STUDY TIME

LEVEL 3 STATISTICS

STATISTICALLY BASED REPORTS

NCEA Workbook Answers

Section One
The Foundations

Part One

The Foundations

1. Key Terms:

a. *i.* A feature that's able to change.

ii. Outside factors that affect the study results and aren't controlled.

iii. The thing that's controlled and changed. It's usually the cause or the explanation of the other variable. Sometimes referred to as the independent variable.

iv. The focus. We measure how much it changes when the explanatory variable changes. Sometimes referred to as the dependent variable.

v. When one variable causes another. As one changes, it makes the other change.

vi. When two variables are related. As one variable changes, the other one tends to, but this doesn't mean they make each other change.

b. *i.* When we take a small group from the population and use it to represent the entire population.

ii. A list of all the members of the population, used to choose a sample.

iii. A sample is representative if it has the same kind of mix of people and demographic features as the population, so it can be used to make claims about the population.

iv. When a sample tends to get a particular kind of answer that is different from the truth, because we picked a bad sample or asked bad questions.

v. When a sample overrepresents or underrepresents certain groups in the population, so the sample is not representative.

vi. Saying that the explanatory variable directly causes the response variable to change.

vii. The real statistics of the real population. This is what we want to have a guess at using our sample.

viii. This means you find whether surveys are true, fair, unbiased and well-represented, or not.

c. *i.* When we compare two groups from the sample that are connected under one question.

ii. When you've two different questions and want to compare their stats. They're not going to affect each other if they're two separate surveys or questions – which is what makes them independent.

iii. Anything over half.

iv. A distance from the sample statistic that we're 95% sure the population statistic falls within.

v. These happen if a sample has bias or doesn't accurately represent the population.

vi. These happen because data is collected from a sample rather than the whole population as one sample will never perfectly reflect the population.

vii. The sample's statistic plus or minus the margin of error. This gives a range that we're 95% confident the population statistic will be in.

d. *i.* When you divide the population into multiple groups, then randomly select entire groups to form the sample.

ii. When you approach passing people to answer the question in a survey.

iii. When a researcher has to sample a certain number of people or qualities in each group to ensure that groups are not underrepresented or ignored.

iv. When a population is numbered off and has an equal chance of being selected.

v. When people in a population choose to write in or respond to a questionnaire or survey.

vi. When the researcher tries to make the sample look as much like the population as possible by grouping it using a different variable and then sampling proportionately within each group.

vii. When the population is ordered then the researcher selects every n^{th} person from a random starting point.

2. Key Equations:

a. *i.* Margin of Error = $\pm\frac{1}{\sqrt{n}}$

ii. Margin of Error of Differences = 2 × Total Margin of Error

iii. MoE of difference = $\pm\ 1.5 \times \frac{MoE_1 + MOE_2}{2}$

iv. Confidence interval = estimate ± Margin of Error

3. Determining Control and Treatment Groups:

a. *i.* Control group: Continue to use social media.

ii. Treatment group: Stop using social media.

b. *i.* Control group: Continue to attend lectures in person.

ii. Treatment group: Watch lectures online.

c. *i.* Control group: Cars with the altered system not on (drivers not altered when they go over the speed limit).

ii. Treatment group: Cars with the alter system turned on (drivers altered when they go over the speed limit).

d. *i.* Control group: Continue with their normal diet.

ii. Treatment group: Change to a low carbohydrate diet.

4. Determining Explanatory and Response Variables:

a. *i.* Explanatory variable: $5000 incentive towards the cost of a vehicle.

ii. Response variable: Type of car that is purchased.

b. *i.* Explanatory variable: Median weekly income.

ii. Response variable: Rating of their happiness.

c. *i.* Explanatory variable: Amount of time spent using social media.

ii. Response variable: Marks of their most recent assessment.

d. *i.* Explanatory variable: The age bracket a person falls into.

ii. Response variable If they have broken a bone in the past year.

5. Identifying the Type of Study Conducted

a. *i.* Type of study: Cluster sampling.

ii. Justification: The school is divided into 10 clusters (the classrooms) and a student is randomly selected from each cluster.

b. *i.* Type of study: Random sampling.

ii. Justification: The students were selected at random, without any previous manipulation of the population.

c. *i.* Type of study: Stratified sampling.

ii. Justification: The retailers are divided in "strata" based on their income, then a sample is taken from each "strata" to get a representative sample.

d. *i.* Type of study: Self-selected sampling.

ii. Justification: People choose whether to complete the survey or not and send it in. There is no obligation to complete the survey.

e. *i.* Type of study: Quota sampling.

ii. Justification: The surveyor wants a representative sample so they continue to sample students until they have met a 'quota' for each of the ethnic groups.

f. *i.* Type of study: Systematic sampling.

ii. Justification: The survey systematically works through the population (the people admitted to hospital) randomly selected the n^{th} number of people to fill the sample.

g. *i.* Type of study: Person on the street sampling.

ii. Justification: The surveyor is standing on the street randomly approaching people who walk by and asks their preference of the advertisement.

6. Calculating the Margin of Error and Confidence Intervals:

a *i.* **Margin of error:**

$MOE = \frac{1}{\sqrt{n}}$

$= \frac{1}{\sqrt{1032}}$

$= 0.0311$

$= 3.11\%$

Confidence interval: 43% ± MOE = 43% ± 3.11%

= [39.89%, 46.11%]

Interpretation of the confidence interval: I am pretty sure that the percentage of divers who frequently use their cell phones while driving is between 39.89% and 46.11%.

ii. **Margin of error:**

$MOE = \frac{1}{\sqrt{n}}$

$= \frac{1}{\sqrt{173}}$

$= 0.076$

$= 7.6\%$

Confidence interval: 69% ± MOE = 69% ± 7.6%

= [61.4%, 76.6%]

Interpretation of the confidence interval: I am pretty sure that the percentage of first homeowners who had family help to obtain the deposit is between 61.4% and 76.6%.

iii. **Margin of error:**

$MOE = \frac{1}{\sqrt{n}}$

$= \frac{1}{\sqrt{592}}$

$= 0.0411$

$= 4.11\%$

Confidence interval: 32% ± MOE = 32% ± 4.11%

= [27.89%, 36.11%]

Interpretation of the confidence interval: I am pretty sure that the percentage of pet owners that own a cat is between 27.89% and 36.11%.

b. *i.* **Margin of error:**

$\text{MOE} = \frac{1}{\sqrt{n}} = \frac{1}{\sqrt{10872}}$

$= 0.00959$

$= 0.9591\%$

$2 \times \text{MOE}$

$= 2 \times 0.959$

$= 1.9182\%$

Difference between values:

Percentage of people who agree = 25%

Percentage of people who disagree = 10%

Difference in percentages = 25% – 10%

= 15%

Confidence interval: 15% ± MOE = 15% ± 1.9182%

= [13.08%, 16.92%]

Interpretation of the confidence interval: I am pretty sure that the percentage of people who agree that Te Reo Māori should be compulsory in New Zealand primary schools is between 13.08% to 16.92% higher than those who disagree that Te Reo Māori should be compulsory.

ii. **Margin of error:**

$\text{MOE} = \frac{1}{\sqrt{n}} = \frac{1}{\sqrt{369}}$

$= 0.0521$

$= 5.2\%$

$2 \times \text{MOE}$

$= 2 \times 5.2\%$

$= 10.4\%$

Difference between values:

Percentage of families that have takeaways 3 times a week = 30%

Percentage of families that have takeaways once a week = 38%

Difference in percentages = 38% – 30%

= 8%

Confidence interval: 8% ± MOE = 8% ± 10.4%

= [-2.4%, 18.4%]

Interpretation of the confidence interval: The confidence interval obtained states that the difference between the percentage of families who have takeaways once a week compared to families that have takeaways once a week is between -2.4% and 18.4%. Therefore, it cannot be stated that there is a higher percentage of families who have takeaways once a week as the confidence interval includes a 0 value.

iii. **Margin of error:** $\text{MOE} = \frac{1}{\sqrt{n}}$

$= \frac{1}{\sqrt{722}}$

= 0.0372

= 3.7%

2 × MOE

= 2 × 3.7%

= 7.4%

Difference between values: Percentage of students who study between 5 to 8 hours = 20%

Percentage of students who study between 9 to 11 hours = 30%

Confidence interval: 10% ± MOE = 10% ± 7.4%

= [2.6%, 17.4%]

Interpretation of the confidence interval: The confidence interval obtained shows that a higher percentage of student's study between 9 and 11 hours per week as the difference is between 2.6% and 17.4%. Therefore, a higher percentage of student's study between 9 and 11 hours.

c. *i.* Margin of error for 2015: $\text{MOE}_{2015} = \frac{1}{\sqrt{n}}$

$= \frac{1}{\sqrt{823}}$

= 0.0349

= 3.49%

Margin of error for 2020:	$MOE_{2020} = \frac{1}{\sqrt{n}}$
	$= \frac{1}{\sqrt{947}}$
	$= 0.0325$
	$= 3.25\%$
Margin of error of the difference:	$MOE = \pm 1.5 \times \frac{(MOE_{2015} + MOE_{2020})}{2}$
	$= \pm 1.5 \times \frac{(3.49 + 3.25)}{2}$
	$= \pm 1.5 \times 3.37$
	$= \pm 5.055\%$
Difference between values:	Percentage who smoke regularly in 2015 = 20%
	Percentage who smoke regularly in 2020 = 5%
	Difference in percentages = 5% – 20%
	= –15%
Confidence interval:	-15% ± MOE = -15% ± 5.055%
	= [-20.06%, -9.95%]
Interpretation of the confidence interval:	As the confidence interval is entirely negative, I am pretty sure that the percentage of 18 to 24 year olds who smoke regularly has decreased. This is because the confidence interval for the difference is entirely negative.
ii. Sample proportion for 2001:	Sample proportion = $\frac{203}{543}$
	$= 0.3738$
	$= 37.38\%$
Margin of error for 2001:	$MOE_{2001} = \frac{1}{\sqrt{n}}$
	$= \frac{1}{\sqrt{543}}$
	$= 0.0429$
	$= 4.29\%$

Sample proportion for 2016:	Sample proportion = $\frac{1000}{1662}$
	= 0.6017
	= 60.17%
Margin of error for 2016:	MOE_{2016}
	$= \frac{1}{\sqrt{n}}$
	$= \frac{1}{\sqrt{1662}}$
	= 0.0245
	= 2.45%
Margin of error of the difference:	$MOE = \pm 1.5 \times \frac{(MOE_{2001} + MOE_{2016})}{2}$
	$= \pm 1.5 \times \frac{(4.29 + 2.45)}{2}$
	= ± 1.5 × 3.37
	= ± 5.055%
Difference between values:	Percentage in 2001 who get > 10 hours sleep = 37.38%
	Percentage in 2016 who get > 10 hours sleep = 60.17%
	Difference in percentages = 60.17% – 37.38%
	= 22.79%
Confidence interval:	22.79% ± MOE = 22.79% ± 5.055%
	= [17.7%, 27.8%]
Interpretation of the confidence interval:	As the confidence interval is entirely positive, I am pretty sure that the percentage of primary school students who get more than 10 hours of sleep on average each night has increased by between 17.7% and 27.8%.
iii. Sample proportion for 2008:	Sample proportion = $\frac{473}{876}$
	= 0.54
	= 54%

Margin of error for 2008:	$MOE_{2001} = \frac{1}{\sqrt{n}}$
	$= \frac{1}{\sqrt{876}}$
	$= 0.0338$
	$= 3.38\%$
Sample proportion for 2018:	Sample proportion
	$= \frac{630}{1235}$
	$= 0.51$
	$= 51\%$
Margin of error for 2018:	$MOE_{2016} = \frac{1}{\sqrt{n}}$
	$= \frac{1}{\sqrt{1235}}$
	$= 0.0285$
	$= 2.85\%$
Margin of error of the difference:	$MOE = \pm 1.5 \times \frac{(MOE_{2008} + MOE_{2018})}{2}$
	$= \pm 1.5 \times \frac{(3.38 + 2.85)}{2}$
	$= \pm 1.5 \times 3.115$
	$= \pm 4.67\%$
Difference between values:	Percentage in 2001 who eat breakfast = 54%
	Percentage in 2018 who eat breakfast = 51%
	Difference in percentages = 51% – 54%
	= –3%
Confidence interval:	–3% ± MOE = –3% ± 4.67%
	= [-7.67%, 1.67%]
Interpretation of the confidence interval:	As the confidence interval goes from -7.67% to 1.67%, the surveys conducted do not provide enough evidence to show that habits around eating breakfast have changed between 2008 and 2018.

Section Two
Exam Skills & Mixed Practice

1. Using Margin of Error to Analyse Reports:

1.

a. *i.* MOE = $\frac{1}{\sqrt{n}}$

$= \frac{1}{\sqrt{4909}}$

$= 0.01427$

$= 1.427\%$

ii. MOEs are needed to take into account the natural variation that always occurs from sample to sample.

b. *i.* MOE = 1.427% (from (a)(i) before)

ii. MOE for differences = 2 × MOE

$= 2 \times 1.427$

$= 2.85\%$

iii. Percentage of Asian parents who fully vaccinate = 92%

Percentage of Māori parents who fully vaccinate = 85%

Difference in percentage of parent who fully vaccinate = 92% – 85%

= 7%

iv. Confidence interval = difference between subgroups ± MOE for difference

$= 7\% \pm 2.85\%$

$= [4.15\%, 9.85\%]$

v. I am pretty sure that the percentage of Asian parents who fully vaccinate their children is between 4.15% and 9.85% higher than Māori parents who fully vaccinate their children.

vi. As zero is not in the confidence interval, it can be claimed that the percentage of Asian parents who had fully vaccinated their children is higher than the percentage of Māori parents who fully vaccinate their children. Therefore, the claim is supported.

c. *i.* 4909 people responded in 2017.

ii. MOE = $\frac{1}{\sqrt{n}}$

Therefore n = $\left(\frac{1}{MOE}\right)^2$

= $\left(\frac{1}{0.03}\right)^2$

= 1111

1111 people responded to the survey in 2013

iii. In 2013, 1111 people responded to the survey, while in 2017, 4909 people responded to the survey. Therefore, a larger number of people in 2017 responded to the survey, which decreased the margin of error of the survey, as the larger sample is more representative of the population.

d. *i.* MOE_{2013} = 3% (from the report)

ii. MOE_{2017} = 1.427% (from a.i. before)

iii. MOE = $\pm\ 1.5 \times \frac{(MOE_{2013} + MOE_{2017})}{2}$

= $\pm\ 1.5 \times \frac{(3\% + 1.427\%)}{2}$

= $\pm\ 1.5 \times \frac{4.427}{2}$

= ± 3.32%

iv. Percentage of parents in 2013 who had fully vaccinated their children = 93.3%

Percentage of parents in 2017 who had fully vaccinated their children = 89.3%

Difference in the percentages = 93.3% – 89.3%

= -4%

v. Confidence interval = difference between subgroups ± MOE for difference

= -4% ± 3.32%

= [-7.32%, -0.68%]

vi. I am pretty sure that the percentage of parents in 2017 who fully vaccinate their children is between 0.68% and 7.32% lower than the percentage of parents in 2013 who fully vaccinate their children.

vii. As zero is not in the confidence interval, it can be claimed that the percentage of parents in 2017 who fully vaccinate their children is lower than the percentage of parents in 2013 who fully vaccinate their children. Therefore, the claim is supported. However, as one of the limits of the confidence interval is close to zero, if a different sample of each of the years was taken, the results may show that the percentage of parents who are fully vaccinating their children is not steadily decreasing.

2.

a. *i.* MOE = $\frac{1}{\sqrt{n}}$

$= \frac{1}{\sqrt{297}}$

$= 0.058$

$= 5.8\%$

ii. Construct the confidence interval.

Confidence interval = point estimate ± MOE

$= 53\% \pm 5.8\%$

$= [47.2\%, 58.8\%]$

iii. I am pretty sure that the percentage of people who support leaving the monarchy is between 47.2% and 58.8%

b. *i.* $MOE_{1995} = 2.5\%$

ii. $MOE_{2019} = 5.8\%$

iii. $MOE = \pm 1.5 \times \frac{(MOE_{1995} + MOE_{2019})}{2}$

$= \pm 1.5 \times \frac{(2.5\% + 5.8\%)}{2}$

$= \pm 1.5 \times \frac{8.3\%}{2}$

$= \pm 6.225\%$

iv. Percentage of people who want to leave the monarchy in 1995 = 45%

Percentage of people who want to leave the monarchy in 2019 = 53%

Difference between years = 53% – 45%

= 8%

Section Two: **Putting it into Context** *v.* Calculate the confidence interval.

Confidence interval = difference ± MOE for the difference

= 8% ± 6.225%

= [1.775%, 14.225%]

vi. I am pretty sure that the percentage of people who want to leave the monarchy in 2019 is between 1.775% and 14.225% more than the percentage of people who wanted to leave the monarchy in 1995.

vii. Yes, there is a difference between the percentage of people who wanted to leave the monarchy in 1995 and the percentage who want to leave in 2019. There is a higher percentage of people who want to leave the monarchy in 2019 compared to 1995.

c. *i.* 297 people were surveyed in 2019.

ii. How many people were surveyed in 1995?

MOE = $\frac{1}{\sqrt{n}}$

Therefore n = $\left(\frac{1}{\text{MOE}}\right)^2$

= $\left(\frac{1}{0.025}\right)^2$

= 1600

1600 people were surveyed in 1995.

iii. MOE for differences = 2 × MOE

= 2 × 7.98%

= 15.96%

d. *i.* Calculate the number of people who want to leave the monarchy.

Number of people who want to leave the monarchy = 0.53 × 297

= 157.41

= 157

ii. MOE = $\frac{1}{\sqrt{n}}$

$= \frac{1}{\sqrt{157}}$

= 0.0798

= 7.98%

iii. Calculate the margin of error for the comparison of two subgroups with one survey.

MOE for differences = 2 × MOE

= 2 × 7.98%

= 15.96%

iv. Percentage who want to leave = 63%

v. Percentage who want to leave = 26% + 9% + 2%

= 37%

vi. Difference = 63% – 37% (values form *iv.* and *v.* which were calculated)

= 26%

vii. Confidence interval = difference ± MOE for differences

= 26% ± 15.96%

= [10.04%, 41.96%]

viii. I am pretty sure that the percentage of people under the age of 24 who want to leave the monarchy is between 10.04% and 41.96% more than the people who are over the age of 25.

ix. Yes, the data does support the claim that the percentage of people under that age of 24 is higher than the percentage of people over the age of 25 who want to leave the monarchy. Therefore, the claim is correct.

2. Analysing Reports to Determine Parameters of Surveys:

1.

a. Identify and describe the explanatory and response variables in the survey in the report above.

i. Increase in petrol tax.

ii. The number of vehicles on the road.

b. i. The percentage decrease in the number of vehicles on New Zealand roads due to a petrol tax increase.

ii. Auckland is the largest population centre in New Zealand, so therefore has the largest number of vehicles on the roads. As a result, relating the results to significantly smaller populations, such as Whanganui, will not accurately represent the potential changes that may occur if a petrol tax was to be implemented.

iii. The data was collected along the Southern Motorway, so it would record people travelling to and from work. Commuting distance to/from work in Auckland may be significantly different from those in other parts of New Zealand, so the extra cost of the fuel tax may encourage more people to find an alternative method for commuting because it is more expensive each week. Depending on how far people have to travel each day, despite the increase, it may be easier for them to continue using the car.

iv. Auckland has a range of alternative transport options, which means it is possible for some people to change the commuting options if the increase in cost due to petrol tax was to occur. However, in other towns/cities around New Zealand, public transport may not be suitable, so a vehicle must be used, or the price of public transport may be more than the cost after the petrol tax increase. This would mean the percentage decrease in the number of vehicles would be smaller than that estimated from the Auckland survey.

c. i. The researchers would have plotted the number of vehicles recorded on the Southern Motorway against the cost of the petrol tax. This would have allowed them to see a relationship between the two variables. If there was a positive relationship, then with increasing petrol tax the number of cars would have also increased. If there was no relationship, then with increasing petrol tax there would be no change in the number of cars. If there was a negative trend, then with increasing petrol tax, the number of cars would decrease.

ii. By plotting the variables of petrol tax and the number of cars on the Southern Motorway, a model could be fitted to assess the relationship. This will allow the researchers to see if there was a relationship between the variables, and how strong the relationship is.

iii. If there were any underlying variables that may have also influenced the number of cars that may have been on the road. For example, the time of the year, if the data was collected in winter, then more people may be taking their car no matter what the cost, compared to summer.

d. i. Confounding variables are any outside factors that change the experiment results.

ii. The number of vehicles on the road in summer may differ to that in winter. Due to the weather, more people may use their vehicles in winter, than compared to summer. If one survey was taken during the summer, then the next in winter then the changes would not reflect the petrol tax changes.

iii. If the survey was taken over a holiday period one week, then a 'normal' work week the following year, then the changes in the traffic would not reflect that of the petrol tax, but also variation in holiday traffic. Likewise, if the survey was taken over a long weekend, then there is usually a lot more traffic on the motorways than during a typical week.

iv. Since 2017, there has been a push to increase the public transport options, as it is one option that can help climate changes. With increasing public transport options, people may not be using a vehicle as often, so the potential decrease in vehicles on the motorway recorded by the survey, may not reflect the petrol tax increase but reflect extenuating factors.

e. *i.* Because then the researchers can look at a percentage increase or decrease in the number of cars, rather than just the total number of cars.

ii. The year before acts as a control variable between years, so that they can be compared.

iii. By measuring the variable twice, it minimises the variation in the survey.

2.

a. *i.* Increase in the fine and demerit points received for using a mobile phone while driving.

ii. The percentage of people who use their mobile phones while driving.

b. *i.* A causal claim. (The harsher penalties are resulting in lower numbers of people using mobile phones while driving)

ii. This is an observational study. The number of mobile phone users before the fine was increased was recorded, then once the fine was increased the number of mobile phone users was recorded again. The survey did not split drivers into groups that had increased the fine for one group and kept the fine the same for the other group, to see if there was a causal relationship. There was no control of the treatment levels.

iii. The heading implies that mobile phone use while driving has decreased for the entire population (New Zealand).

iv. The survey was only conducted in Wellington CBD. This is only one specific location in New Zealand, so it would not be recommended to extrapolate the results to the entirety of New Zealand. The title should read, "Harsher penalties discourage the use of mobile phones while driving around Wellington CBD".

c. *i.* If the intersections were used as the clusters, then a set of intersections would be randomly selected from all the intersections in the Wellington CBD. Then, at each of the intersections, a specified number of cars would be randomly selected to see if the driver was using a mobile phone or not.

ii. If the roads were used as the clusters, then a set of roads would be randomly selected from all the roads in Wellington CBD. Then along each of these roads, a specified number of cars would be randomly selected to see if the driver was using a mobile phone or not.

If the roads were used as the clusters, then a set of roads would be randomly selected from all the roads in Wellington CBD. Then along each of these roads, a specified number of cars would be randomly selected to see if the driver was using a mobile phone or not.

d. i. The initial survey in 2015 was conducted nationwide, but then when it was repeated in 2020 the survey was only conducted in Wellington. Then the two results were compared. As we do not know what the baseline results for Wellington, before the fine was increased, then we should not compare the results of the two surveys as this can lead to misleading statistics being quoted in the report.

ii. The 2015 survey was conducted 5years after the initial fine was put into place, so people may have got complacent with the rules, or think that police are no longer looking for people using their mobile phone. In comparison, the 2020 survey was completed just over 3 years following the penalty increase. At this time, people may still be getting used to the new rules or the fact that police are increasing surveillance of mobile phone usage, may deter people more than the fine.

iii. In 2015, a smaller sample of vehicles were selected for the survey, as the margin of error for the survey was higher. In 2020, more vehicles were surveyed, as the margin of error is smaller. The 2020 sample would be more representative of the population, as it is larger, so the results would better reflect what is happening in the population. The 2015 sample would not be as representative, so comparing the results could lead to misleading information.

iv. In the surveys you would want all genders and age groups to be represented in the sample as this would accurately reflect the population. Some genders/age groups may be more likely to use a mobile phone, so if these groups are over/under-represented then the results are not going to accurately reflect what is occurring back in the population.

3. Analysing Reports to Determine Parameters of Scientific Studies and Experiments

1.

a. Control Group:

Group which are given no instruction on how to study.

Treatment Group:

Group which are given instruction on how to use the Pomodoro Technique while studying.

b. Describe the allocation method for this experiment and explain why it is important to allocate participants to the groups in this way.

i. Random allocation was used. The students taking part in the study would have been given a number and then the numbers would have been randomly allocated to either the control or the treatment group.

ii. It will attempt to create two unbiased/fair/balanced groups.

iii. This will reduce the bias in the groups to allow for a fair comparison of the variable of interest.

c. *i.* The principal would have compared the mean of the control group to the mean of the treatment group. The control group had a mean score of 68, while the treatment group has a mean score of 79. As the control group has the lower mean score then the control group had lower marks on the test.

ii. The researchers could have calculated the difference between the mean of each group then constructed a confidence interval for the difference. If the confidence interval did not include zero, then it would be likely that the groups are different. This would also help show if the control group did have a lower mark.

iii. The researchers would have taken the mark of the second test then subtracted the mark of the first test, and compared which group had the largest change. For the control group the change in average mark would be 68 – 54 = 14. For the treatment group the change in average mark would be 79 - 55 = 24. As the change in the average mark for the control group is lower than the treatment group the control group did not improve as much as the treatment group.

iv. The researchers could have calculated the difference between the change in average mark for each of the groups and constructed a confidence interval. If the confidence interval includes zero, then there would be no difference in the change in average mark. If the confidence interval did not include zero, then it would help to show that the difference in groups is significant.

d. *i.* The students sat the same test at the start of the study and the same test at the end of the study. Some students may struggle with sitting tests, so the test mark may not truly reflect whether the study technique did help the student improve.

ii. All the students would have been in the same lessons, learning the same material, and all students did some study leading up to the test. As the treatment variable is the study technique used by the students, it is not possible to isolate how this one factor influenced the outcome. This would mean that stating that not using the study method resulted in lower marks cannot be made, because there are other variables that may have influenced the marks.

iii. The researchers only used a maths exam to make the statement, however, some students may find maths more difficult than others. This may mean that they get a lower grade than those who find maths easier. By making the students take multiple tests, over a range of subjects, the researchers would be able to see if the study techniques did help improve the student's grades.

2.

a. Control Group:

Keep the diet the same.

Treatment Group:

Adopted a vegan diet.

b. *i.* This is an experiment.

ii. It is an experiment because the researchers divided the participants into two groups, and one group continued with their normal lifestyle (control group), while the others implemented a different lifestyle (vegan diet, treatment group).

iii. The claim that is made by the researchers, is a causal claim: A vegan lifestyle will result in lower values of health measuring parameters. As the researchers have controlled the treatment levels, a causal claim can be supported.

c. *i.* People in different towns/cities have different ideas about veganism, as well as access to ingredients/products that are conducive with a vegan lifestyle. Christchurch is a fairly large population in New Zealand, so views towards change may be more open and access to a range of different products is more likely. Extending the results to smaller population centres may not be accurate because it may not reflect the ideas/changes that could be made due to changing lifestyle.

ii. People between the ages of 18 and 34 tend to be more receptive to change, and currently are the key drivers of health and environmental change. This age group may have a different health response to changes in diet compared to older age groups so extending the results to ages outside of this range may not be appropriate.

iii. Not every person will respond in the same way as the treatment group. By extending the results too far, it will not accurately reflect what the potential changes may be. The study was only conducted on a small group of people, so in order to extend the results there should be multiple treatment groups with a range of different physiologies, to see how changing a diet can affect the measured health responses.

d. *i.* While the treatment group was asked to take on a vegan lifestyle, the participants may not have strictly followed the diet/lifestyle. If they did not follow the lifestyle then changes in the health factors that were measured cannot be fully accounted for by the lifestyle change. Depending on how closely the participants followed the diet, the change in health factors could be more significant than that observed, but whether people want to continue will be lower because they did not follow the lifestyle during the experiment.

ii. Just because people followed a vegan lifestyle does not mean that they eat healthily during that time. If what a participant ate during the trial was not healthy, then their results at the end of the trial may not be any different compared to when they started. Likewise, if a person ate really healthy during the trial, then significant differences between the start and end may be observed. The results may not truly reflect a change from veganism.

iii. People's underlying health conditions will influence how the measurements taken in the trial will change over the trial. Some people may show significant changes due to changes in lifestyle, while others may show very little, because they respond differently.

iv. Some people who were in the treatment group may already eat a vegetarian diet, so changing to a vegan diet may not show as much of a change compared to a person that changed from an omnivorous diet. This may be reflected in the results, and the changes that may be observed may not truly reflect the lifestyle change.

Section Three
Practice Exam

Question One

a. MOE = $\frac{1}{\sqrt{n}}$

$= \frac{1}{\sqrt{10000}}$

= 0.01

= 1%

MOEs are needed to take into account the natural variation that always occurs from sample to sample.

b. Any of the following percentages could be identified:

- 5% (strongly disagree);
- 10% (disagree) or;
- 20% (neither agree nor disagree)

This survey percentage is outside of the 30% to 70% range that the rule of thumb $\frac{1}{\sqrt{n}}$ can be applied to. The rule of thumb MOE will overestimate the size of the MOE.

c. MOE = $\pm 1.5 \times \frac{(MOE_{2012} + MOE_{2019})}{2}$

$= \pm 1.5 \times \frac{(1 + 1)}{2}$

$= \pm 1.5 \times 1$

= 1.5%

Percentage who disagree in 2019 = 4%

Percentage who disagree in 2012 = 7%

Difference in percentages = 7% – 4%

= 3%

Confidence interval = point estimate ± MOE

= 3% ± 1%

= [2%, 4%]

I am pretty sure that the percentage of people in 2019 who disagree that climate change is a real phenomenon is between 2% and 4% lower than the percentage of people in 2012 that disagree.

Yes, the following claim can be made because it is supported by the data that was collected in the surveys.

d. Percentage of people in 2000 that strongly agree = 3%
Percentage of people in 2019 that strongly agree = 35%

3 × 10 = 30% which is slightly smaller than 35%.

Yes, there is statistical evidence that the researchers claim is true. This is because 3% of people in 2000 strongly agree that climate change is real, while in 2019 35% of people strongly agree.

Question Two

a. The control group is sections of river that did not have anything planted. The treatment group is sections of river that were intensively planted.

b. The sections of streams would have been randomly allocated to each of the two groups. Each of the stream sections may have been given a number, then those numbers would have randomly assigned to either the treatment or the control group.

It is important because it will attempt to create two unbiased/fair/balanced groups. This will reduce the bias in the groups to allow for a fair comparison between the treatment and the control.

c. Any of the following could be talked about:

- Only North Island farms were used in the experiment, but the results were extended to all farms. If the planting was to occur in the South Island, the results may not be the same, as the plants may take up pollutants in a different manner.
- Only dairy farms were used in the experiment, so the plants used help reduce the pollutants associated with dairy farming but may not work as well for all farms. This would mean the results for other farms may not follow that of the results of the study.

d. Any two of the following could be talked about:

- The land used upstream may change while the study is taking place. This could be confounding because if a higher level of pollutants are going into the stream further up then the pollutant levels where the measurements were initially taken are going to vary with or without intensive planting of natives. Therefore, any results that are identified could not be solely put down to intensive planting.
- The land use surrounding the section of stream. Like the previous point, if land use around the section of stream changed then the level of pollutants is going to change with or without intensive planning.
- Time of year. This could be confounding because throughout the year the level of pollutants can vary throughout the year, and plants may be able to take up more pollutants at different times of the year, either increasing or decreasing the pollutant level. This means that planting cannot be solely linked to changes in the pollutant levels.
- Changes in the amount of water going through the streams. If water was moving more quickly through the streams/rivers, then the level of pollutants would alter on top of the changes due to planting. Likewise, if the water levels drop in the streams/rivers then the number of pollutants may increase because it is not being moved on.

Question Three

a Explanatory variable:

Increase in the infringement given.

Response variable:

Number of people caught overfishing.

b. Any of the following could be talked about:

- The two surveys were taken in two different locations. This could cause bias because the Auckland survey may not be representative of the entirety of New Zealand. By comparing these two locations, if there is a significant difference between the Auckland results and the rest of New Zealand, then the results will display a bias towards the Auckland data.
- Different numbers of stops were used in each of the surveys. The smaller the sample that is taken the less representative of the population the sample is going to be. By changing the number of stops between surveys the samples may not be representative of the population.
- Some people may refuse to stop. We are not told if cars were able to refuse being stopped or if any cars did not stop, as well as the time of day that these stops were set up. If many cars refused to stop, or weren't stopped due to the time then the sample that is taken may not be representative of the population.

c. One of the following explanations:

- The heading implies a causal claim, the increase in infringement penalties is reducing the amount of overfishing. However, this is an observational study. With an observational study there is no control of the treatment levels so a connection between the change and the response cannot be fully determined because there are a range of other factors that can influence the results.
- The heading implies the change is for the entirety of the country, however, the repeated survey was only conducted in Auckland. Therefore, the statement about increasing infringement penalties reducing overfishing should only be made for Auckland and not the entirety of the country.

