Level 3 – AS91584 – 4 Credits – External

Probability Concepts

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Achievement	Achievement with Merit	Achievement with Excellence
Evaluate statistically based reports.	Evaluate statistically based reports, with justification.	Evaluate statistically based reports, with statistical insight.

Contents

Part 1: Terminology

In this topic there are a number of words you need to be familiar with the meaning of. In this section we will look at a few of them that will help with the understanding throughout the rest of the topic.

Populations and Samples

Population is a collection of all objects or individuals of interest that have properties that someone wishes to record. For example: "all people aged 18 and over who were living in New Zealand on 23 August 2018" or "all possible 15-watt LED light bulbs that could be produced by a manufacturing plant." Usually when we are looking at data we look at a **sample**. This is because it is not normally feasible to do a **census** (which looks at everything in a **population**). The sample is a group of objects, individuals or values that are chosen from the population. The idea is that this group will be representative of the population. Usually, the bigger the sample, the more reliable our estimates of the population (**point estimates**) are likely to be. When taking a **sample** it is important we avoid **bias**, which is anything that might cause favouritism to be shown towards one group or set of results. Sampling isn't the only time **bias** can occur, but is definitely one of them.

Variables

A **variable** is a measurement or a characteristic, for example weight or gender. **Explanatory** variables are variables that may provide information about another variable. **Response** variables are the variables that might be affected by the **explanatory** variable. **Control** variables are variables that are part of a controlled experiment that help ensure the results are valid.

Data Types

Qualitative (or categorical) data is data in which the values can be organised into distinct groups. These distinct groups (or categories) must be chosen so that they do not overlap and that every value belongs to one and only one group, and there should be no doubt as to which one. For example, eye colour.
Quantitative data is data in which the values result from counting or measuring. Measurement data is quantitative, as is whole-number data. There are two types on quantitative data, **discrete** and **continuous**. **Discrete** data is data where the data can only take on specific values, often whole numbers, for example, the number of people in a room. **Continuous** data is data which can be any value inside the range, for example the length of your foot.

Point Estimates

Because we are looking at a **sample** rather than the **population**, we need to make an **estimate** of what we think the **population** will be like. We can never be totally sure about this **estimate**, but it is our best guess based on our **sample**. An 'average' is a good example of a **point estimate** or **population parameter**, as based on our sample, we are **estimating** what we think the 'average' of the population will be. Usually, when referring to 'average', people are referring to the **mean**, which is calculated by adding all the values together and dividing by the number of points. 'Average' however can also refer to the **median**, which is the middle number when all the numbers are put in order, or the **mode**, which is the value that is most likely to occur.

Part 1.1: Terminology Exercise

Match the words with the definitions

Bias	A collection of all objects or individuals of interest that have properties that someone wishes to record.
Census	A group of objects, individuals, or values selected from a population. The intention is for this sample to provide estimates of population parameters.
Continuous Data	A measurement, or characteristic (e.g weight or gender)
Control Variable	A statistic calculated from a sample that is used as an approximate value for a population parameter.
Discrete Data	A study that attempts to measure every unit in a population.
Explanatory Variable	A value in a distribution of a numerical variable that occurs more frequently than other values.
Mean	A variable that is controlled in an experiment to help ensure the results are valid
Median	Calculated by adding the values and then dividing this total by the number of values.
Mode	Data in which the values can be organised into distinct groups
Point Estimate	Data in which the values result from counting or measuring. Measurement data are quantitative, as are whole-number data
Population	Data that can only take on distinct values, often whole numbers
Qualitative Data	Data that can that can take any value in an (appropriately-sized) interval of numbers.
Quantitative Data	Something that causes favouritism
Response Variable	The central or middle value of an ordered dataset
Sample	The number of objects, individuals, or values in a sample.
Sample Size	The variable which may be affected by the other variable, (the explanatory variable)
Variable	The variable which may provide information about the other variable, (the response variable)

Part 1.1 Answers

Bias	Something that causes favouritism
Census	A study that attempts to measure every unit in a population.
Continuous Data	Data that can that can take any value in an (appropriately-sized) interval of numbers.
Control Variable	A variable that is controlled in an experiment to help ensure the results are valid
Discrete Data	Data that can only take on distinct values, often whole numbers
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Median	The central or middle value of an ordered dataset
Mode	A value in a distribution of a numerical variable that occurs more frequently than other values.
Point Estimate	A statistic calculated from a sample that is used as an approximate value for a population parameter.
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Qualitative Data	Data in which the values can be organised into distinct groups
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Sample Size	The number of objects, individuals, or values in a sample.
Variable	A measurement, or characteristic (e.g weight or gender)

Part 2: Study Designs

There are 4 main study designs that we look at as part of this standard. They are **polls**, **surveys**, **experiments**, and **observational studies**. The conclusions we can make and how we talk about each study are slightly different, so it is important to be able to identify the different study designs.

Polls and **Surveys** are very similar in that they ask a sample of people questions to determine either the **opinion distribution** (for a **poll**) or a **population parameter** (for a **survey**). A **population parameter** is a number representing a property of a population, for example the mean, median, a proportion etc. An **opinion distribution** is the proportion of the target population that has each opinion, for example the proportion of people planning on voting for each political party. **Polls** typically have very few questions and are multi-choice only. Surveys have many questions, may have branches and skips, may have a "tick multiple boxes" questions and may have open-ended, write a comment questions.

An **experiment**, while the term is more general, in this standard refers to a study in which a researcher attempts to understand the effect that a variable (an explanatory variable) may have on some phenomenon (the response) by controlling the conditions of the study. In an **experiment** the researcher controls the conditions by allocating individuals to groups (ideally **randomly**) and giving each group different conditions (different values of the explanatory variable). The different condition given is called the **treatment**. By **randomly** putting people in groups, this attempts to make the characteristics of each group very similar to each other so that if each group was given the same **treatment** the groups should respond in a similar way, on average. **Experiments** usually have a control group, a group that receives no treatment or receives an existing or established treatment. This allows any differences in the response, on average, between the control group and the other group(s) to be visible. When the groups are similar in all ways apart from the treatment received, then any observed differences in the response (if large enough) among the groups, on average, is said to be **caused** by the **treatment**. **Experiments** are the only study where a **causal claim** can be made.

Observational Studies are studies which a researcher attempts to understand the effect a variable (an explanatory variable) may have on something (the response variable), but the researcher cannot control conditions in the study. The researcher can observe what is going on, but cannot control what is happening (cannot control the explanatory variable). Because the groups in the study are made by what just what happened to happen, and not by **randomisation**, there may be other variables as well that are influencing which group people end up in. Therefore **causal claims** cannot be made, as the differences could just be due to the makeup of the groups.

Part 2.1: Matching Terminology

Match the words with the definitions

Causal Claim	A systematic collection of data about opinions on issues taken by questioning a sample of people taken from a population in order to determine the opinion distribution of the population.
Control group	A systematic collection of data taken by questioning a sample of people taken from a population in order to estimate a population parameter.
Experiment	A study in which a researcher attempts to understand the effect that a variable (an explanatory variable) may have on some phenomenon (the response) by controlling the conditions of the study.
Observational Study	A study in which a researcher attempts to understand the effect that a variable (an explanatory variable) may have on some phenomenon (the response) without having any control over the variables.
Opinion Distribution	The proportion of the target population that has each opinion.
Poll	A number representing a property of a population, for example the mean, median, a proportion etc.
Population Parameter	An applied change or influence that should result in a change in the *response variable*.
Random Allocation	Process of randomly assigning *experimental units* to groups using, for example a deck of cards or flipping a coin.
Survey	The group who does not receive the treatment.
Treatment	A claim that the treatment causes the effect. Only valid if the study was an experiment.

Part 2.1: Answers

Causal Claim	A claim that the treatment causes the effect. Only valid if the study was an experiment.
Control group	The group who does not receive the treatment.
Experiment	A study in which a researcher attempts to understand the effect that a variable (an explanatory variable) may have on some phenomenon (the response) by controlling the conditions of the study.
Observational Study	A study in which a researcher attempts to understand the effect that a variable (an explanatory variable) may have on some phenomenon (the response) without having any control over the variables.
Opinion Distribution	The proportion of the target population that has each opinion.
Poll	A systematic collection of data about opinions on issues taken by questioning a sample of people taken from a population in order to determine the opinion distribution of the population.
Population Parameter	A number representing a property of a population, for example the mean, median, a proportion etc.
Random Allocation	Process of randomly assigning *experimental units* to groups using, for example a deck of cards or flipping a coin.
Survey	A systematic collection of data taken by questioning a sample of people taken from a population in order to estimate a population parameter.
Treatment	An applied change or influence that should result in a change in the *response variable*.

Part 2.2: Identifying Study Types

Identify each of the studies below as either a **poll**, **survey**, **experiment**, or **observational study**.

1. A study by researchers at Harvard School of Public Health, investigated the relationship between low childhood IQ and adult mental health disorders. The study participants were a group of children born in 1972 and 1973 in Dunedin. Their IQs were assessed at ages 7, 9 and 11 and mental health disorders were assessed at ages 18 through to 32 in interviews by health professionals who had no knowledge of the individuals' IQ or mental health history.
2. In the 1980s the Physicians' Health Study investigated whether a low dose of aspirin had an effect on the risk of a first heart attack for males. The study participants, about 22,000 healthy male physicians from the United States, were randomly allocated to receive aspirin or a placebo. About 11,000 were allocated to each group.
3. In 2017 the AA asked its members how many of them would be willing to support the speed limit lowering from 100km/h on open roads to 90 km/h.
4. The Ministry of Business, Innovation and Employment conducts a study of international visitors to New Zealand where they are asked how much money they have spent while visiting New Zealand.
5. Global market research group Ipsos asked 501 New Zealanders in July 2018 if they, or someone they knew, had been affected by cyber bullying.
6. Stockholm School of Economics studied the behaviours and life satisfaction of people who had won and not won the Swedish lottery.
7. The New Zealand Herald asked people what their salary using an online popup.
8. 16 males and 16 females who attended the Bing Nursery School of Stanford University were randomly allocated into two groups, half of the children were given two marshmallows and told they could eat one now or have two in 10 minutes time; the other half were only given one marshmallow and told they could have it now, or be given two in 10 minutes time. If they chose to eat the one marshmallow, or wait to eat two was recorded.

Part 2.2 Answers

1. This is an **observational study** because the researchers had no control over the explanatory variable, childhood IQ. The researchers could only record the assessed childhood IQ. The response was whether or not the individual had suffered from a mental disorder during adulthood.
2. This is an **experiment** because the researchers allocated individuals to two groups and decided that one **group** would receive a low dose of aspirin and the other group would receive a placebo. The treatments are aspirin and placebo. The response was whether or not the individual had a heart attack during the study period of about five years.
3. This is a **poll** as the final result would give a percentage of people in each group.
4. This is a **survey** as the final result would allow population parameters such as means, medians or quartiles to be estimated.
5. Poll
6. Observational Study
7. Survey
8. Experiment

Part 3: Non Sampling Errors

There are two possible reasons that an estimate from a sample and the true value of the population parameter (eg: proportion, mean, median) might be different. The first reason is because we have taken a sample, which isn't going to be exactly the same as the population. This is called **sampling error**, and we will look at this later when we look at margins of error.

The second reason is because of **non-sampling errors**. Non-sampling errors have the potential to cause bias in surveys or samples as they make the sample non-representative. There are many different types of non-sampling errors, and the names used for each of them can vary, but the names below are fairly well recognized as being acceptable.

Non-sampling errors can be much larger than sampling errors and we try and reduce them as much as possible when we design the poll or survey. It is often impossible to correct for them after the survey is completed and virtually impossible to determine how badly they will affect the result. Good surveys will try to minimize non-sampling errors in the design of the survey, often this is done by doing a pilot survey of a small group first.

Non-Sampling Error	Description	Example
Selection Bias	The sampling process is such that a specific group is excluded or under-represented in the sample, deliberately or inadvertently. If the excluded or under-represented group is different, with respect to survey issues, then bias will occur.	If the target population is adults in New Zealand, and the survey is done by phoning people, there are going to be people missed as not all adults in New Zealand have a phone.
Self-Selection Bias	The sampling process allows individuals to select themselves. Individuals with strong opinions about the survey issues or those with substantial knowledge will tend to be over-represented, creating bias.	With polls on the internet normally only people who are interested in a particular topic will respond. This usually results in only people with strong opinions one way or another responding, and not giving a representative sample.
Behavioural Considerations	Answers given by respondents do not always reflect their true beliefs because they may feel under social pressure not to give an unpopular or socially undesirable answer.	For example in a survey about using cell phones when driving, people are less likely to be honest, as they know it is illegal to use a cell phone when driving.
Interviewer Effects	Answers given by respondents may be influenced by the desire to impress an interviewer. The sex, race, religion and manner of the interviewer can all influence how people respond to a particular question.	If the interviewer was a Catholic priest or a leader of a mosque, the way people may respond might be quite different if the interviewer didn't have any obvious religious affiliation.
Transfer of Findings	Taking the data from one population and transferring the results to another can lead to incorrect conclusions being made.	A survey done in Wellington may not be able to be applied to people all around New Zealand.

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Non-Sampling Error	Description	Example
Non-Response Bias	If people who refuse to answer are different, with respect to survey issues, from those who respond then bias will occur. This can also happen with people who are never contacted and people who have yet to make up their mind. Also, if the response rate (the proportion of the sample that takes part in a survey) is low, bias can occur because respondents may tend consistently to have views that are more extreme than those of the population in general.	In an survey about working hours, those that do not respond are likely to be those who work long hours as they don't have time to respond.
Question Effects	The wording of questions can influence survey results. Even small changes can make big differences in results.	On 18 August 1980 New York Times/CBS News ran a Poll and asked two questions as part of a longer survey: • "Do you think there should be an amendment to the constitution prohibiting abortions?" Yes 29% No 62% • "Do you think there should be an amendment to the constitution protecting the life of the unborn child?" Yes 50% No 39% We can see while the questions are asking opinions on the same topic, the results are very different.
Survey Format Effects	The order in which questions are asked, how the survey is conducted (in person, online, via the phone), and the number and type of options offered can influence survey results.	If this question was asked: "To what extent do you think teenagers are affected by peer pressure when drinking alcohol ?" Followed by: "Name the top 5 peer pressures you think teenagers face today." It is likely to result in skewed answers to the second question. (see video here for a great example) Long surveys are also likely to get people rushing through and not thinking carefully about their answers.

For Achieved in this standard you need to be able to identify the non-sampling errors. For Merit and Excellence you are expected to identify and describe the non-sampling errors in context.

Part 3.1: Looking at Reports for Non-Sampling Errors

Look at each of the reports below and identify at least two non-sampling errors from each article:

1. New survey reveals New Zealand's youth among worst in cyberbullying rates
   https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12113026
   Extra Info:
   These are the findings of a Global Advisor Cyberbullying Study. In total 20,793 interviews were conducted between March 23 – April 6, 2018 among adults aged 18-64 in the US and Canada, and adults aged 16-64 in all other countries.
   The survey was conducted in 28 countries around the world via the Ipsos Online Panel system.

2. Teens Are Over Face-to-Face Communication, Study Says
   http://time.com/5390435/teen-social-media-usage/
   Extra Info:
   The survey was conducted online, and participants had to confirm their sign up via email

3. Kiwis generally positive about relationship with China
   https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12114256
   Extra Info:
   This research used a quantitative online survey of 1,001 New Zealanders aged 18 years and over, conducted between the 2nd and 9th of February 2018. To ensure the survey sample reflected the New Zealand population, quotas were set for gender, age and regions. After fieldwork, the data was weighted in terms of age and education level to match the population profile using information from the 2013 Census.

4. Getting over the barriers to financial advice
   https://www.cffc.org.nz/latest-news/financial-literacy/getting-over-the-barriers-to-financial-advice/

Alternative links (archive of each article)

1. https://students.mathsnz.com/3.12/pdfs/Article1.pdf
2. https://students.mathsnz.com/3.12/pdfs/Article2.pdf
3. https://students.mathsnz.com/3.12/pdfs/Article3.pdf
4. https://students.mathsnz.com/3.12/pdfs/Article4.pdf

Part 3.1 Answers

Note: the answers below are just some examples.

1. **Selection Bias / Survey Format Effects** – survey was conducted online. People who have access to the internet are much more likely to face cyber bullying than those that do not.
   Behavioural Considerations – parents were asked about their children. Many parents feel like they should be protecting their children, so hence would not say they had experienced cyber bullying even if they had.

2. **Transfer of Findings** – This is only relevant to teens in the US, not New Zealand. Teens in New Zealand may be similar, but may be very different.
   Selection Bias – people had to complete the survey online, and people who have access to the internet are likely to have different opinions than those that do not.

3. **Interviewer Effects** – because the survey was conducted by the New Zealand China Council, people would be more likely to give favourable responses about China.
   Survey Format Effects – because the survey was all about China, it would lead people into answering Mandarin as the most useful language. If the survey was about another country the results could be very different.

4. **Transfer of Findings** – Survey was targeted at people who have registered with the Sorted.org.nz database and so have demonstrated an interest in improving their financial circumstance. This is not representative of New Zealand as a whole
   Behavioural Considerations / Interviewer Effects – because the survey was being carried out by the Commission for Financial Capability, and people know they should be good with money, they are more likely to give favourable answers.

Part 4: Causal Claims

Causal claims can only be made when an experiment has been conducted. Often media articles refer to experiments when they don't meet the precise definition of an experiment in statistics.

It is important to note that it is not always possible to conduct a true experiment for ethical reasons, and designing a perfect experiment is very difficult, and often time-consuming and expensive. Experiments must:

1. Have participants **randomly allocated** to the treatments
2. The **variable of interest must be measured**
3. The **results must be compared** between the treatment groups, or between the treatment and control groups.

When looking at an experiment we want to make sure that these things have all happened before a causal claim can be made. It is also worth thinking about the **ethical** considerations if it was an experiment.

For any article that is referring to an experiment it is important to ask the following questions. We will use an example of a new drug being tested.

1. **Who was the experiment conducted on?**
   It is important to note who the experiment was conducted on. Often times the experiments are not conducted on people, but rather on mice or cells in a lab. It is also worth noting if the experiment was conducted only on males or only on females, as males and females can react differently to drugs. It is important the results are only applied to the group on which the experiment is conducted on.
2. **What is the explanatory variable?**
   The explanatory variable is the variable that attempts to explain or cause (at least in part) the changes observed in the response variable. In our example the explanatory variable would be the amount of the new drug received. All other variables must remain unchanged.
3. **What is the treatment?**
   The treatment is one of, or a combination of, explanatory variables assigned by the researcher. In our example there could be several treatment groups, one that gets none of the new drug, and the other groups receive various levels of the new drug.
4. **What is the response variable?**
   This is what we are measuring or wanting to see change. In our example this might be a measure relating to how much the symptoms for the disease the drug is trying to combat have reduced.
5. **How were the participants put into groups?**
   It is really important that people are put into the groups randomly. This is because this helps balance out any characteristics that we cannot control. It helps makes the groups similar apart from the treatment they receive, which allows researchers to say the treatment caused the observed result.
6. **Was there a control group?**
   Often in experiments there is a control group. This group creates a baseline of what would happen if there was no treatment. In our example this would be the group who did not receive any of the new drug.
7. **Was a placebo used?**
   A control group is sometimes given a placebo. This is often a sugar pill with no drug inside it. This is done because of the "placebo effect". This is when people who receive no drug still experience positive changes. For more information about the placebo effect watch this video.
8. **Was blinding used?**
   Often times researchers who are creating a new drug really want their drug to work, so are biased towards seeing positive results. To avoid such biases, good researchers will use a blinding procedure. There are two types of blinding – single blinding and double blinding. With single

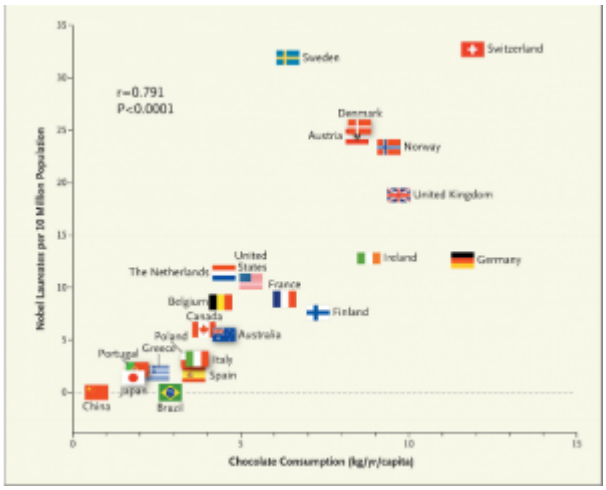
blinding either the participant knows **OR** the researcher knows who has received which treatment. With double blinding neither the researcher nor the participant knows who has received which treatment. When this happens an independent party will allocate the participants to the two groups. Only after all measurements have been taken will they reveal which treatment group participants belonged to. Double blinded experiments are always better than single blinded experiments, however sometimes they are not practical.

9. **Are there any ethical considerations that need to be made?**
   In many situations it is not ethical to conduct an experiment. For example, you can't get some pregnant mothers to drink alcohol and some not to, to see how it affects the development of their unborn child. In this case only an observational study can be done where you record which mothers did and didn't drink and the effect on their unborn child's development. Because there may be other variables connecting those that choose to drink and those that do not a causal claim cannot be made.

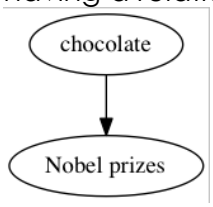
If you think about these 9 points when looking at a causal claim you should cover off everything that needs to be covered for the answer.

It is important to note, just because there is a correlation (two variables are related to each other) it doesn't mean that one causes the other.

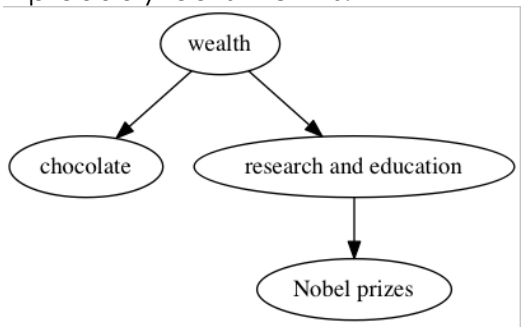
For example, this graph on the right shows the correlation between chocolate consumption and the number of Nobel Laureates.



There is clearly a correlation, but there is probably a **lurking variable** involved. This means rather than having a relationship that looks like this:



It probably looks like this:



If you want to read more on this there is an excellent article here:
https://www.statschat.org.nz/2017/03/09/causation-correlation-and-gaps/

But this is why we need to be careful when we look at causal claims.

Part 4.1: Critiquing Causal Claims

For each of the articles below, identify the causal claim, and work through the 9 questions covered in the previous section:

1. What is the explanatory variable?
2. What is the treatment?
3. What is the response variable?
4. Who was the experiment conducted on?
5. How were the participants put into groups?
6. Was there a control group?
7. Was a placebo used?
8. Was blinding used?
9. Are there any ethical considerations that need to be made?

In some cases you won't be able to answer all the questions. If an article doesn't answer these questions, does it affect your ability to judge the conclusions it draws?

Articles:

1. A promising drug to slow the progression of Alzheimer's was just unveiled
   https://www.vox.com/2018/7/25/17607376/dementia-alzheimers-drug-trial-biogen-eisai
2. Blue light from phone screens accelerates blindness, study finds
   https://www.theguardian.com/society/2018/aug/09/blue-light-from-phone-screens-accelerates-blindness-study-finds
3. Phones ring alarm bells
   https://www.odt.co.nz/lifestyle/magazine/phones-ring-alarm-bells
4. Late-night phone use is linked to poor sleep and moodiness
   https://www.dailymail.co.uk/news/article-5733765/Turn-phone-10pm-avoid-risk-mental-health-problems.html

Alternative links (archive of each article)

1. https://students.mathsnz.com/3.12/pdfs/Article5.pdf
2. https://students.mathsnz.com/3.12/pdfs/Article6.pdf
3. https://students.mathsnz.com/3.12/pdfs/Article7.pdf
4. https://students.mathsnz.com/3.12/pdfs/Article8.pdf

Part 4.1 Answers

1. **A promising drug to slow the progression of Alzheimer's was just unveiled**
   Causal claim: new drug slows progression of Alzheimer's by 30%
   1. Who was the experiment conducted on?
      856 patients with early Alzheimer's
   2. What is the explanatory variable?
      Amount of drug given
   3. What is the treatment?
      If people were given the drug or not
   4. What is the response variable?
      Amount of reduction in Alzheimer's symptoms
   5. How were the participants put into groups?
      Randomly
   6. Was there a control group?
      Yes
   7. Was a placebo used?
      Yes
   8. Was blinding used?
      Yes – double blinding
   9. Are there any ethical considerations that need to be made?
      Is giving someone who has Alzheimer's a drug that doesn't do anything ethical? In order to test if the drug is effective it must be done.

2. **Blue light from phone screens accelerates blindness, study finds**
   Causal claim: looking at your smart phone accelerates blindness
   1. Who was the experiment conducted on?
      Not a who in this case, but a what. It was conducted on the cells from the eye in lab conditions. There is more information on this here:
      https://www.statschat.org.nz/2018/08/13/smartphone-blues/
   2. What is the explanatory variable?
      Level of exposure to blue light
   3. What is the treatment?
      Exposure to blue light or not
   4. What is the response variable?
      The number of cells that died
   5. How were the participants put into groups?
      Doesn't say
   6. Was there a control group?
      Doesn't say
   7. Was a placebo used?
      Doesn't say
   8. Was blinding used?
      Doesn't say
   9. Are there any ethical considerations that need to be made?
      Testing treatments on humans that is likely to make them go blind is completely unethical. This is why the experiment was conducted on cells.

3. Phones ring alarm bells

Causal claim: radiation from mobile phones causes cancer

1. Who was the experiment conducted on?
   Rats and mice
2. What is the explanatory variable?
   Amount of radiation the rats and mice were exposed to
3. What is the treatment?
   Rats and mice were exposed to a "lifetimes" worth of radiation
4. What is the response variable?
   If cancer is found in the rats or mice
5. How were the participants put into groups?
   Doesn't say
6. Was there a control group?
   Doesn't say
7. Was a placebo used?
   Doesn't say
8. Was blinding used?
   Doesn't say
9. Are there any ethical considerations that need to be made?
   Deliberately causing cancer in humans would be unethical, therefore the trial can't be conducted on humans, so rats and mice are the next best thing

More Notes:

A response to this article was published in the Guardian. Read it here.

4. Late-night phone use is linked to poor sleep and moodiness

Causal claim: Using a phone at night causes depression, bipolar disorder and neuroticism.

1. Who was the experiment conducted on?
   91,000 people 37 to 73 (but it wasn't an experiment)
2. What is the explanatory variable?
   Should have been if you use your phone at night, however it was actually how active you were in the night based on your Fitbit activity.
3. What is the treatment?
   There wasn't one…
4. What is the response variable?
   The proportion that were suffering from bipolar disorder or depression
5. How were the participants put into groups?
   They weren't…
6. Was there a control group?
   Nope.
7. Was a placebo used?
   Nope.
8. Was blinding used?
   Nope
9. Are there any ethical considerations that need to be made?
   Running an experiment where you could cause people to suffer from depression or bipolar disorder is not really okay. This is why it was ***an observational study***.

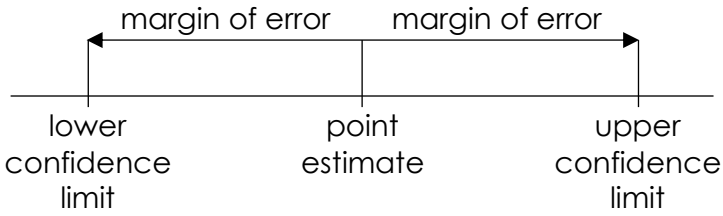
Read more on this here: https://www.statschat.org.nz/2018/05/25/tweet-dreams/

Part 5: Margins of Error

One of the things we need to be able to do is test how reliable a claim is that is made in the media. There are three types of claim that we need to be familiar with, and identifying which type of claim we are looking at is really important.

The reason we have a margin of error is because we have taken a sample. A sample is never going to perfectly represent the population, so we need to allow for this in our claims. The bigger the sample size is, the more reliable the estimates we get from it are likely to be. For example if we ask a group of 10 people we are likely to be a lot less certain than if we ask a group of 100, or 1000.

It can be helpful to visualise the margin of error like this:



The **point estimate** is what we get from our sample, and the **margin of error** is how much we expect the **point estimate** to be out by. This means we can be reasonably confident the value for the population is between the **lower confidence** limit and the **upper confidence** limit.

There are three types of claims that we look at:

- **No** comparison (1 group). This is where we get given a statement like "55% of people think that …."
- Comparison within **1 group**. This is where we are comparing two answers within one question asked to one group. For example "15% more people think … than …"
- Comparison between **two independent groups**. This is where we have asked two separate groups a question. For example "15% more boys think … than girls."

For each of these claims there is a different formula we use, and a different interpretation.

There are two rule that always hold true though:

- **The bigger the sample, the smaller the margin of error**. This is really important to remember. The reverse is also true, **the smaller the sample, the larger the margin of error**.
- The rules only work if the percentage from the sample is **between 30% and 70%.** That is because the rules are based on 50%, and from around 30% to 70% they are still pretty close, outside of that range the margin of error is **smaller**. This is because the further away from 50% you get the smaller the margin of error.

Part 5.1: No Comparison

The first type of claim we look at is where we are given a claim with no comparison. This could be something like "the majority of …" or "55% of people…".

The "rule of thumb" formula for the no-comparison 95% margin of error is

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

where n is the sample size.

This formula only works when the percentage in the sample is between **30% and 70%.** Outside of this range the margin of error is **smaller**. You cannot use this formula if the percentage is outside this range.

If you want to play around with seeing where this formula comes from see the simulator used in the videos here: https://www.mathsnz.com/resources/files/3.12/moe

Let's look at an example for when there is no comparison: "Majority of French no longer see US as trusted ally, poll finds".
We are given some more information as well:

- The survey questioned 1,007 people
- 44 percent said the US was a "trusted ally"

Source: https://www.france24.com/en/20180912-more-half-french-people-think-usa-trump-no-longer-trusted-ally-ifop-survey
Alternative Link: https://students.mathsnz.com/3.12/pdfs/Article9.pdf
Note: we are ignoring the fact this was an online poll for the sake of this question.

Looking at this we can see 44% of people surveyed said the US was a "trusted ally", by inference then 56% of people do not. We need to see if the 56% from the sample is actually enough for us to conclude that there is a majority (more than 50%) back in the population.

There are four things we need to do now:

- **Find the margin of error:** $\frac{1}{\sqrt{1007}} = 0.0315\ (3\text{sf}) = 3.15\%$.
- **Construct the confidence interval:** 56% ± 3.15% = (52.9%, 59.1%)
- **Interpret what this means:** We can say, with 95% confidence, that the percentage of French who do not see the US as a trusted ally is somewhere between 52.9% and 59.1%.
  Note: *The phrase "we can say, with 95% confidence," doesn't have to be stated that way, but we do need some indication of uncertainty, as we can't be 100% confident about the values. We could also say something like "It is a fairly safe bet that… " or "I'm pretty sure…"*
- **Make a judgement:** The percentage of French who don't see the US as a trusted ally could only be as low as 52.9%, and so this confidence interval does support a claim of over 50% as implied by the "majority" statement in the article.

It is **really important** that you keep these last as two separate sentences, as that is something the markers have specifically said, as often when people combine them into one sentence they end up mixing up the two.

Part 5.1 Questions

Fill in the blanks below. With each question the blanks get slightly bigger.

1. **Claim**: "Majority of kiwi school students bring their own device to school"
   Percentage from Survey: 65% bring own device to school.
   Sample Size: 1000
   Margin of Error: $\frac{1}{\sqrt{n}} = \frac{1}{\sqrt{\quad}} =$ _____ (3sf) = _____%
   Construct the confidence interval: _____% ± _____% = (_____%, _____%)
   Interpret what this Means: We can say, with 95% confidence, that the percentage of kiwi school students who bring their own device to school is somewhere between ____% and ____%.
   Make a Judgement: The percentage of kiwi school students who bring their own device to school could be as low as _____%, and so this confidence interval _____ support a claim of over 50% as implied by the "majority" statement.

2. **Claim**: "Over half of people support the new law"
   Percentage from Survey: 54% support the new law
   Sample Size: 300
   Margin of Error: $\frac{1}{\sqrt{n}} = \frac{1}{\sqrt{\quad}} =$ _____ (3sf) = _____%
   Construct the confidence interval: _____% ± _____% = (_____%, _____%)
   Interpret what this Means: It is a fairly safe bet that the percentage of people who support the new law is somewhere between ____% and ____%.
   Make a Judgement: The percentage of _____
   could be as low as _____%, and so this confidence interval _____ support a claim of over 50% as implied by the "over half" statement.

3. **Claim**: "Less than half of New Zealanders have an iPhone"
   Percentage from Survey: 36% have an iPhone
   Sample Size: 100
   Margin of Error: $\frac{1}{\sqrt{n}} = \frac{1}{\sqrt{\quad}} =$ _____ = _____%
   Construct the confidence interval: _____% ± _____% = (_____%, _____%)
   Interpret what this Means: I am fairy sure that the percentage of _____
   _____ is somewhere between ____% and ____%.
   Make a Judgement: The percentage of _____
   could be as ____ as _____%, and so this confidence interval _____ support a claim of _____
   50% as implied by the "_____" statement.

4. **Claim**: "Majority of kiwi school students have a Facebook account"
   Percentage from Survey: 51% have a Facebook account
   Sample Size: 1000
   Margin of Error: $\frac{1}{\sqrt{n}} = \frac{1}{\sqrt{\quad}} =$ _____ = _____%
   Construct the confidence interval: _____% ± _____% = (_____%, _____%)
   Interpret what this Means: _____
   _____ is somewhere between ____% and ____%.
   Make a Judgement: The percentage of _____
   could be as ____ as _____%, and so this confidence interval _____ support a claim of _____
   50% as implied by the "_____" statement.

Part 5.1 Answers

1. **Margin of Error**: $\frac{1}{\sqrt{n}} = \frac{1}{\sqrt{1000}} = 0.0316$ (3sf) = 3.16%
   Construct the confidence interval: 65% ± 3.16% = (61.8%, 68.2%)
   Interpret what this Means: We can say, with 95% confidence, that the percentage of kiwi school students who bring their own device to school is somewhere between **61.8%** and **68.2%**
   Make a Judgement: The percentage of kiwi school students who bring their own device to school could be as low as **61.8%** and so this confidence interval **does** support a claim of over 50% as implied by the "majority" statement.

2. **Margin of Error**: $\frac{1}{\sqrt{n}} = \frac{1}{\sqrt{300}} = 0.0577$ (3sf) = 5.77%
   Construct the confidence interval: 54% ± 5.77% = (48.2%, 59.8%)
   Interpret what this Means: It is a fairly safe bet that the percentage of people who support the new law is somewhere between **48.2%** and **59.8%.**
   Make a Judgement: The percentage of that the percentage of **people who support the new law** could be as low as **48.2%** and so this confidence interval **does not** support a claim of over 50% as implied by the "over half" statement.

3. **Margin of Error**: $\frac{1}{\sqrt{n}} = \frac{1}{\sqrt{100}} = 0.1 = 10\%$
   Construct the confidence interval: 36% ± 10% = (26%, 46%)
   Interpret what this Means: I am fairly sure that the percentage of **New Zealanders that have an iPhone** is somewhere between **26%** and **46%.**
   Make a Judgement: The percentage of **New Zealanders who own an iPhone** could be as **high** as **46%** and so this confidence interval **does** support a claim of **under** 50% as implied by the "**less than half**" statement.

4. **Margin of Error**: $\frac{1}{\sqrt{n}} = \frac{1}{\sqrt{1000}} = 0.0316$ (3sf) = 3.16%
   Construct the confidence interval: 51% ± 3.16% = (48.8%, 54.2%)
   Interpret what this Means: We can say, with 95% confidence, that the percentage of **kiwi school students who have a Facebook account** is somewhere between **47.8%** and **54.2%**.
   Make a Judgement: The percentage of **kiwi school students who have a Facebook account** could be as **low** as **47.8%**, and so this confidence interval **doesn't** support a claim of **over** 50% as implied by the "**majority**" statement.

Part 5.2: Comparison Within One Group

The second type of claim we look at is where we are given a claim comparing numbers from within one group. This could be something like "more people have an iPhone than a Samsung phone."

The "rule of thumb" formula for the comparison within one group 95% margin of error is

$$2 \times \frac{1}{\sqrt{n}}$$

where n is the sample size. The reason this is multiplied by two is that each of the groups has the variation of $\frac{1}{\sqrt{n}}$ so to account for both groups we have to multiply it by two.

This formula only works where **both** the percentages you are comparing are between **30% and 70%**. Outside of this range the margin of error is **smaller**. You cannot use this formula if **either** of the percentages are outside this range.

If you want to play around with seeing where this formula comes from see the simulator used in the videos here: https://www.mathsnz.com/resources/files/3.12/moe
And change the type to "Comparison within one group".

Let's look at an example for when we are making a claim with a comparison inside a group: "more kiwi students have an iPhone than a Samsung phone."
We are given some more information as well:

- The survey questioned 770 people
- 40 percent said they owned an iPhone
- 33 percent said they owned a Samsung Phone

Looking at this we can see the number of people who said they owned an iPhone was 7 percentage points higher than said owned a Samsung. We need to see if the 7 percentage points difference from the sample is actually enough for us to conclude that there is a difference back in the population.

There are four things we need to do now.

- **Find the margin of error:** $2 \times \frac{1}{\sqrt{770}} = 0.0721\ (3\text{sf}) = 7.21\%$.
- **Construct the confidence interval:** 7% ± 7.21% (-0.21%, 14.21%)
- **Interpret what this means:** It is a fairly safe bet that the percentage of kiwi students who own an iPhone is somewhere between 0.21 percentage points lower and 14.21 percentage points higher than the percentage of kiwi students who own a Samsung Phone.
- **Make a judgement:** This confidence interval does not support the claim that a higher percentage of kiwi students own iPhones than own Samsung phones because zero is contained within the confidence interval.

It is **really important** that you keep these last as two separate sentences, as that is something the markers have specifically said, as often when people combine them into one sentence they end up mixing up the two.

There are three types of judgements we can make:

- The confidence interval **does not** support the claim that … because **zero is contained within the confidence interval**.
- The confidence interval **does** support the claim that … because **the confidence interval is entirely positive**.
- The confidence interval **does** support the claim that … because **the confidence interval is entirely negative**.

Part 5.2 Questions

Fill in the blanks below. With each question the blanks get slightly bigger.

1. **Claim**: "More businesses expect their activity to increase in the next 12 months than don't"
   Percentages from Survey: 41% expect their activity to increase, 32% expect to decrease
   Sample Size: 300
   Margin of Error: $2 \times \frac{1}{\sqrt{n}} = 2 \times \frac{1}{\sqrt{\quad}} =$ _____ (3sf) = _____%
   Construct the confidence interval: _____% ± _____% = (_____%, _____%)
   Interpret what this Means: We can say, with 95% confidence, the percentage of businesses which expect their activity to increase is somewhere between _____ percentage points _____ and _____ percentage points _____ than the percentage of businesses which expect their activity to decrease.
   Make a Judgement: This confidence interval _____ support the claim that a higher percentage of businesses expect their activity to increase than those that expect their activity to decrease because _____.

2. **Claim**: "More people support national than labour"
   Percentages from Survey: 37% plan to vote labour, 44% plan to vote national
   Sample Size: 1000
   Margin of Error: $2 \times \frac{1}{\sqrt{n}} = 2 \times \frac{1}{\sqrt{\quad}} =$ _____ (3sf) = _____%
   Construct the confidence interval: _____% ± _____% = (_____%, _____%)
   Interpret what this Means: We can be fairly sure the percentage of _____ _____ is somewhere between _____ percentage points _____ and _____ percentage points _____ than the percentage of _____.
   Make a Judgement: This confidence interval _____ support the claim that a higher percentage of _____ than _____ because _____.

3. **Claim**: "More people prefer Sean Connery as James Bond than Daniel Craig"
   Percentages from Survey: 35% like Daniel Craig, 43% like Sean Connery.
   Sample Size: 2,205
   Margin of Error: $2 \times \frac{1}{\sqrt{n}} = 2 \times \frac{1}{\sqrt{\quad}} =$ _____ (3sf) = _____%
   Construct the confidence interval: _____% ± _____% = (_____%, _____%)
   Interpret what this Means: It is a fairly safe bet the percentage of _____ _____ is somewhere between _____ percentage points _____ and _____ percentage points _____ than the percentage of _____.
   Make a Judgement: This confidence interval _____ support the claim that _____ _____ than _____ because _____.

4. **Claim**: "People prefer Prisoner of Azkaban to Deathly Hallows when looking at Harry Potter films"
   Percentages from Survey: 35% like Deathly Hallows, 39% Prisoner of Azkaban.
   Sample Size: 2,881
   Margin of Error: $2 \times \frac{1}{\sqrt{n}} = 2 \times \frac{1}{\sqrt{\quad}} =$ _____ (3sf) = _____%
   Construct the confidence interval: _____% ± _____% = (_____%, _____%)
   Interpret what this Means: _____ _____ _____.

Make a Judgement: _____
_____.

Part 5.2 Answers

1. **Margin of Error**: $2 \times \frac{1}{\sqrt{n}} = 2 \times \frac{1}{\sqrt{300}} = 0.115$ (3sf) = 11.5%
   Construct the confidence interval: 9% ± 11.5% = (-2.5%, 20.5%)
   Interpret what this Means: We can say, with 95% confidence, the percentage of businesses which expect their activity to increase is somewhere between **2.5** percentage points **lower** and **20.5** percentage points **higher** than the percentage of businesses which expect their activity to decrease.
   Make a Judgement: This confidence interval **does not** support the claim that a higher percentage of businesses expect their activity to increase than those that expect their activity to decrease because **zero is contained within the confidence interval**.

2. **Margin of Error**: $2 \times \frac{1}{\sqrt{n}} = 2 \times \frac{1}{\sqrt{1000}} = 0.0632$ (3sf) = 6.32%
   Construct the confidence interval: 7% ± 6.32% = (0.68%, 13.32%)
   Interpret what this Means: We can be fairly sure the percentage of **people who support national** is somewhere between **0.68** percentage points **higher** and **13.32** percentage points **higher** than the percentage of **people who support labour.**
   Make a Judgement: This confidence interval **does** support the claim that a higher percentage of **people support national** than **labour** because **the confidence interval is entirely positive**.

3. **Margin of Error**: $2 \times \frac{1}{\sqrt{n}} = 2 \times \frac{1}{\sqrt{2205}} = 0.0426$ (3sf) = 4.26%
   Construct the confidence interval: 8% ± 4.26% = (3.74%, 12.26%)
   Interpret what this Means: It is a fairly safe bet the percentage of **people who prefer Sean Connery as James Bond** is somewhere between **3.74** percentage points **higher** and **12.26** percentage points **higher** than the percentage of **people who prefer Daniel Craig as James Bond.**
   Make a Judgement: This confidence interval **does** support the claim that **more people prefer Sean Connery as James Bond** than **Daniel Craig** than because **the confidence interval is entirely positive**.

4. **Margin of Error**: $2 \times \frac{1}{\sqrt{n}} = 2 \times \frac{1}{\sqrt{2881}} = 0.0373$ (3sf) = 3.73%
   Construct the confidence interval: 4% ± 3.73% = (0.27%, 7.73%)
   Interpret what this Means: It is a fairly safe bet the percentage of people who prefer Prisoner of Azkaban is somewhere between 0.27 percentage points higher and 7.73 percentage points higher than the percentage of people who prefer the Deathly Hallows as their favourite Harry Potter Film.
   Make a Judgement: This confidence interval does support the claim that more people prefer The Prisoner of Azkaban than The Deathly Hallows when looking at Harry Potter films because the confidence interval is entirely positive.

Part 5.3: Comparison Between Two Independent Groups

The third type of claim we look at is where we are given a claim comparing numbers from two independent groups. This could be something like "a greater percentage of boys have an iPhone than girls."

The "rule of thumb" formula for the comparison between two independent groups 95% margin of error is

$$\text{MoE1} = \frac{1}{\sqrt{n_1}} \quad \text{MoE2} = \frac{1}{\sqrt{n_2}} \quad \text{Overall MoE} = \text{Average MoE} \times 1.5$$

Or

$$1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{n_1}} + \frac{1}{\sqrt{n_2}}\right)$$

where n_1 is the sample size of the first group and n_2 is the sample size of the second group.

This formula only works where **both** the percentages you are comparing are between **30% and 70%**. Outside of this range the margin of error is **smaller**. You cannot use this formula if **either** of the percentages are outside this range.

If you want to play around with seeing where this formula comes from see the simulator used in the videos here: https://www.mathsnz.com/resources/files/3.12/moe
And change the type to "Comparison between two independent groups".

Let's look at an example for when we are making a claim for a comparison between to independent groups: "a greater percentage of boys have an iPhone than girls."
We are given some more information as well:

- The survey questioned 540 males and 430 females
- 43 percent of males said they owned an iPhone
- 36 percent of females said they owned an iPhone

Looking at this we can see the number of males who said they owned an iPhone was 7 percentage points higher than females. We need to see if the 7 percentage points difference from the sample is actually enough for us to conclude that there is a difference back in the population.

There are four things we need to do now.

- **Find the margin of error:** $1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{540}} + \frac{1}{\sqrt{430}}\right) = 0.0684\ (3\text{sf}) = 6.84\%$.
- **Construct the confidence interval:** 7% ± 6.84% = (0.16%, 13.84%)
- **Interpret what this means:** It is a fairly safe bet that the percentage of male kiwi students who own an iPhone is somewhere between 0.16 percentage points higher and 13.84 percentage points higher than the percentage of female kiwi students who own an iPhone.
- **Make a judgement:** This confidence interval does support the claim that a higher percentage of male kiwi students own iPhones than female students because the confidence interval is entirely positive.

It is **really important** that you keep these last as two separate sentences, as that is something the markers have specifically said, as often when people combine them into one sentence they end up mixing up the two.

There three types of judgement we can make are the same as in the last section.

Part 5.3 Questions

Fill in the blanks below. With each question the blanks get slightly bigger.

1. **Claim**: "More people have a favourable opinion of Donald Trump than Robert Mueller"
   Percentages from Survey: 36% have a favourable opinion of Robert Mueller, 42% of Trump
   Sample Sizes: 1,003 were asked about Robert Mueller, 1,500 about Trump
   Margin of Error: $1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{n_1}} + \frac{1}{\sqrt{n_2}}\right) = 1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{\quad}} + \frac{1}{\sqrt{\quad}}\right) =$ _____ (3sf) = _____%
   Construct the confidence interval: _____% ± _____% = (_____%, _____%)
   Interpret what this Means: We can say, with 95% confidence, the percentage of people who have a favourable opinion about Donal Trump is somewhere between _____ percentage points _____ and _____ percentage points _____ than the percentage of people who have a favourable opinion of Robert Mueller.
   Make a Judgement: This confidence interval _____ support the claim that a higher percentage of people have a favourable opinion of Donald Trump than Robert Mueller because _____.

2. **Claim**: "More people in Wellington have problems with damp houses than Auckland"
   Percentages from Survey: 56% in Auckland, 58% in Wellington
   Sample Sizes: Wellington: 548, Auckland 2746
   Margin of Error: $1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{n_1}} + \frac{1}{\sqrt{n_2}}\right) = 1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{\quad}} + \frac{1}{\sqrt{\quad}}\right) =$ _____ (3sf) = _____%
   Construct the confidence interval: _____% ± _____% = (_____%, _____%)
   Interpret what this Means: We can be fairly sure the percentage of _____ _____ is somewhere between _____ percentage points _____ and _____ percentage points _____ than the percentage of _____.
   Make a Judgement: This confidence interval _____ support the claim that a higher percentage of _____ than _____ because _____.

3. **Claim**: "A greater percentage of people from Christchurch think their city has got better in the last year compared with Porirua"
   Percentages from Survey: 56% Christchurch, 37% Porirua.
   Sample Sizes: Christchurch 487, Porirua 576
   Margin of Error: $1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{n_1}} + \frac{1}{\sqrt{n_2}}\right) = 1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{\quad}} + \frac{1}{\sqrt{\quad}}\right) =$ _____ (3sf) = _____%
   Construct the confidence interval: _____% ± _____% = (_____%, _____%)
   Interpret what this Means: It is a fairly safe bet the percentage of _____ _____ is somewhere between _____ percentage points _____ and _____ percentage points _____ than the percentage of _____.
   Make a Judgement: This confidence interval _____ support the claim that _____ _____ than _____ because _____.

4. **Claim**: "More females travel to school by car than males"
   Percentages from Survey: Females 42%, Males 35%
   Sample Sizes: Female 340, Male 330
   Margin of Error: $1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{n_1}} + \frac{1}{\sqrt{n_2}}\right) = 1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{\quad}} + \frac{1}{\sqrt{\quad}}\right) =$ _____ (3sf) = _____%
   Construct the confidence interval: _____% ± _____% = (_____%, _____%)
   Interpret what this Means: _____ _____ _____.

Make a Judgement: _____
_____.

Part 5.3 Answers

1. **Margin of Error**: $1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{n_1}} + \frac{1}{\sqrt{n_2}}\right) = 1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{1003}} + \frac{1}{\sqrt{1500}}\right) = 0.0430$ (3sf) = 4.30%
   Construct the confidence interval: 6% ± 4.3% = (1.7%, 10.3%)
   Interpret what this Means: We can say, with 95% confidence, the of people who have a favourable opinion about Donal Trump is somewhere between **1.7** percentage points **higher** and **10.3** percentage points **higher** than the percentage of people who have a favourable opinion of Robert Mueller.
   Make a Judgement: This confidence interval **does** support the claim that a higher percentage of people have a favourable opinion of Donald Trump than Robert Mueller because **the confidence interval is entirely positive**.

2. **Margin of Error**: $1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{n_1}} + \frac{1}{\sqrt{n_2}}\right) = 1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{548}} + \frac{1}{\sqrt{2746}}\right) = 0.0464$ (3sf) = 4.64%
   Construct the confidence interval: 2% ± 4.64% = (-2.64%, 6.64%)
   Interpret what this Means: We can be fairly sure the percentage of **people in Wellington who have problems with damp houses** is somewhere between **2.64** percentage points **lower** and **6.64** percentage points **higher** than the percentage of **people in Auckland who have more problems with damp houses.**
   Make a Judgement: This confidence interval **doesn't** support the claim that a higher percentage of **people in Wellington have problems with damp houses** than **Auckland** because **zero is contained within the confidence interval**.

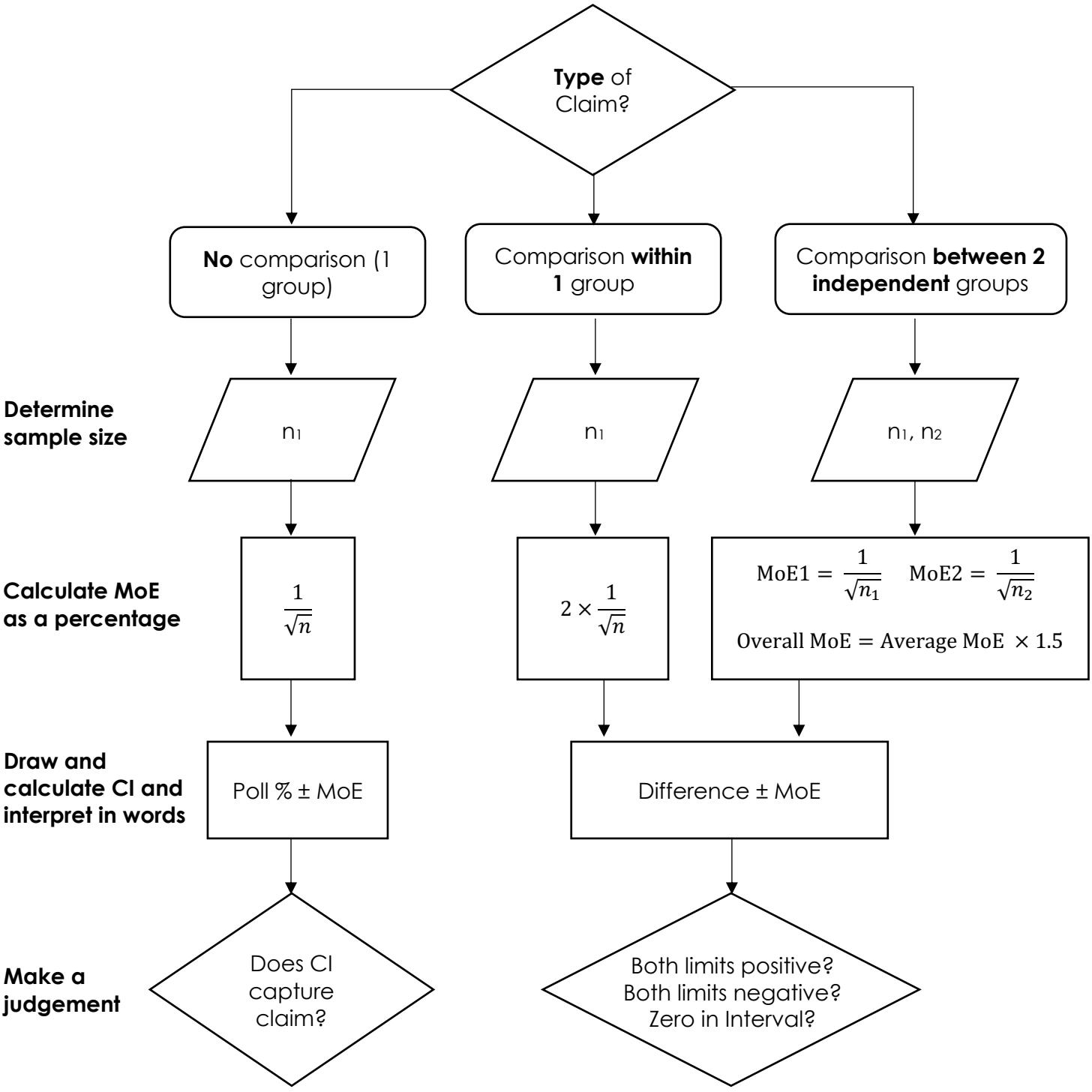
3. **Margin of Error**: $1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{n_1}} + \frac{1}{\sqrt{n_2}}\right) = 1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{487}} + \frac{1}{\sqrt{576}}\right) = 0.0652$(3sf) = 6.52%
   Construct the confidence interval: 19% ± 6.52% = (12.48%, 25.52%)
   Interpret what this Means: It is a fairly safe bet the percentage of **people from Christchurch who think their city has got better in the last year** is somewhere between **12.48** percentage points **higher** and **25.52** percentage points **higher** than the percentage of **people from Porirua who think their city has got better in the last year.**
   Make a Judgement: This confidence interval **does** support the claim that **A greater percentage of people from Christchurch think their city has got better in the last year** than **those from Porirua** because **the confidence interval is entirely positive**.

4. **Margin of Error**: $1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{n_1}} + \frac{1}{\sqrt{n_2}}\right) = 1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{340}} + \frac{1}{\sqrt{330}}\right) = 0.0820$ (3sf) = 8.20%
   Construct the confidence interval: 7% ± 8.20% = (-1.2%, 15.2%)
   Interpret what this Means: It is a fairly safe bet that the percentage of females who travel by car is somewhere between 1.2 percentage points lower and 15.2 percentage points higher than the percentage of males who travel by car."
   Make a Judgement: This confidence interval doesn't support the claim that more females travel to school by car than males films because zero is contained within the confidence interval.

Part 5.4: Choosing the Right Claim Type

One of the things that you need to be careful with when looking at this standard is identifying the type of claim and then using the correct formula and judgement.

You might find this flow chart helpful:



Part 5.4 Questions

For each of the claims below, determine the type of claim, calculate the margin of error, work out the confidence interval, interpret it in words and state if the claim is justified or not.

1. **Claim:** "More than half of NZ thinks Te Reo Māori should be core primary school subject, new survey reveals"
   Source: https://www.tvnz.co.nz/one-news/new-zealand/more-than-half-nz-thinks-te-reo-m-ori-should-core-primary-school-subject-new-survey-reveals
   Alternative Source: https://students.mathsnz.com/3.12/pdfs/Article10.pdf
   Extra Info: Survey asked 8,000 people

2. **Claim:** "More businesses store backups in the cloud than use physical media (disk to tape, removable, tape) combined"
   Source: https://itbrief.co.nz/story/why-enterprises-are-still-grappling-with-data-loss
   Alternative Source: https://students.mathsnz.com/3.12/pdfs/Article11.pdf

3. **Claim:** "Male Millennials more interested in investing in crypto currency than male Gen Xers"
   Source: https://www.chainbits.com/news/survey-says-men-more-interested-in-crypto-investment-than-women/
   Alternative Source: https://students.mathsnz.com/3.12/pdfs/Article12.pdf
   Extra Info: Survey asked 3,000 people in total, 503 Male Millennials and 478 Male Gen Xers

4. **Claim:** "National overtakes Labour in latest TVNZ poll"
   Source: https://www.stuff.co.nz/national/politics/103149694/national-takes-over-labour-in-tvnz-poll
   Alternative Source: https://students.mathsnz.com/3.12/pdfs/Article13.pdf
   Extra Info: Survey asked 1,007 people

5. **Claim:** "There's nearly a Nixon '74 level of public support for impeaching Trump (there was a higher support for impeaching Nixon in 1974 than there is to impeach Trump in 2018)"
   Source: https://edition.cnn.com/2018/06/22/politics/impeach-trump-nixon-support-bill-clinton-poll/index.html
   Alternative Source: https://students.mathsnz.com/3.12/pdfs/Article14.pdf
   Extra Info: Survey asked 1,003 voters in 2018 and 1,407 households in 1974

6. **Claim:** "Just over half of Facebook users ages 18 and older say they have adjusted their privacy settings in the past 12 months"
   Source: http://www.pewresearch.org/fact-tank/2018/09/05/americans-are-changing-their-relationship-with-facebook/
   Alternative Source: https://students.mathsnz.com/3.12/pdfs/Article15.pdf
   Extra Info: Survey asked 4,594 people

Part 5.4 Answers

1. **Type of claim**: No Comparison
   Margin of error: $\frac{1}{\sqrt{n}} = \frac{1}{\sqrt{8000}} = 0.0112$ (3sf) = 1.12%
   Confidence interval: 53% ± 1.12% = (51.88%, 54.12%)
   CI Interpretation: I am fairy sure that the percentage of New Zealanders who think Te Reo Māori should be core primary school subject is somewhere between 51.88% and 54.12%
   Judgement: The percentage of New Zealanders who think Te Reo Māori should be core primary school subject could be as low as 51.88% and so this confidence interval does support a claim of over 50% as implied by the "more than half" statement.

2. **Type of claim**: Comparison within 1 group
   Margin of error: $2 \times \frac{1}{\sqrt{n}} = 2 \times \frac{1}{\sqrt{800}} = 0.0707$ (3sf) = 7.07%
   Confidence interval: 5% ± 7.07% = (-2.07%, 12.07%)
   CI Interpretation: It is a fairly safe bet the percentage of businesses that store backups in the cloud is somewhere between 2.07 percentage points lower and 12.07 percentage points higher than the percentage of businesses that store backups on physical media.
   Judgement: This confidence interval doesn't support the claim that More businesses store backups in the cloud than use physical media (disk to tape, removable, tape) combined than because zero is contained within the confidence interval.

3. **Type of claim**: Comparison between 2 groups
   Margin of error: $1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{n_1}} + \frac{1}{\sqrt{n_2}}\right) = 1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{503}} + \frac{1}{\sqrt{478}}\right) = 0.0677$ (3sf) = 6.77%
   Confidence interval: 8% ± 6.77% = (1.23%, 14.77%)
   CI Interpretation: It is a fairly safe bet the percentage of male millennials interested in investing in cryptocurrencies is somewhere between 1.23 percentage points higher and 14.77 percentage points higher than the percentage of male gen xers interested in investing in cryptocurrencies.
   Judgement: This confidence interval does support the claim that Male Millennials more interested in investing in crypto currency than male Gen Xers because the confidence interval is entirely positive.

4. **Type of claim**: Comparison within 1 group
   Margin of error: $2 \times \frac{1}{\sqrt{n}} = 2 \times \frac{1}{\sqrt{1007}} = 0.0630$ (3sf) = 6.30%
   Confidence interval: 1% ± 6.3% = (-5.3%, 7.3%)
   CI Interpretation: It is a fairly safe bet the percentage of voters that support National is somewhere between 5.3 percentage points lower and 6.3 percentage points higher than the percentage of voters that support Labour.
   Judgement: This confidence interval doesn't support the claim that National has more support than Labour because zero is contained within the confidence interval.

5. **Type of claim**: Comparison between 2 groups
   Margin of error: $1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{n_1}} + \frac{1}{\sqrt{n_2}}\right) = 1.5 \times \frac{1}{2}\left(\frac{1}{\sqrt{1003}} + \frac{1}{\sqrt{1407}}\right) = 0.0437$ (3sf) = 4.37%
   Confidence interval: 1% ± 4.37% = (-3.37%, 5.37%)
   CI Interpretation: It is a fairly safe bet the percentage of people who supported impeaching Nixon in 1974 is somewhere between 3.37 percentage points lower and 5.37 percentage points higher than the percentage of people who support impeaching Trump in 2018.
   Judgement: This confidence interval doesn't support the claim that there was more support for impeaching Nixon in 1974 than there is for impeaching Trump in 2018 because zero is contained within the confidence interval.

6. **Type of claim**: No Comparison
   Margin of error: $\frac{1}{\sqrt{n}} = \frac{1}{\sqrt{4594}} = 0.0148$ (3sf) = 1.48%
   Confidence interval: 54% ± 1.48% = (52.52%, 55.48%)
   CI Interpretation: I am fairy sure that the percentage of Facebook users aged 18 and older who say they have adjusted their privacy settings in the past 12 months is somewhere between 52.52% and 55.48%
   Judgement: The percentage of Facebook users aged 18 and older who say they have adjusted their privacy settings in the past 12 months could be as low as 52.52%, and so this confidence interval does support a claim of over 50% as implied by the "just over half" statement.

Part 6: Writing a Good Response

When answering questions there are a number of things that help make a good response.

- Make sure you read numbers correctly off graphs
- Always link to the context
- Use specific quotes from the report to support your answer
- Use "common sense" to comment on key features
- Focus on specific claims being made and if the statistical processes described in the report support that claim
- A short, succinct and well supported answer is better than a lengthy, generic statement
- Integrate statistical and contextual knowledge in your response

When looking at a report there are a number of questions that are useful to think about:

- Is the report based on **sound research**? Find the original research article to determine this. Was it published in a reputable journal? Was it conducted by reputable researchers from a University or Research Institute for example? *Note: this can't be always done during an exam, but is worth doing when looking at articles that aren't in the exam.*
- Identify the **type of study** undertaken – poll, survey, experiment or observational study?
- Who **funded** the research? Did they have a vested interest in the outcome? For example, was it a drug company trying to compare their new drug over an existing treatment?
- Were reliable **data collection methods** used? If data was collected from the past or people's memories, how was accuracy checked? Could confounding variables have changed over time?
- **Who or what** was studied?
- How were the participants **selected**?
- What **measurements** were taken or what **questions** were asked and how? Are questions defined and responses provided? Are the measurements appropriate for the effect that is being observed? For example, is an IQ test an acceptable measure of intelligence. How were measurements taken – interview, online, questionnaire. Could this have had an impact on responses?
- **Where and when** were measurements taken or questions asked? Sometimes if measurements are taken in an unfamiliar setting for the participant, atypical responses can be observed. Some measurements will vary according to the time they are taken – morning/evening, summer/winter, weekend/weekday.
- Is the size of the observed effect **backed up with numbers** or just described? Is a claim made that Drug A reduces blood pressure OR that Drug A reduces blood pressure by 15%. Beware of unquantified claims.
- Are there any **confounding or lurking variables** that should be considered?
- Have the **results been extended** inappropriately?
- Is there **complete data**? Was non-response or missing data a problem?
- Do the results **make sense**? Is there a scientific or biological reason to support the evidence? Is there any alternative explanation.
- Are the results **convincing**? Would the results persuade you or someone you know to modify or change their behaviour?
- What is your **overall conclusion** about the research findings? Justify why the study was good or why it was not. Do other studies reveal similar findings? What further information about the study might be useful.

Part 6.1: Looking at Reports

Either using the reports we have looked at in the previous sections, or using any media articles you can find online, think about all of the above questions and write up a response to at least 4 articles. Searching online new sites for "study", "poll", "survey" or "results" usually will find a number of interesting articles.

The articles we have looked at in the previous sections can all be accessed from here:

1. New survey reveals New Zealand's youth among worst in cyberbullying rates
   https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12113026

2. Teens Are Over Face-to-Face Communication, Study Says
   http://time.com/5390435/teen-social-media-usage/

3. Kiwis generally positive about relationship with China
   https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12114256

4. Getting over the barriers to financial advice
   https://www.cffc.org.nz/latest-news/financial-literacy/getting-over-the-barriers-to-financial-advice/

5. A promising drug to slow the progression of Alzheimer's was just unveiled
   https://www.vox.com/2018/7/25/17607376/dementia-alzheimers-drug-trial-biogen-eisai

6. Blue light from phone screens accelerates blindness, study finds
   https://www.theguardian.com/society/2018/aug/09/blue-light-from-phone-screens-accelerates-blindness-study-finds

7. Phones ring alarm bells
   https://www.odt.co.nz/lifestyle/magazine/phones-ring-alarm-bells

8. Late-night phone use is linked to poor sleep and moodiness
   https://www.dailymail.co.uk/news/article-5733765/Turn-phone-10pm-avoid-risk-mental-health-problems.html

9. More than half of French people think US no longer a 'trusted ally', survey says
   https://www.france24.com/en/20180912-more-half-french-people-think-usa-trump-no-longer-trusted-ally-ifop-survey

10. More than half of NZ thinks Te Reo Māori should be core primary school subject, new survey reveals
    https://www.tvnz.co.nz/one-news/new-zealand/more-than-half-nz-thinks-te-reo-m-ori-should-core-primary-school-subject-new-survey-reveals

11. Why enterprises are still grappling with data loss
    https://itbrief.co.nz/story/why-enterprises-are-still-grappling-with-data-loss

12. Survey Says Men More Interested in Crypto Investment Than Women
    https://www.chainbits.com/news/survey-says-men-more-interested-in-crypto-investment-than-women/

13. National overtakes Labour in latest TVNZ poll
    https://www.stuff.co.nz/national/politics/103149694/national-takes-over-labour-in-tvnz-poll

14. There's nearly a Nixon '74 level of public support for impeaching Trump
https://edition.cnn.com/2018/06/22/politics/impeach-trump-nixon-support-bill-clinton-poll/index.html

15. Americans are changing their relationship with Facebook
http://www.pewresearch.org/fact-tank/2018/09/05/americans-are-changing-their-relationship-with-facebook/

16. Forget 10,000 steps! A brisk ten-minute walk is just as good if you want to stay fit and healthy, says Public Health England
https://www.dailymail.co.uk/health/article-5801837/Brisk-ten-minute-walk-just-good-10-000-steps-says-Public-Health-England.html

Alternative links (archive of each article)

1. https://students.mathsnz.com/3.12/pdfs/Article1.pdf
2. https://students.mathsnz.com/3.12/pdfs/Article2.pdf
3. https://students.mathsnz.com/3.12/pdfs/Article3.pdf
4. https://students.mathsnz.com/3.12/pdfs/Article4.pdf
5. https://students.mathsnz.com/3.12/pdfs/Article5.pdf
6. https://students.mathsnz.com/3.12/pdfs/Article6.pdf
7. https://students.mathsnz.com/3.12/pdfs/Article7.pdf
8. https://students.mathsnz.com/3.12/pdfs/Article8.pdf
9. https://students.mathsnz.com/3.12/pdfs/Article9.pdf
10. https://students.mathsnz.com/3.12/pdfs/Article10.pdf
11. https://students.mathsnz.com/3.12/pdfs/Article11.pdf
12. https://students.mathsnz.com/3.12/pdfs/Article12.pdf
13. https://students.mathsnz.com/3.12/pdfs/Article13.pdf
14. https://students.mathsnz.com/3.12/pdfs/Article14.pdf
15. https://students.mathsnz.com/3.12/pdfs/Article15.pdf
16. https://students.mathsnz.com/3.12/pdfs/Article16.pdf

Part 7: Past Exams

One of the most important things you can do to prepare for the exam is do lots of practice exam questions. Fortunately NZQA publishes all their exams online, along with answers.

You can access the exams from the links below:

2017: Exam Resource Answers
2016: Exam Resource Answers
2015: Exam Resource Answers
2014: Exam Answers
2013: Exam Answers

You can access all the past exams as well as resources such as markers reports and students papers here: https://www.nzqa.govt.nz/ncea/assessment/view-detailed.do?standardNumber=91584

It is also worth reading comments from the markers as to what points they were looking for at each level of achievement: https://www.nzqa.govt.nz/ncea/subjects/assessment-reports/statistics-l3/

Appendix: Standard & Curriculum Details

Below is the details from the standard and the curriculum documents relating to the content of this standard.

Standard Details

Evaluating statistical reports requires familiarity with:

- the statistical enquiry cycle
- principles of experimental design
- surveys and polls, including potential sources of bias
- interpreting statistical inferences
- interpreting a wide variety of statistical tables and graphs
- analysing a wide variety of statistical situations
- critiquing causal-relationship claims
- interpreting margins of error.

Curriculum Elaborations

Evaluate a wide range of statistically based reports, including surveys and polls, experiments, and observational studies:

A. critiquing causal-relationship claims

- Identifies the type of study, that is, survey, poll, experiment, or observational study.
- Draws on understandings of statistical investigations and how the different types of studies are conducted, uses Statistical literacy critical questions to evaluate the study, makes a judgment about the claim and justifies it.

B. interpreting margins of error.

The approach here is new to the statistics curriculum. It is based on making informed approximations or rules of thumb to interpret reported margins of error and is linked to confidence intervals.

- Explains the connections among sample, population, sampling variability, sample size, confidence level, and poll percentages in relation to the reported margin of error.
- Estimates the margin of error for subgroups of the poll percentages.
- See key mathematical ideas on NZMaths.

More details on the Senior Secondary Guide on TKI