesis.

4. 



If the null hypothesis is true, for samples of size 50, 



This is a one-tail test so this is the *p*-value.

0.07865 < 0.1

Therefore, as the *p*-value is less than the significance level, we reject which means there is sufficient evidence against the null hypothesis.

5. Let be the number of viewers from the sample of 100 watching the “Cook off” and  the proportion of the population who watch the “Cook off”.



If the null hypothesis is true, 

The observed value of 28 would be in the upper tail.



This is a two-tail test, 

Therefore we do not reject  which means there is insufficient evidence against the null hypothesis that the new presenters have affected viewing figures.

6. (i)  where *μ* is the population mean lifetime for the light bulbs.

(ii) Let be the lifetime of a light bulb.



For a random sample of size 8, if the null hypothesis is true, 

This is a one-tail test. The critical value, *k*, is such that 

Using the inverse Normal,  (4sf)

The critical region is 

7. Let be the number of questions that someone gets correct and represents the probability of getting a question correct.



If the null hypothesis is true, .

 ; this is the *p*-value. The *p*-value is much less than the 5% significance level so there is evidence that Harry is doing worse than someone who is just guessing.

8. Let be the time in seconds achieved by the athlete running 400 m.

 where *μ* is the population mean of the athlete’s times.

If the null hypothesis is true, then for a random sample of 10 runs, 



This is a one-tail test so this is the *p*-value.

0.0175 < 0.03

Therefore, as the *p*-value is smaller than the significance level, we reject which means there is sufficient evidence against the null hypothesis suggesting that the new trainers do improve the running times of the athlete.

9. (i)  where *p* is the population correlation coefficient between BMI and   
 height.

(ii) The *p*-value is more than the 5% significance level so do not reject the null hypothesis. There is insufficient evidence of correlation in the population.

10. (i) 

(ii) 

****

Standard deviation = 

(iii)  where *μ* is the population mean weight of a packet of biscuits.

If the null hypothesis is true,  where *σ* is the population standard deviation. The sample is large so  can be used as an estimate of .



For a 2 tail test at the 5% level, the critical values, *a* and *b*, are such that  and . Using the inverse Normal,  and . The critical region is  or  . The sample mean is in the critical region so there is evidence that the mean weight of packets of biscuits is different to 500 grams.

**Extension**

(i) Sample mean depends on the sample taken.

(ii)  where *μ* is the population mean.

If the null hypothesis is true, 

For a 2 tail test at the 5% level, the critical region is  or .

(iii) You would expect 5% of samples to have the sample mean in the critical region when the null hypothesis is true.

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