Mathematics Level 8

Chapter 6 — Statistics: samples, sampling and variation

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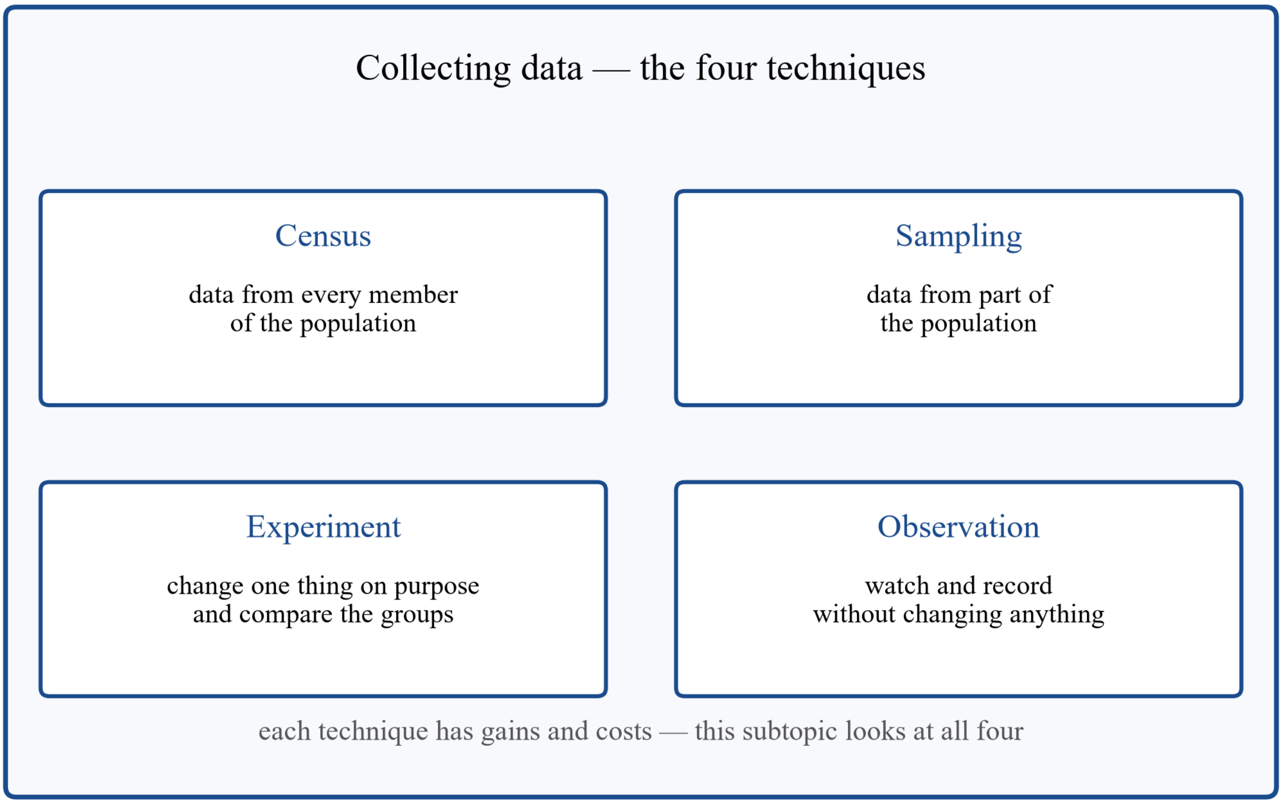
Populations and samples; census, sampling, experiment and observation

Curriculum: Victorian Curriculum F–10 Version 2.0, Mathematics, Level 8 — `VC2M8ST01` *(Statistics): "distinguish between a population and a sample, and investigate techniques for data collection including census, sampling, experiment and observation, and explain the practicalities and implications of obtaining data through these techniques." Achievement-standard extract: "Students conduct statistical investigations and explain the implications of obtaining data through sampling."*

In Year 7 you planned and conducted statistical investigations using data from primary and secondary sources, calculated the range, median, mean and mode, and described the shape, centre and spread of data distributions (`VC2M7ST01`–`VC2M7ST03`). That work is assumed here, not re-taught. This subtopic starts one step earlier, with the question every investigation must answer first: **where does the data come from, and how was it collected?** A conclusion is only as strong as the data behind it, and the method of collection decides what the data can tell you.



A card with four boxes naming the four ways of collecting data: census, sampling, experiment and observation, each with a short note

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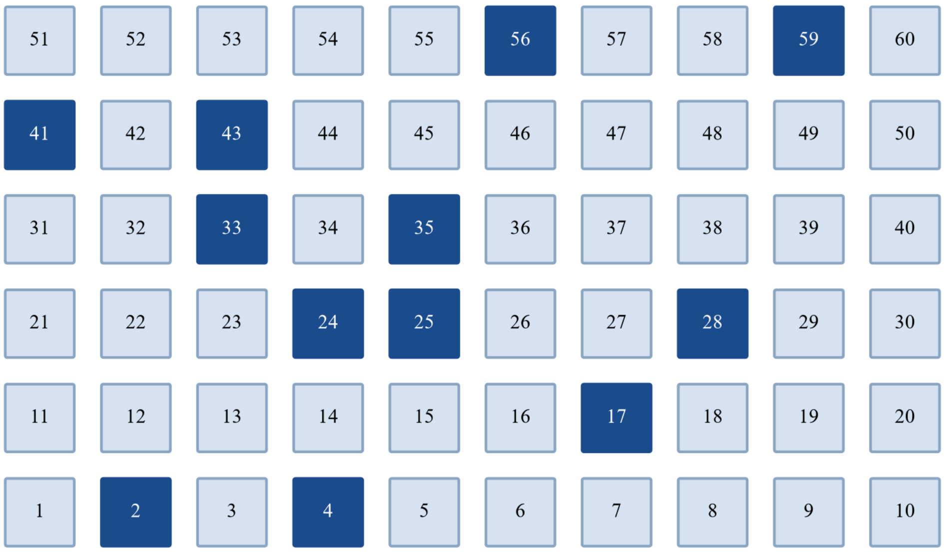
Theory

Populations and samples

In this book, *population* carries its statistical meaning: **the whole group of people, objects or events that we want information about**. Everyday English usually uses the word for the people living in a place; the statistical meaning is wider. A population can be all the students at a school, but it can also be all the light globes a factory makes in a week, every bag of apples in a crate, or every race a sprinter runs in a season. Each person or object in the population is called a **member** of that population.

A **sample** is the part of the population from which data is actually collected.

Population and sample



population: all 60 members

sample: the 12 members in blue — the part of the population the data comes from

A grid of 60 numbered members with 12 of them filled in blue, showing the sample as part of the population

> **Key idea.** Most statistical questions cannot be answered by measuring the whole population, so we collect data from a sample and use it to say something about the population. This only works when the sample is **representative** of the population — that is, when it reflects the population in the ways that matter for the question being asked.

Example. Suppose the question is “How do students at our school travel to school?” and the school has 1,200 students. The population is all 1,200 students. If 60 students are surveyed, those 60 students are the sample, and the answer we get is an **estimate** of what is true for the whole school, not an exact count.

Census

A **census** collects data from **every member** of the population.

A census is the right technique when:

- the population is small enough to measure completely — counting every student in your class, or scanning every returned library book for damage;
- an exact figure is needed and the work can be done — the Australian Bureau of Statistics (ABS) runs a census of the whole country every five years. The 2021 Census counted 25,422,788 people in Australia on census night, 10 August 2021.

Source: Australian Bureau of Statistics, 2021 Census of Population and Housing; retrieved 19 August 2026.

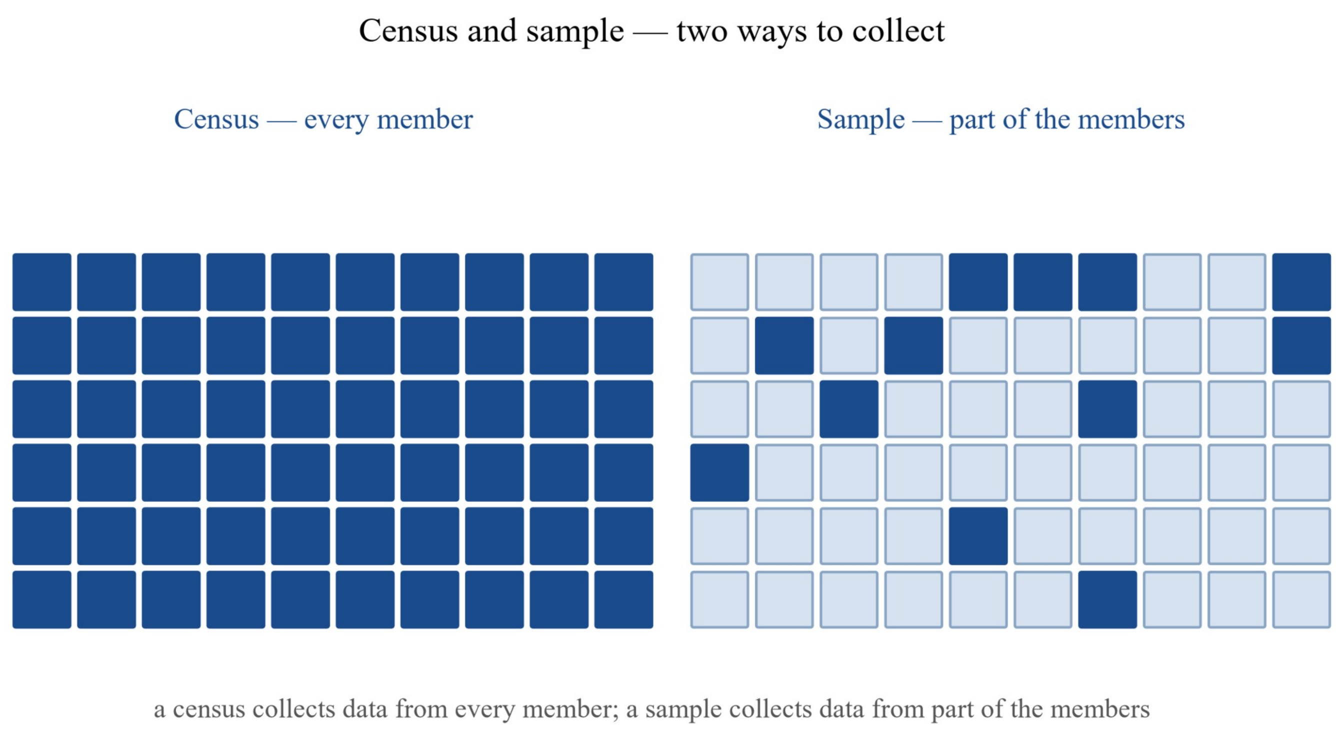
A census is often not possible:

- the population is too large to count often. Between censuses, the ABS **estimates** Australia’s population. At 31 December 2025 the estimate was 27,801,023 people;
- the test destroys the item. To find how long a light globe lasts, it must be run until it stops working — the factory cannot test every globe and still sell them;
- the cost or the time is too great, or the population cannot be reached completely (all the fish in a lake, all the water in a river).

Source: Australian Bureau of Statistics, "National, state and territory population", December 2025; retrieved 19 August 2026.

Sampling

Sampling collects data from part of the population only. The gains are speed and cost — and sometimes sampling is the only way, as when a test destroys the item. The cost of sampling is uncertainty: a sample gives an estimate of what is true for the population, not an exact figure.

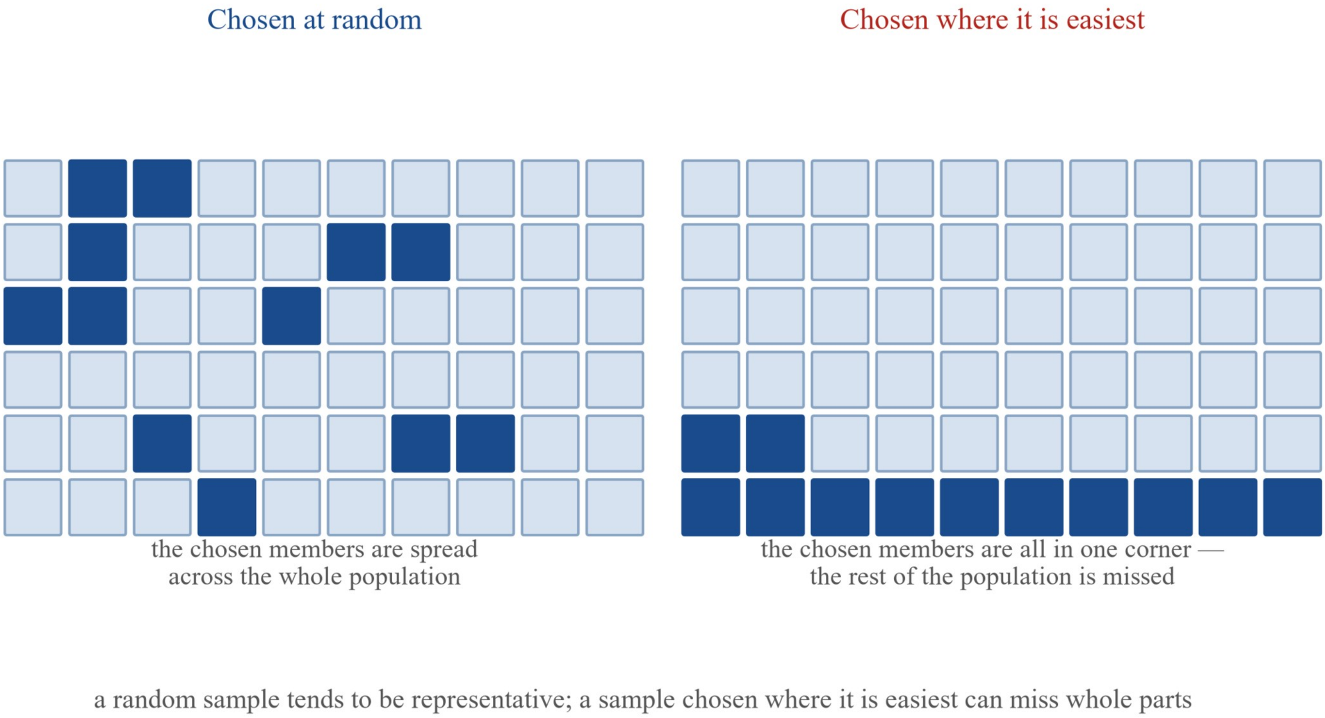


Two grids of 60 members: on the left every member is filled in blue for a census, and on the right only 12 members are filled in blue for a sample

How the sample is chosen matters as much as how large it is:

- A sample chosen **at random** — by chance, so that every member of the population has the same chance of being selected — tends to be representative. *Random* here has a precise meaning: selection by chance, not picking "any old how".
- A sample chosen by someone's own selection, or collected where it is easiest to collect, can easily miss parts of the population.

Choosing a sample — at random, or not at random



Two grids of 60 members: on the left the 12 chosen members are spread across the whole grid, and on the right they are all in one corner

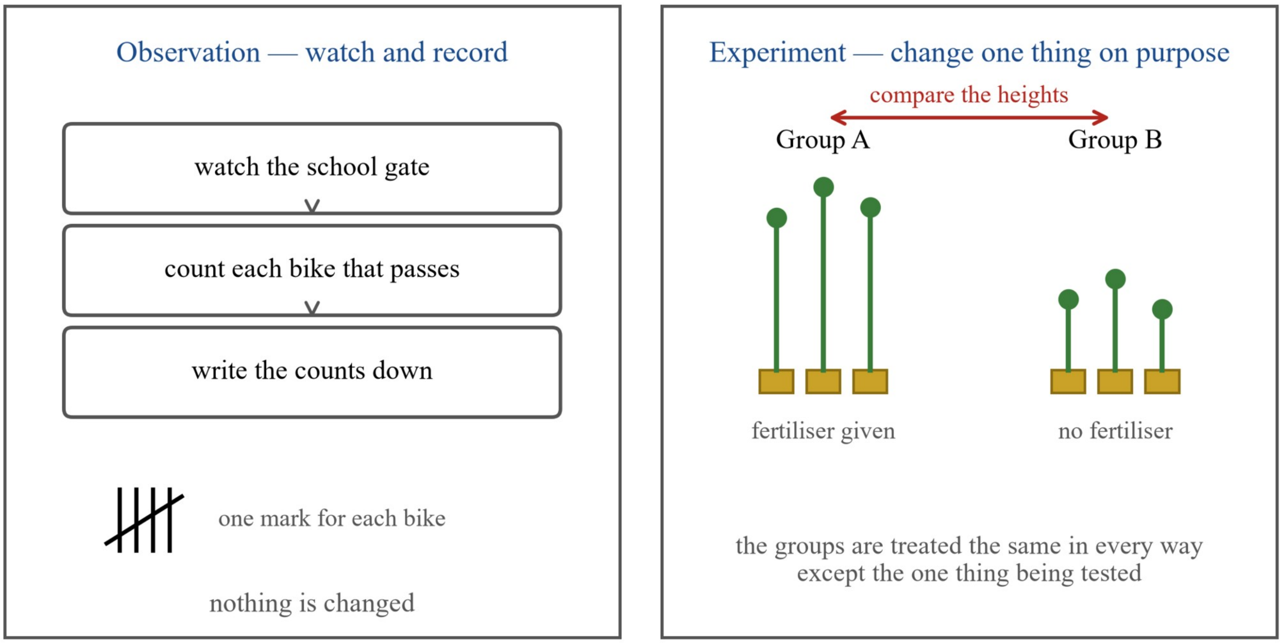
The implication: **a sample that is not representative can give a misleading answer — and making a misleading sample bigger does not fix it**. Section 6B names the specific sampling methods (simple random, systematic, stratified, quota, cluster, convenience and judgement sampling) and when each one is used; Section 6C looks at how samples vary; Section 6D has you plan and run your own investigation.

Experiment and observation

The other two collection techniques in this subtopic are experiments and observations.

- In an **observation**, you watch and record what happens **without changing anything**. Counting the bikes that pass the school gate, recording the colours of the cars in the car park, and writing down the noon temperature each day are all observations. The weather records kept by the Bureau of Meteorology are collected by observation.
- In an **experiment**, you **change or control something on purpose** and record the effect, usually by comparing two or more groups. Growing one group of plants with fertiliser and another group without it, then comparing their heights, is an experiment.

Observation and experiment



Two panels: on the left the bikes at a gate are watched and counted without changing anything, and on the right two groups of plants are grown with and without fertiliser and their heights compared

Practicalities and implications of each:

- In an experiment you set the conditions. The groups must be treated the same in every way **except the one thing being tested**; otherwise the comparison is not fair, and you cannot say what caused any difference you see.
- In an observation you cannot control conditions — you can only record what is there. People who know they are being watched may also change how they act.
- An experiment can show the effect of a change. An observation can show what is happening, but on its own it cannot separate one cause from another.

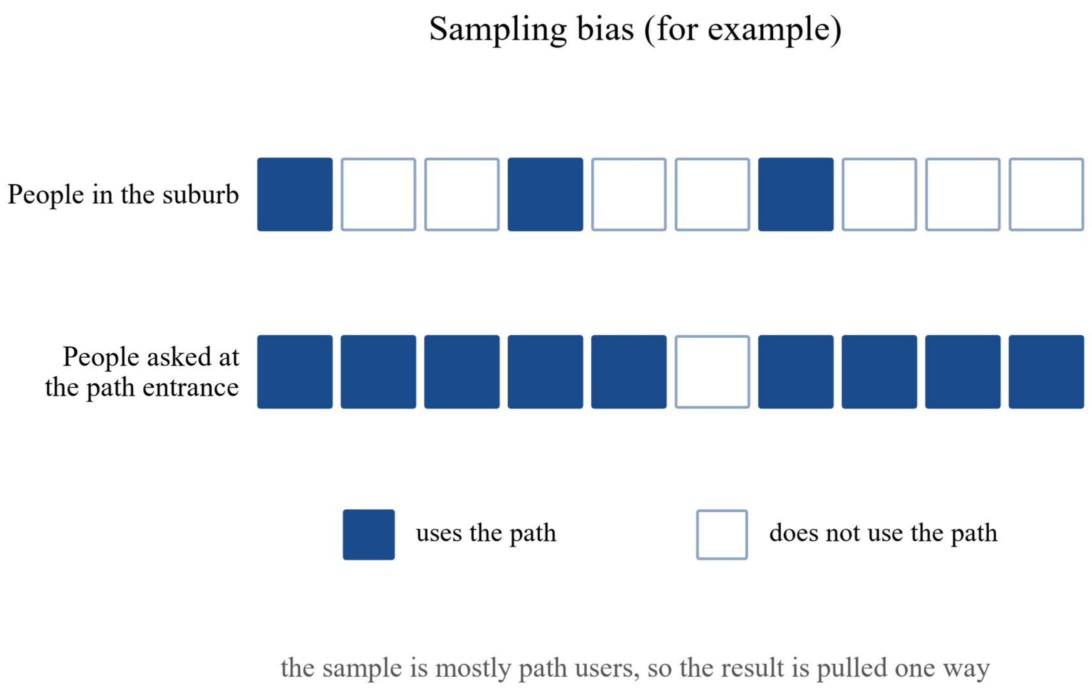
Bias

Bias in everyday English means an unfair preference for one side. In statistics it has a sharper meaning about method:

> **Bias** occurs when the way data is collected makes some members of the population, or some outcomes, more likely to appear in the data than others. **Sampling bias** occurs when certain members of a population are more likely to be selected in a sample than others — the sense used by the Victorian Curriculum (`VC2M8ST01.E03`).

Examples:

- A survey about a new walking path asks only the people walking past the path entrance on Saturday morning. People who never use the path are never asked.
- A call-in radio poll counts only the people who feel strongly enough to phone in.
- An online survey misses everyone without internet access.
- An experiment can be biased too: if one plant group sits in the sun and the other in the shade, the sunlight — not the thing being tested — may cause any difference. Environmental conditions can bias the results of an investigation when the conditions are not kept the same (`VC2M8ST01.E03`).
- An observation can be biased: counting traffic only on fine days says nothing about wet days.

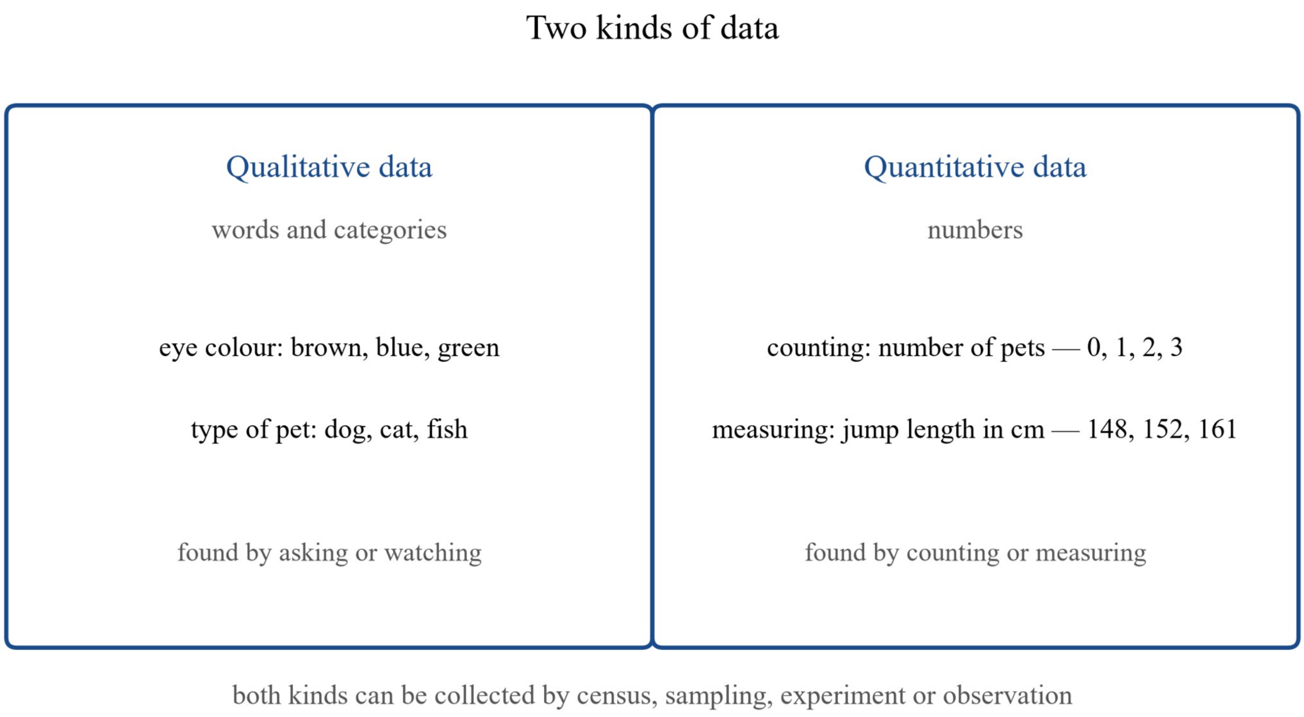


Two rows of ten boxes: three of the ten people in the suburb use the path, but nine of the ten people asked at the path entrance use it, showing sampling bias

The implication: biased data pulls the result in one direction. A conclusion built on biased data can be wrong even when the sample is large.

Precision and error

Data is not always numbers. **Qualitative data** describes qualities — words and categories, such as eye colour or the type of pet. **Quantitative data** is numerical — counts (how many) or measurements (how much). Both kinds can be collected by census, sampling, experiment or observation, and digital tools such as simulations and digital measuring devices can be used to observe, measure and record both kinds.

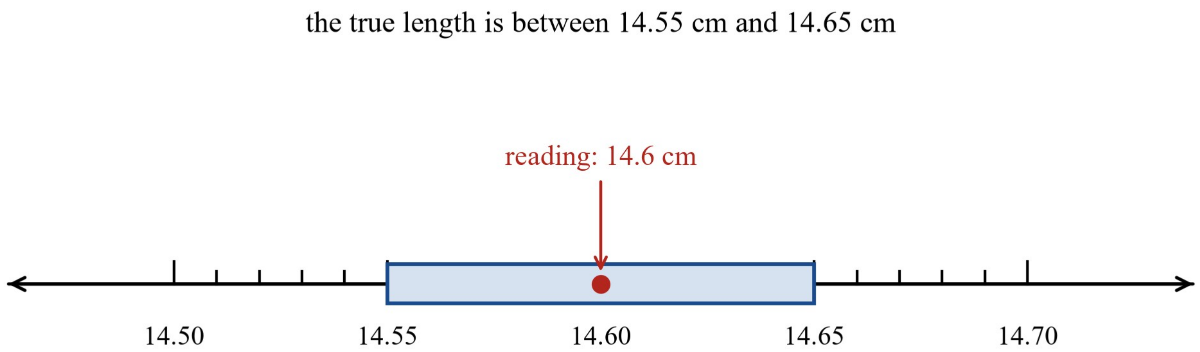


Two boxes: the left one lists word data such as eye colour, and the right one lists number data found by counting or measuring

When data comes from measuring, every measuring instrument has a **precision**: the smallest unit it can measure or display. A ruler marked in millimetres measures to the nearest millimetre; a kitchen scale may read to the nearest gram; a stopwatch may read to the nearest 0.01 s; a thermometer may read to the nearest 1 °C.

A measurement to the nearest unit is a rounded value, so the true value can sit at any point within half a unit of the reading:

> A length recorded as 14.6 cm, to the nearest millimetre, means the true length is between 14.55 cm and 14.65 cm.



A number line from 14.5 to 14.7 with the part between 14.55 and 14.65 shaded to show where the true length can lie

Implications of error:

- Two people measuring the same object can get different readings, and both can be right — the readings differ because of the precision of the instrument and the person reading it.
- The instrument must match the task: a clock that reads only to the nearest minute cannot time a 100 m race.
- Small errors can matter when parts must fit together, or when a result is used to make a decision.
- Digital measuring devices also have a smallest unit they can read; being digital does not make a reading exact.

Worked examples

Example 1 — scaffolded

The canteen at a school with 850 students wants to know which lunch most students buy. The student council surveys 85 students chosen at random.

a) Identify the population and the sample. b) Name the collection technique. c) Will the canteen get an exact figure or an estimate? Explain.

Step	Comment
Population: all 850 students at the school.	The population is the whole group the question is about.
Sample: the 85 students surveyed.	The sample is the part of the population the data comes from.
The sample is 85 out of 850, or 1 in 10 students.	It was chosen at random, so every student had the same chance of selection.
Technique: sampling (a survey).	Not every student was asked, so it is not a census.
The canteen gets an estimate, not an exact figure.	Only part of the population was asked; the result stands in for the whole.

Example 2 — scaffolded

Classify each as a **census**, a **sample**, an **experiment** or an **observation**. Give a reason.

a) A teacher records the height of every student in Year 8 at the school.
b) A factory tests 20 batteries from a batch of 5,000 to find how long they last.
c) A student counts the bikes that pass the school gate on Tuesday morning.
d) Two groups of plants are grown, one given fertiliser and one not, and their heights are compared after three weeks.

Item	Classification	Reason
a	Census	Every member of the group of interest (the Year 8 students) is measured.
b	Sample	Only 20 of the 5,000 batteries are tested, and testing one uses it up, so a census of the batch is not possible.
c	Observation	Nothing is changed; the student only watches and records.
d	Experiment	Something is changed on purpose (the fertiliser) and two groups are compared.

Example 3 — scaffolded

A council wants to know whether residents use the new walking path. On Saturday morning, a worker stands at the path entrance and asks the people walking past.

a) Identify the bias in this method. b) Suggest a way to collect the data with less bias.

Step	Comment
The people asked are already at the path.	Anyone who does not use the path never walks past the entrance.
Only Saturday-morning users are asked.	People who would use the path at other times are missed.
The sample has too many path users in it.	This is sampling bias: some residents are much more

Step	Comment
	likely to be selected than others.
b) Ask a random sample of residents from across the suburb, such as names drawn from a list of the suburb's residents.	Then every resident has a chance to be included, whether they use the path or not.

Example 4 — unscaffolded

Mia measures her desk with a ruler marked in millimetres and records 118.3 cm. Her brother measures the same desk with a tape marked in centimetres and records 118 cm.

a) What is the smallest unit Mia's ruler can measure?

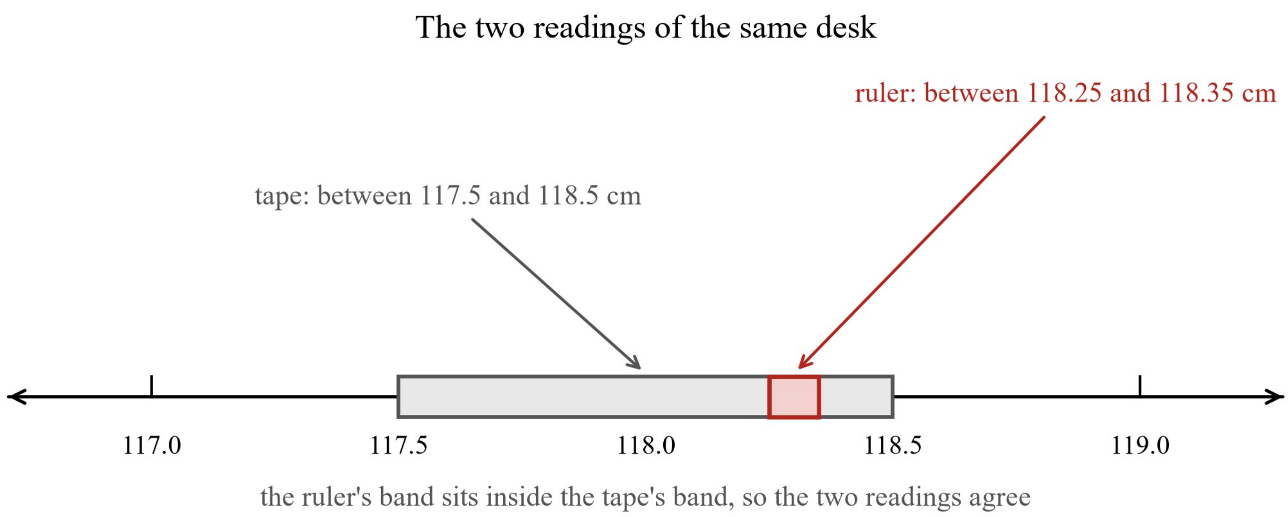
b) Based on Mia's reading, between what two values does the true length of the desk lie?

c) Is either reading wrong? Explain, using the idea of precision.

d) 1 mm (= 0.1 cm).

e) The reading is 118.3 cm to the nearest millimetre, so the true length lies between 118.25 cm and 118.35 cm.

f) Not necessarily. The tape reads only to the nearest centimetre, so its reading of 118 cm means the true length lies between 117.5 cm and 118.5 cm. Mia's reading sits inside that range, so the two readings agree. The ruler is the more precise instrument because its unit (1 mm) is smaller than the tape's (1 cm).



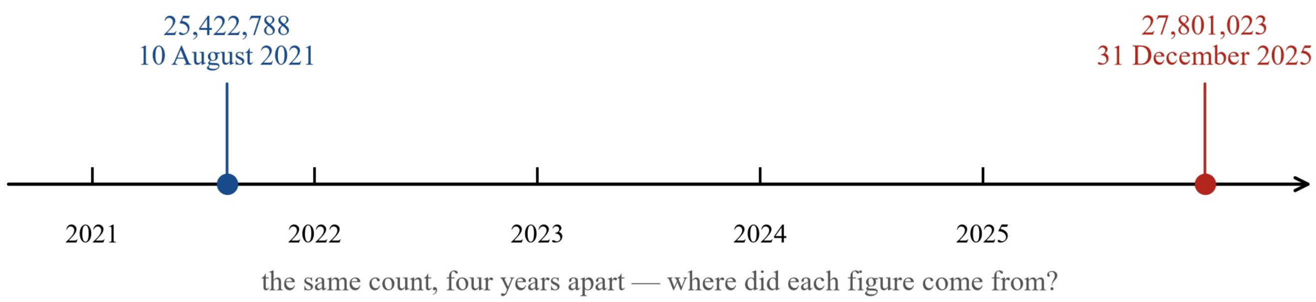
A number line from 117 to 119 with a wide band from 117.5 to 118.5 and a narrow band from 118.25 to 118.35 sitting inside it

Example 5 — unscaffolded

The 2021 Census counted 25,422,788 people in Australia on census night, 10 August 2021. At 31 December 2025, the ABS estimated Australia's population at 27,801,023.

Sources: Australian Bureau of Statistics, 2021 Census of Population and Housing; Australian Bureau of Statistics, "National, state and territory population", December 2025; both retrieved 19 August 2026.

Two figures for Australia's population



A timeline from 2021 to 2025 with the two figures for the population of Australia, one on 10 August 2021 and one on 31 December 2025

a) Which figure comes from a census and which is an estimate?

b) By how many people did the figure grow between these two dates?

c) Give two reasons why the ABS estimates the population between censuses instead of running a new census every year.

d) 25,422,788 comes from the census — every person in the country was counted on census night. 27,801,023 is an estimate — no new census was run between 2021 and 2025.

e) 27,801,023 − 25,422,788 = 2,378,235 people.

f) Any two of: a census is expensive to run; it takes a long time to collect and process the answers from every person in the country; running one every year would be far more work than the value of the exact figure; estimates let the ABS track the population all the time, not just once every five years.

Practice questions

Scaffolded

Q1. Complete each sentence in your own words.

- The population is the ______.
- A sample is ______.
- A census collects data from ______.
- Sampling collects data from ______.

Q2. State whether each is a **census** or a **sample**, and give a reason.

a) The librarian scans every returned book for damage.
b) A researcher asks 50 shoppers at a market about a new drink.
c) The school takes a photo of every student for the yearbook.
d) On the packing line, one bag in every ten is checked for faults.

Q3. State whether each is an **experiment** or an **observation**, and give a reason.

a) Sitting in a park and counting how many people use the walking path before 9 am.
b) Giving one group of plants 50 mL of water a day and another group 100 mL a day, then comparing their growth after two weeks.

Q4. A factory tests 30 ropes from a batch of 2,000 by pulling each one until it breaks.

a) What is the population? b) What is the sample? c) Why is a sample used here instead of a census?

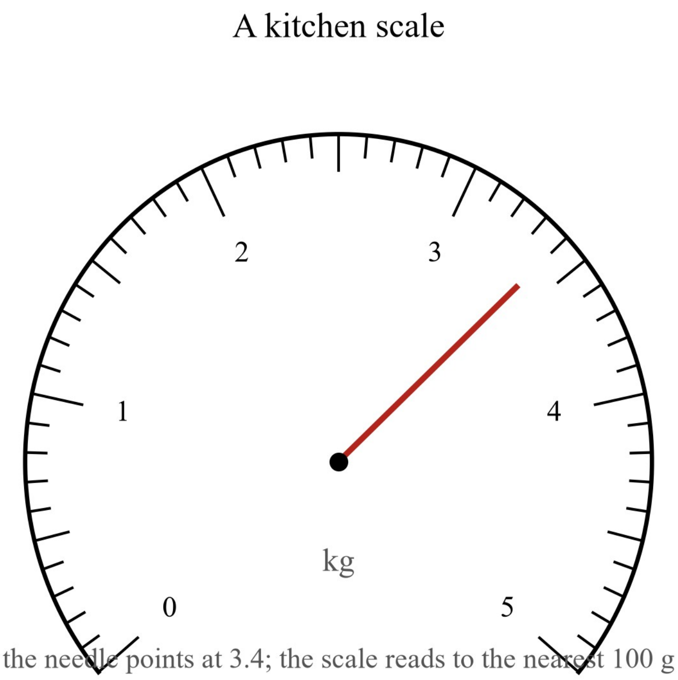
Q5. A radio station asks listeners to phone in during the show and say whether they support a new bus route. Of the 50 calls, 45 support the route (90%), and the station reports: "Nine in ten people support the new route."

a) Give two reasons why this sample is biased. b) Name one group of people not included in the sample.

Q6. State whether each data set is **qualitative** or **quantitative**.

a) The eye colour of each student in a class.
b) The length of each student's standing jump, in cm.
c) The time it takes each student to get to school, in minutes.
d) The type of pet each student has at home.

Q7. A kitchen scale reads to the nearest 100 g. It shows 3.4 kg for a bag of apples.



A kitchen scale with the needle pointing at 3.4 on a dial marked in kg

a) What is the smallest unit the scale can measure? b) Between what two values does the true mass of the bag lie?

Q8. A teacher asks all 26 students in her class how many hours they slept last night.

a) Is this a census or a sample of the class? b) The teacher says her results tell us about all 180 Year 8 students at the school. Is the class data a census or a sample of that larger group? Explain.

Unscaffolded

Q9. State whether a **census** or a **sample** is the better way to collect the data, and give a reason.

a) Finding how long this brand of battery lasts.
b) Counting every person in Australia on census night.
c) Checking every egg in a carton for cracks before it is sold.
d) Finding the volume of water in a lake.

Q10. A sports club wants to find which of three sports — football, basketball or cricket — students at a school prefer. Describe a method for choosing a sample of 40 students from the school's 400 students so that every student has the same chance of selection.

Q11. Two groups of young plants are used to test a fertiliser. Group A sits on a sunny windowsill and Group B sits in a dark cupboard. After two weeks, the heights of the two groups are compared.

a) Why is this comparison not fair? b) State one way to fix the investigation.

Q12. Tom stands at the school gate from 8:40 am to 8:50 am on Monday and counts the cars that arrive. He writes: "Most students at our school travel by car." State two problems with this conclusion.

Q13. The 2021 Census counted 25,422,788 people in Australia on census night, 10 August 2021. At 31 December 2025, the ABS estimated Australia's population at 27,801,023. Between censuses, the ABS builds its estimates from the most recent census and from records of births, deaths and people moving into and out of the country.

Sources: Australian Bureau of Statistics, 2021 Census of Population and Housing; Australian Bureau of Statistics, "National, state and territory population", December 2025; both retrieved 19 August 2026.

a) Which figure comes from a census and which is an estimate? b) By how many people did the figure grow between these two dates? c) Give two reasons why the ABS estimates the population between censuses instead of running a new census every year. d) Explain why the estimate can change every year even though no new census has been run.

Q14. A stopwatch reads to the nearest 0.01 s. Priya records her sprint time as 13.46 s.

a) What is the smallest unit the stopwatch can measure? b) Between what two values does her true time lie? c) Explain why a clock that reads only to the nearest minute is not the right instrument for timing a sprint.

Q15. State whether each is **qualitative** or **quantitative**. For each quantitative item, state whether it is found by counting or by measuring.

a) The favourite pet of each student in a class.
b) The mass of a pet, in kg.
c) The number of pets in each home.
d) Whether each pet has fur, feathers or scales.

Q16. Explain what it means for a sample to be **representative** of a population. Use an example of your own.

Q17. State whether each is an **experiment** or an **observation**, and give a reason.

a) A nurse records the heart rate of 20 students before and after they run for 5 minutes.
b) A student records the noon temperature at school every day for a month.

Q18. A survey of 25 students in one Year 8 class finds that all 25 like pizza. The student council then reports: "More than half of the 1,200 students at our school like pizza."

a) Is the class data a census or a sample — and of what? b) Give one reason why the council's conclusion may be wrong.

Answers

Q1. Population: the whole group we want information about. Sample: the part of the population from which data is collected. Census: every member of the population. Sampling: part of the population.

Q2. a) Census — every returned book is scanned. b) Sample — only 50 of the shoppers are asked. c) Census — every student is photographed. d) Sample — only one bag in ten is checked.

Q3. a) Observation — nothing is changed; the student only watches and counts. b) Experiment — the amount of water is changed on purpose and two groups are compared.

Q4. a) All 2,000 ropes in the batch. b) The 30 ropes tested. c) The test destroys the rope, so a census would leave nothing to sell.

Q5. a) Only listeners of that show can answer, and only people who feel strongly enough to phone in do so. b) For example: people who do not listen to that station; people at work or school during the show; people without a phone.

Q6. a) Qualitative. b) Quantitative. c) Quantitative. d) Qualitative.

Q7. a) 100 g (= 0.1 kg). b) Between 3.35 kg and 3.45 kg.

Q8. a) A census of the class — all 26 students were asked. b) A sample of the 180 Year 8 students — only one class of the 180 was asked.

Q9. a) Sample — testing a battery uses it up, and there are many batteries. b) Census — every person is counted, and that is the point of a census. c) Census — the group is small, each egg matters, and the check does not destroy the egg. d) Sample — the water in a lake cannot all be measured.

Q10. For example: write each of the 400 students' names on slips of the same size, put them in a bag and mix them, then draw 40 slips without looking.

Q11. a) The two groups differ in more than the one thing being tested — Group A has sunlight and Group B does not, so any difference in height may be caused by the light, not the fertiliser. b) Put both groups in the same place (or give both groups the same light).

Q12. Any two of: he counted cars, not students — one car may carry several students, and students who walk or ride are not in the car count at all; one ten-minute window on one day may not represent the whole week; students arriving after 8:50 am are missed.

Q13. a) 25,422,788 is the census figure; 27,801,023 is the estimate. b) 2,378,235 people. c) Any two of: a census is expensive; it takes a long time to collect and process; running one every year is far more work than the value of the exact figure; estimates let the ABS track change all the time. d) The true population changes every day as people are born, die, and move into and out of the country, and the estimate is updated from those records.

Q14. a) 0.01 s. b) Between 13.455 s and 13.465 s. c) Its precision is 1 minute (= 60 s), which is far too big for a race lasting about 13 s — every runner would round to the same minute.

Q15. a) Qualitative. b) Quantitative, by measuring. c) Quantitative, by counting. d) Qualitative.

Q16. A sample is representative when it reflects the population in the ways that matter for the question. Example: to find the favourite sport of a school, the sample should include students from every year level, not only one class.

Q17. a) Experiment — a change is made on purpose (the running) and the heart rate before and after is compared. b) Observation — nothing is changed; the temperature is only watched and recorded.

Q18. a) A census of that class of 25 students, but only a sample of the school. b) For example: the sample is only 25 of the 1,200 students, and one Year 8 class may not reflect the whole school.

Fully-worked solutions

Q1. The population is the whole group of people, objects or events we want information about. A sample is the part of the population from which data is actually collected. A census collects data from every member of the population. Sampling collects data from part of the population only.

Q2. In each case, ask: was every member of the group measured, or only some of them? a) Every returned book is scanned, so the librarian has data on the whole group — a census. b) Only 50 shoppers are asked out of all the shoppers at the market — a sample. c) Every student is photographed — a census. d) Only one bag in ten is checked, so most bags are not checked at all — a sample.

Q3. Ask: did the investigator change anything on purpose? a) No — the student only sits, watches and counts, so it is an observation. b) Yes — the amount of water is changed on purpose and two groups are compared, so it is an experiment.

Q4. a) The population is the whole group the question is about: all 2,000 ropes in the batch. b) The sample is the part the data comes from: the 30 ropes tested. c) Pulling a rope until it breaks destroys it. A census would mean breaking all 2,000 ropes, leaving none to sell — so the factory tests a sample instead and uses the result as an estimate for the whole batch.

Q5. a) First, only people who listen to that show can answer, so everyone else in the area is excluded. Second, phoning in takes effort, so the sample is mostly people with strong feelings about the route — people who do not care either way rarely call. (A third reason: 50 calls is a small sample for a whole area.) b) One group not included: people who do not listen to that radio station. The station's "nine in ten" figure describes the callers, not the whole area.

Q6. Ask: is the data words and categories, or numbers? a) Eye colour is a category — qualitative. b) Jump length is a number found by measuring — quantitative. c) Travel time is a number found by measuring — quantitative. d) Type of pet is a category — qualitative.

Q7. a) The scale reads in steps of 100 g, so the smallest unit is 100 g, which is 0.1 kg. b) The reading 3.4 kg is to the nearest 0.1 kg, so the true mass lies within half of 0.1 kg of 3.4 kg: between 3.35 kg and 3.45 kg.

Q8. a) All 26 students in the class were asked, so it is a census — of the class. b) The larger group is all 180 Year 8 students. Only one class of 26 was asked, so the class data is a sample of that larger group. Whether it is a representative sample is another question — one class may not reflect the whole year level.

Q9. a) Sample. Testing how long a battery lasts runs it down — the test destroys the battery — and a brand makes great numbers of batteries, so only some can be tested. b) Census. The point of census night is to count every person, and the ABS has the resources to run it every five years. c) Census. A carton holds only a small number of eggs, each one matters to the buyer, and checking for cracks does not destroy the egg. d) Sample. A lake holds far too much water to measure all of it, so measurements are taken from parts of it.

Q10. One fair method: number the 400 students 1 to 400 on a list, then use a random number generator (or numbered slips of the same size drawn from a bag) to choose 40 different numbers, and select the students with those numbers. Every student then has the same chance of selection, which is what makes the selection random. Any method that gives every student the same chance of selection earns the mark.

Q11. a) In a fair experiment, the groups must be treated the same in every way except the one thing being tested. Here Group A has sunlight and Group B does not, so there are two differences between the groups (fertiliser and light). If Group A grows more, we cannot say whether the fertiliser or the sunlight caused it. b) Put both groups in the same place so both get the same light — then the only difference between the groups is the fertiliser.

Q12. Problem 1: Tom counted cars, not students. One car may carry several students, so the car count is not the student count — and students who walk or ride are not in the car count at all. Problem 2: one ten-minute window on one Monday may not represent the week — wet days, different days and students arriving after 8:50 am could all change the picture. Two problems are enough; either of these earns the marks.

Q13. a) The 2021 figure (25,422,788) comes from the census — every person in Australia was counted on census night. The 2025 figure (27,801,023) is an estimate, because no census was run between 2021 and 2025. b) 27,801,023 − 25,422,788 = 2,378,235 people. c) Two reasons from: a census costs a great deal of money; collecting and processing answers from every person in the country takes a long time; running a census every year would be far more work than the value of the exact figure; estimates let the ABS track the population all the time, not just once every five years. d) The true population is not standing still: people are born, people die, and people move into and out of the country every day. The ABS updates the estimate from records of those changes, so the estimate can change every year even though no new census has been run.

Q14. a) The stopwatch reads in steps of 0.01 s, so the smallest unit is 0.01 s. b) The reading 13.46 s is to the nearest 0.01 s, so the true time lies within half of 0.01 s of 13.46 s: between 13.455 s and 13.465 s. c) A clock that reads to the nearest minute has a precision of 60 s. A sprint lasts about 13 s, so every runner would round to the same minute and no two times could be separated — the instrument does not match the task.

Q15. a) Favourite pet is a category (words, not numbers) — qualitative. b) Mass is a number found by measuring with a scale — quantitative, by measuring. c) The number of pets is a number found by counting — quantitative, by counting. d) Fur, feathers or scales is a category — qualitative.

Q16. A sample is representative of a population when it reflects the population in the ways that matter for the question being asked. Example: to find the favourite sport of students at a school of 1,200, a representative sample would include students from every year level and every kind of student in the school — not just one football team, whose answer would be biased toward football. A representative sample gives the estimate a fair chance of matching the population; a sample that is not representative can mislead even when it is large.

Q17. a) Experiment. The nurse makes a change on purpose — the students run for 5 minutes — and compares the heart rate before the change with the heart rate after it. b) Observation. The student does not change anything; the temperature is only watched and recorded, day after day.

Q18. a) Every student in the class of 25 was asked, so the data is a census — of that one class. For the school of 1,200 students, the class is only a sample. b) The council's conclusion may be wrong because one Year 8 class of 25 students may not represent the whole school: 25 is a small sample out of 1,200, and students in other year levels may give different answers. A result from a sample that may not be representative cannot be reported as if it came from the whole population.

Random and non-random sampling; analysing and reporting a distribution

Curriculum: Victorian Curriculum F–10 Version 2.0, Mathematics, Level 8 — `VC2M8ST02` *(Statistics): "analyse and report on the distribution of data from primary and secondary sources using random and non-random sampling techniques." Achievement-standard extract: "Students analyse and describe the distribution of data."*

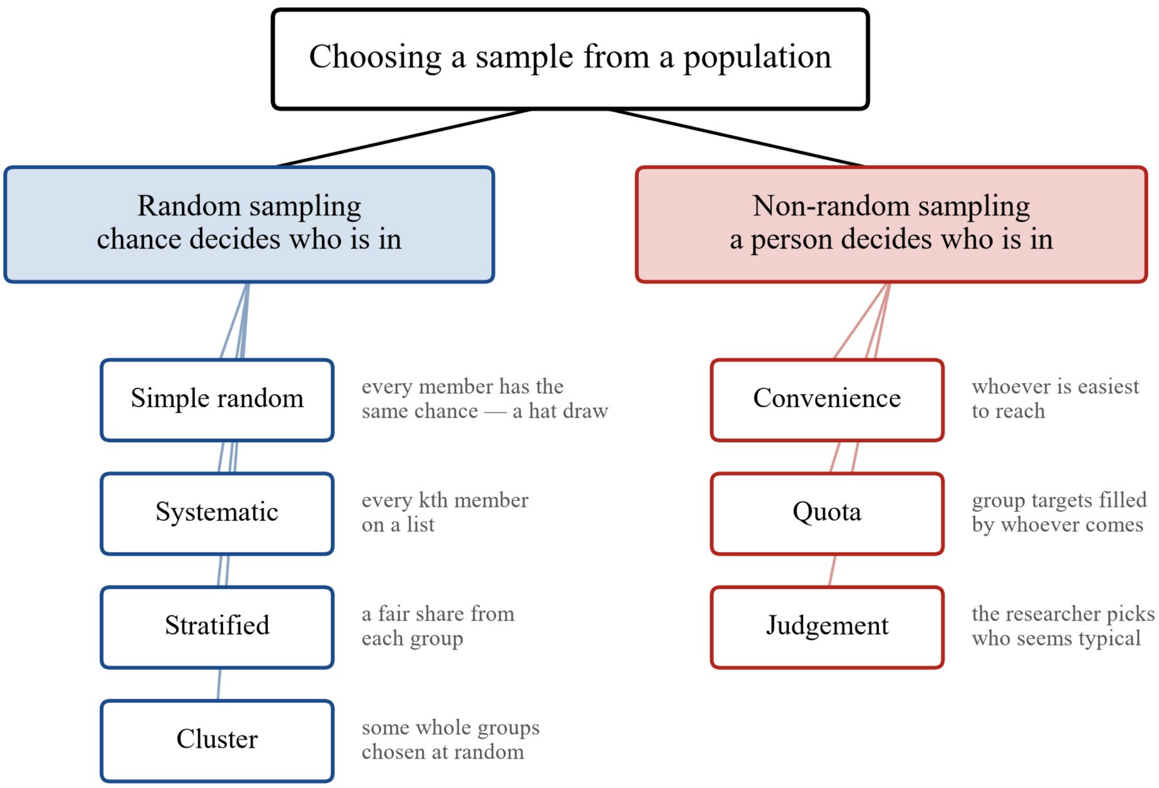
In 6A you met the four collection techniques — census, sampling, experiment and observation — and saw that a conclusion is only as strong as the data behind it. You also met **bias**, and the rule that a sample must be **representative** of its population if it is to say anything about that population. This subtopic goes one step further. When data is collected by sampling, two questions decide everything the data can tell you: **how was the sample chosen?** and **what does the data it gave actually look like?** You will learn the seven sampling methods named in the curriculum — simple random, systematic, stratified, quota, cluster, convenience and judgement — and then use samples to analyse and report the shape, centre and spread of distributions, from data a class collected itself (primary) and from the Australian Bureau of Statistics (secondary).

Theory

Random and non-random sampling

A **sample** is the part of the population from which data is actually collected, and how that part is chosen matters as much as how large it is. The seven sampling methods of this subtopic fall into two families, and the split is the same as the one in 6A: either **chance decides** who is in the sample, or **a person decides**.

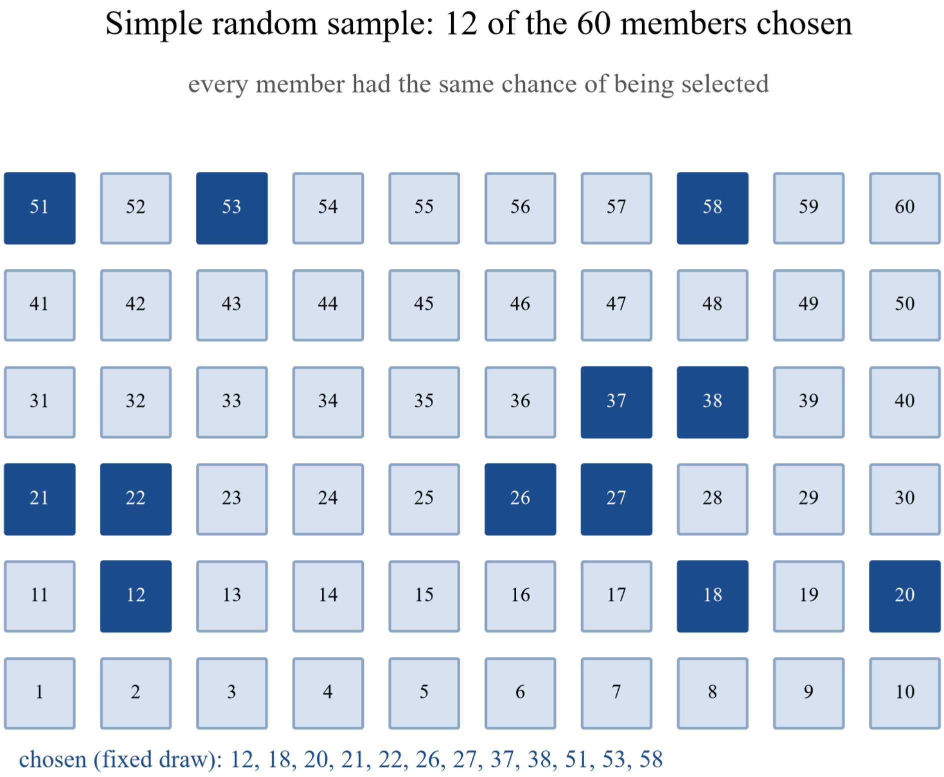
> **Key idea.** In **random sampling**, chance decides who is in the sample, so no one can pick the result in advance. In **non-random sampling**, a person decides who is in. Chance cannot favour one group over another, so a random sample is the fairest way to hear from every part of a population.



A tree diagram sorting the seven sampling methods into a random branch and a non-random branch

Random sampling methods

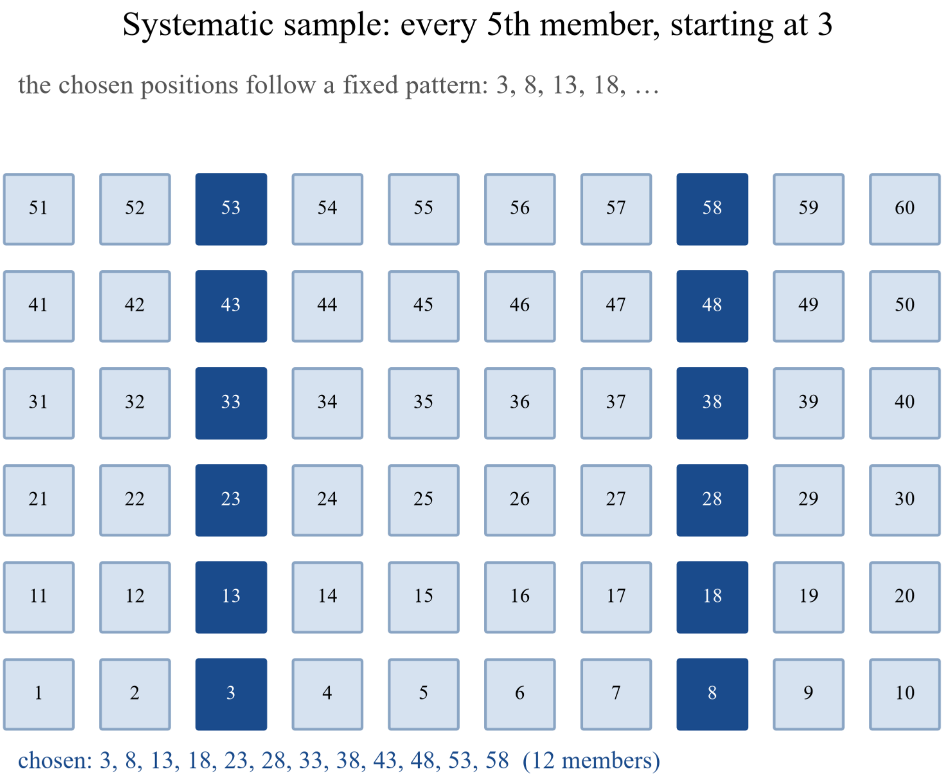
Simple random sampling — every member of the population has the same chance of being selected. Number the members 1 to N, then choose by drawing numbered slips from a hat, or by using random numbers. The draw is like a raffle: chance picks, nobody favours anyone.



A grid of 60 numbered members with the 12 members of a simple random sample filled in blue

In this figure, 12 of the 60 members are chosen — members 12, 18, 20, 21, 22, 26, 27, 37, 38, 51, 53 and 58. Every one of the 60 had the same chance of being picked. Simple random sampling works well for a small population with a complete list. Its weakness is practical: you need the full list, and a member chosen by the draw may be hard to reach on the day.

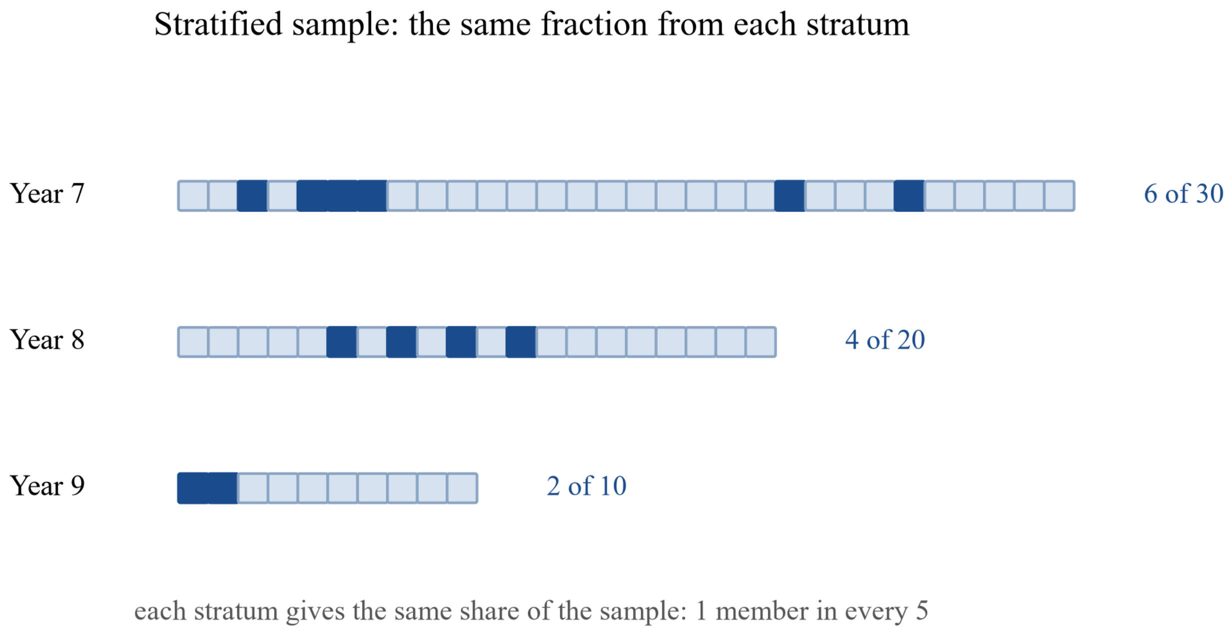
Systematic sampling — pick a random starting point on the list, then take every kth member, where the interval k is the population size divided by the sample size.



A grid of 60 numbered members with every fifth member from the third filled in blue, showing a systematic sample

Here a list of 60 gives a sample of 12: $k = 60 \div 12 = 5$, the random start is 3, and the chosen positions run 3, 8, 13, 18, … — 12 members spread evenly along the whole list. Systematic sampling is quick to run on a long list. Its weakness: if the list repeats a pattern that lines up with the interval (a list ordered house–house–flat–flat checked every second member), the sample can miss whole parts of the population.

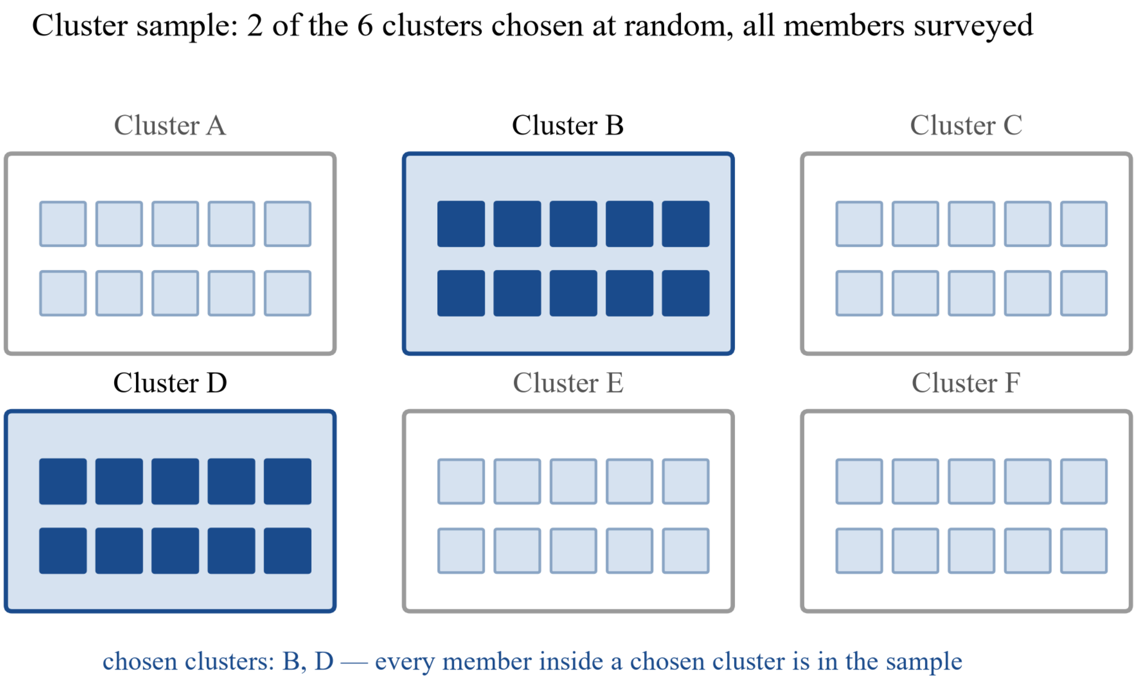
Stratified sampling — first split the population into groups that differ in a way that matters for the question; each group is called a **stratum** (plural **strata**). Then take the same fraction of members from each stratum, choosing at random within each stratum.



Three strata of members, each giving the same fraction of the sample in a stratified sample

The figure takes a sample of 12 from 60, so each stratum gives 1 member in every 5: 6 of the 30 Year 7s, 4 of the 20 Year 8s, and 2 of the 10 Year 9s. Stratified sampling is the right choice when the groups differ in size or in the thing being measured — it stops a small group from missing out by chance. Its weakness: you must know the size of every stratum and keep a list for each one before you start.

Cluster sampling — split the population into groups that are easy to reach as a block, such as home groups or classes; each group is a **cluster**. Choose some clusters at random, then survey **every member** of each chosen cluster.



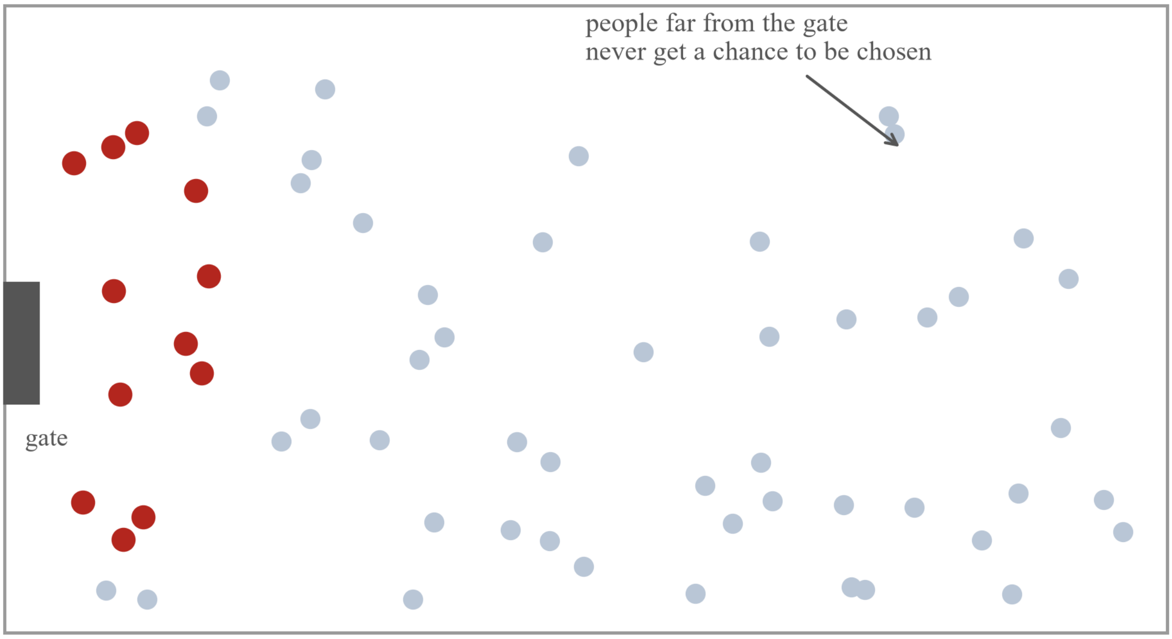
Six clusters of ten members with two clusters chosen at random and all of their members in the sample

The figure chooses 2 of the 6 clusters at random (clusters B and D) and takes all 20 members inside them. Cluster sampling is used when the population is spread across many natural groups — it is far quicker to survey two rooms of students than to chase 20 single students around the school. Its weakness: a whole cluster may share something (one home group may all walk from the same end of the suburb), so the chosen clusters may not look like the population.

Non-random sampling methods

Convenience sampling — ask whoever is easiest to reach.

Convenience sample: only the people near the gate are asked



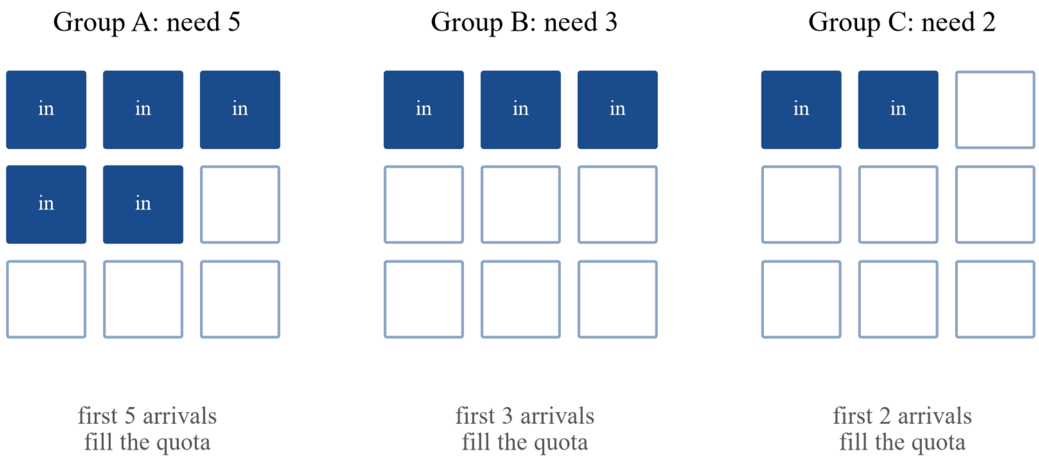
the 12 members nearest the gate (red) are the whole sample

Sixty people spread across a yard with only the 12 closest to the gate asked, showing a convenience sample

The 12 people nearest the gate are asked; everyone else never gets a chance to be chosen. Convenience sampling is cheap and quick, and sometimes it is all there is time for — but it is biased by method, because whole parts of the population have no chance of appearing in the sample.

Quota sampling — decide a fixed target (a **quota**) for each group, then fill each target by whoever comes first.

Quota sample: fixed targets for each group, filled by whoever comes first



like stratified in its group targets — unlike stratified, nothing inside each group is chosen at random

Three groups with fixed targets filled by the first people to arrive, showing a quota sample

The figure fills a quota of 5, 3 and 2 with the first arrivals in each group. Quota sampling looks like stratified sampling — both set group targets — but unlike stratified sampling, nothing inside each group is chosen at random, so who gets in still depends on who happens to come by.

Judgement sampling — the researcher picks the members they judge to be typical of the population. It is quick and uses the researcher's knowledge, but one person's judgement of "typical" can miss whole parts of the picture, and the method gives no way to check.

> **Key idea.** Non-random methods are used when a random sample is too hard, too slow or too expensive — but the conclusions they support are less reliable, because the sample may miss whole parts of the population. A report built on one must say so.

Source, size and reliability

Source. Data is **primary** when you collect it first-hand for your own question, and **secondary** when someone else collected it and you use it. Both kinds only support a conclusion if they were collected by a sound method — and a secondary source must be named and dated so a reader can check it.

Size. For a random sample, a larger sample tends to give a more reliable picture of the population — 6C looks at this in more detail. But size alone never fixes bias: a convenience sample of 500 people still misses the same people a convenience sample of 50 misses.

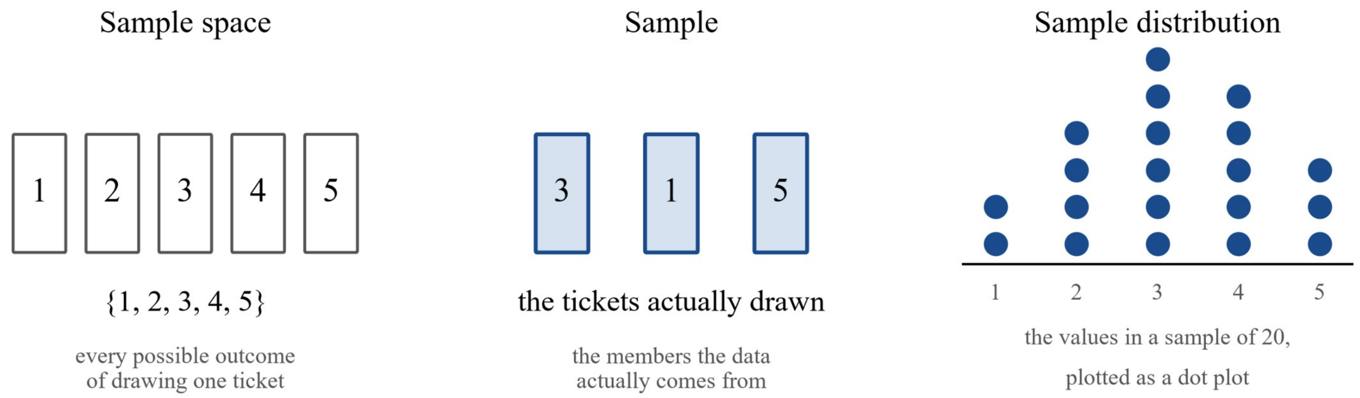
Reliability. Putting the two together:

- a conclusion from a random sample is more reliable than one from a non-random sample of the same size;
- a random sample drawn from a complete list (simple random or systematic with a random start) is more reliable than one where a person picks who gets in (convenience, quota, judgement);
- stratified adds fairness across groups that differ; cluster trades a little reliability for speed and cost;
- whatever the method, the source and the size of the sample belong in any report.

Four words that look alike

These four terms are examinable, and they are easy to mix up because they share a root.

- **Random** describes *how* the selection is made: chance decides, so every possible result can happen and nobody can pick the outcome in advance. It does not mean "any old how".
- The **sample space** is the set of **all possible** outcomes of a random selection.
- The **sample** is the members **actually chosen** — the part of the population the data comes from.
- The **sample distribution** is the distribution of the **values in a sample** — what the data looks like once it is displayed.



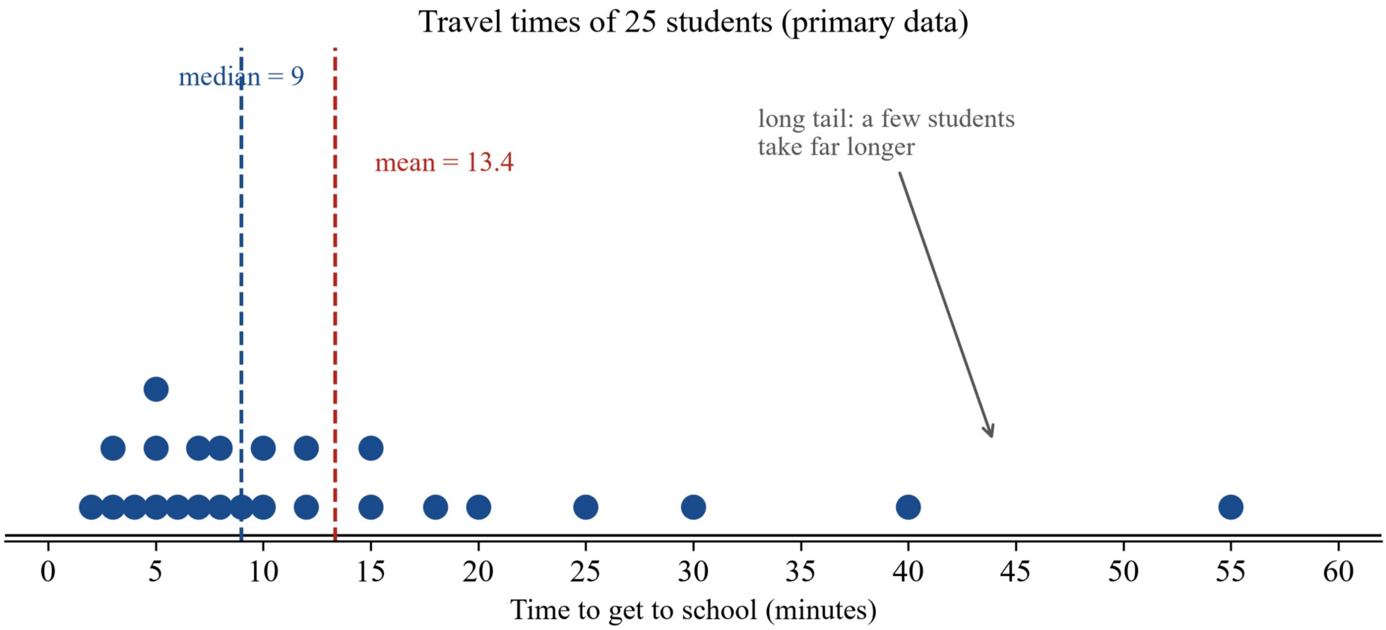
Three panels showing the sample space, the sample and the sample distribution of the same ticket draw

One draw from a bag of tickets numbered 1 to 5 has the sample space {1, 2, 3, 4, 5}. Drawing three tickets and getting 3, 1 and 5 gives one sample. And when many draws are recorded — here a sample of 20 values — the dot plot of those values is the sample distribution. The sample space is about what *could* happen; the sample is about what *did* happen; the sample distribution is about the shape of the values that came out.

Analysing a distribution from primary data

A Year 8 class of 25 students surveyed itself, each student recording how many minutes they take to get to school. The class collected the data first-hand for its own question, so it is primary data. The 25 times, in minutes, are:

2, 3, 3, 4, 5, 5, 5, 6, 7, 7, 8, 8, 9, 10, 10, 12, 12, 15, 15, 18, 20, 25, 30, 40, 55



A dot plot of the times 25 students take to get to school, with the median and the mean marked

The analysis, using the measures from Level 7:

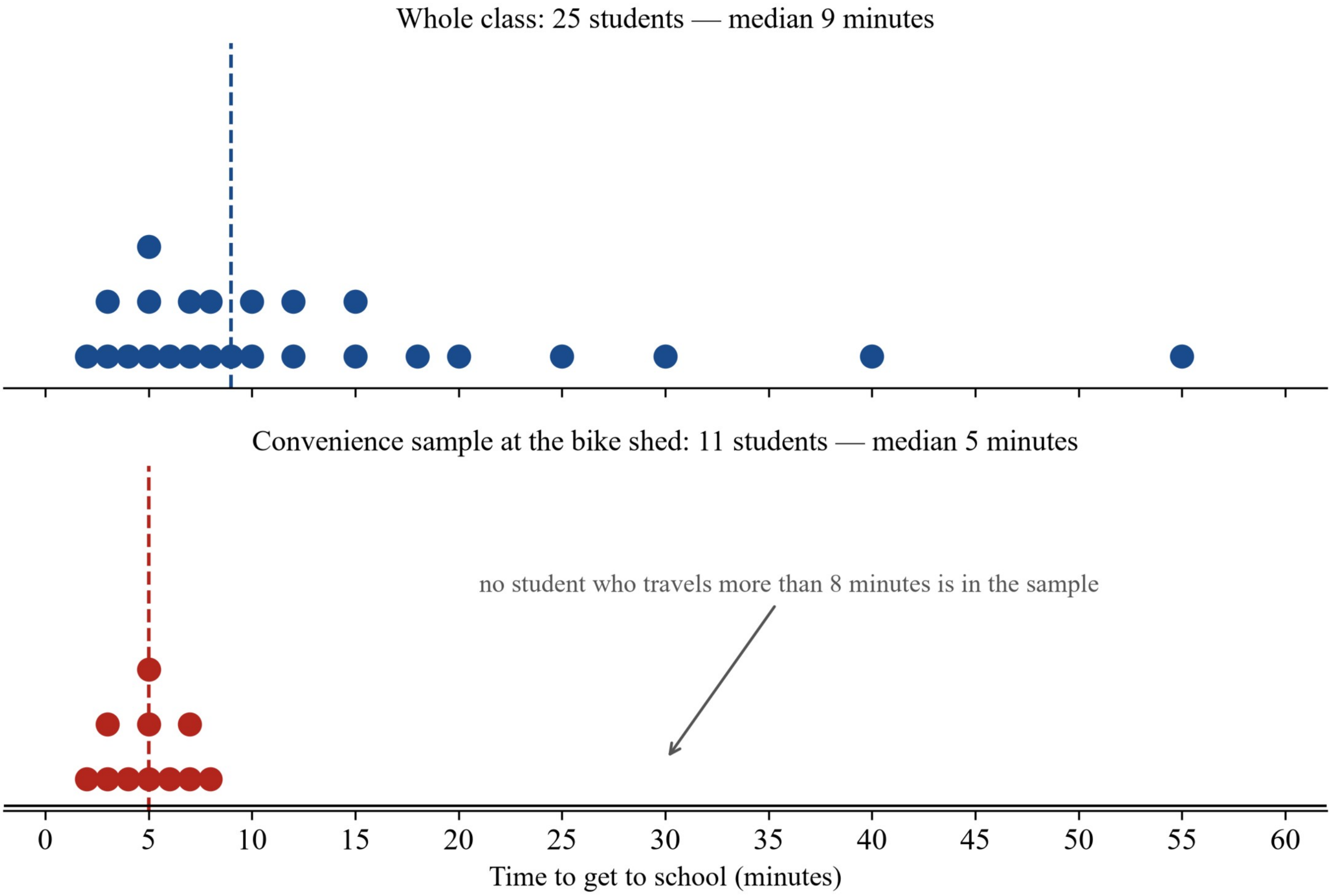
- **Mode:** 5 minutes (the most common time).
- **Median:** the 13th value in order, 9 minutes.
- **Mean:** the sum is 334, so 334 ÷ 25 = 13.36, about 13.4 minutes.
- **Range:** 55 − 2 = 53 minutes.
- **Shape:** the distribution is **skewed** to the right. Most values cluster between 2 and 15 minutes, and a long tail runs out to 55. The values 40 and 55 sit apart from the rest.

Because the tail pulls the mean up, the mean (13.4) is well above the median (9). For a skewed distribution like this one, the median is the better picture of a typical time.

What a biased sample does to the picture

Suppose instead of surveying the whole class, one student had stood at the bike shed before school and asked the first 11 students there. Those 11 times are a convenience sample:

2, 3, 3, 4, 5, 5, 5, 6, 7, 7, 8



Two dot plots comparing the travel times of the whole class with a convenience sample taken at the bike shed

The convenience sample gives a mean of 55 ÷ 11 = 5 minutes and a median of 5 minutes. A report built on it would say students take about 5 minutes to get to school — but the true class median is 9. The reason: the bike shed mostly serves students who ride, and riders mostly live near the school. Students who take the bus, the tram or a car from further away never pass the bike shed, so they never get a chance to be in the sample. Notice that asking more students at the bike shed would not help — a bigger convenience sample repeats the same mistake.

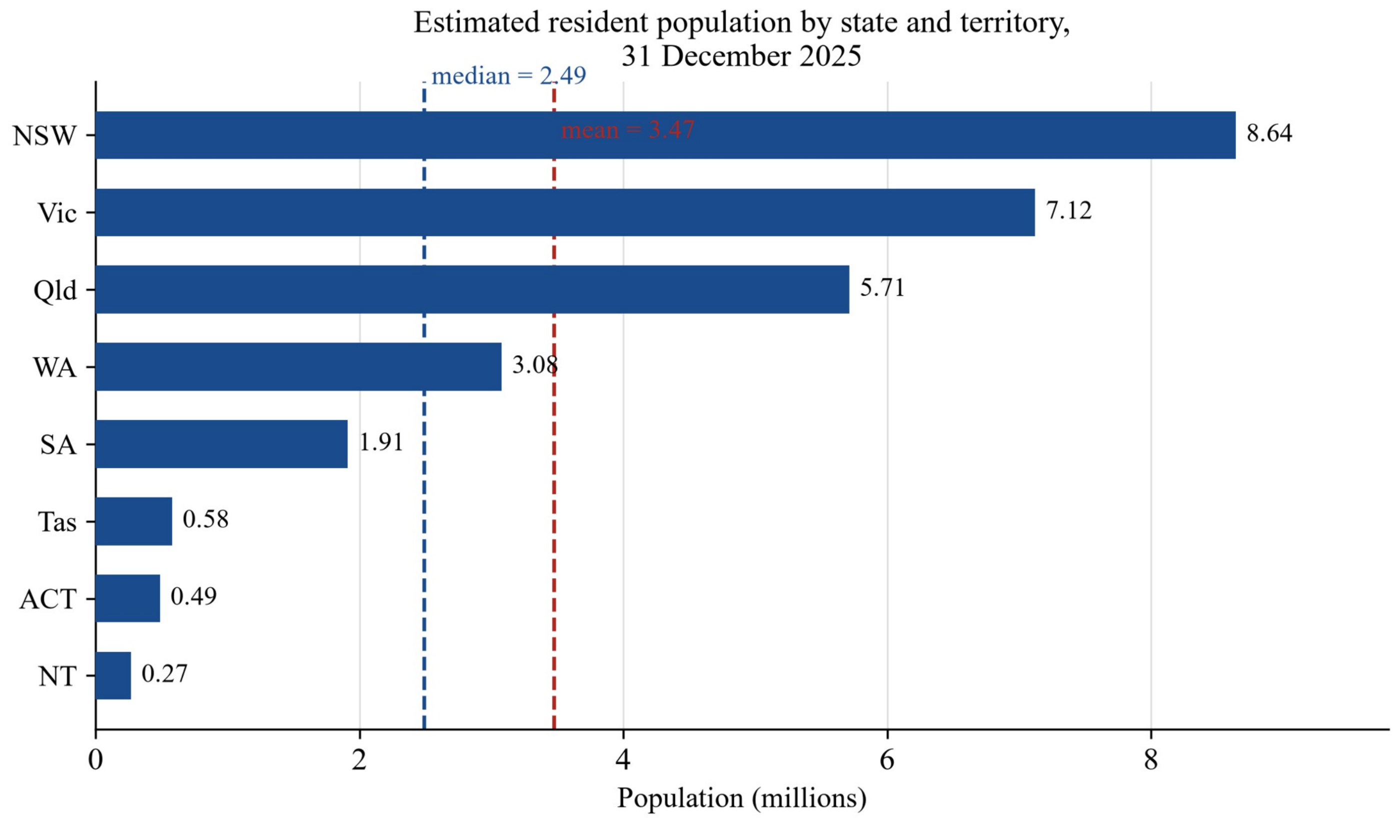
Analysing a distribution from secondary data

Now a real secondary source. The ABS publishes estimated resident population for each state and territory, together with the growth rate over the year.

State or territory	Population at 31 Dec 2025 (thousands)	Growth rate, year to 31 Dec 2025 (%)
NT	267.5	1.6
ACT	487.2	1.3
Tas	579.1	0.5
SA	1,910.6	1.0
WA	3,076.5	2.2
Qld	5,712.1	1.6
Vic	7,121.9	1.7
NSW	8,641.1	1.2

Source: Australian Bureau of Statistics, "National, state and territory population", December 2025; retrieved 20 August 2026.

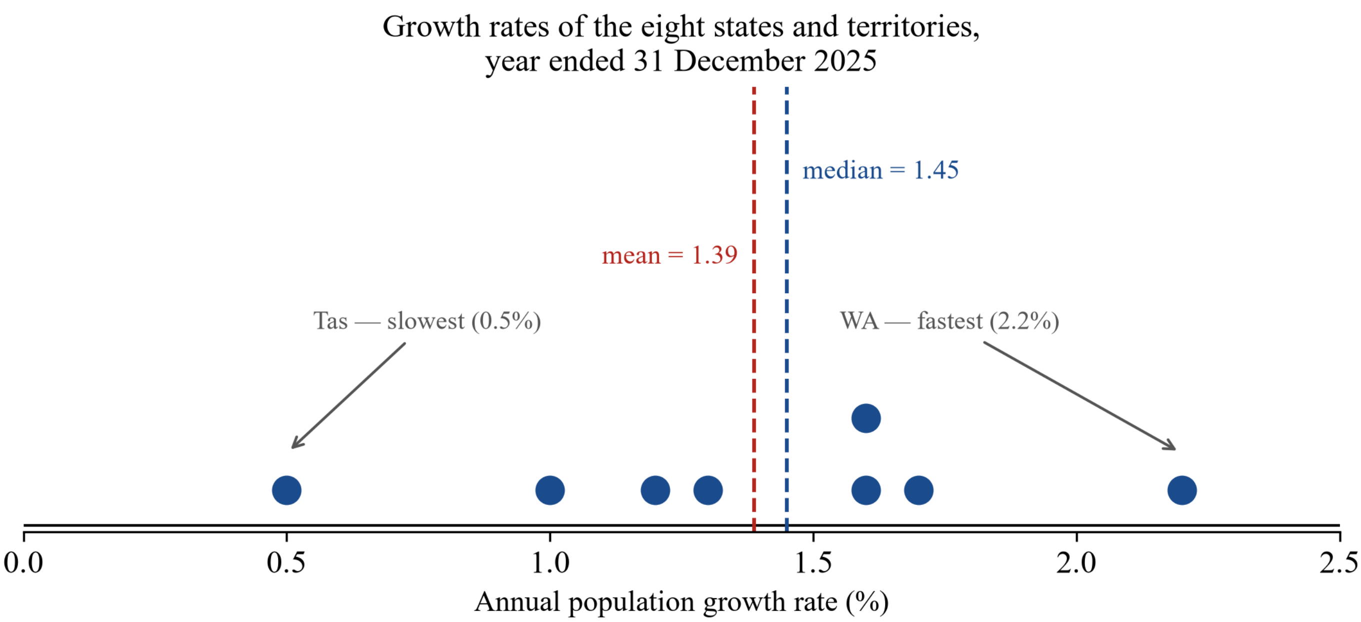
The population figures are secondary data — the ABS collected and worked on them, and we are re-using them — so the source is named and dated. Read from smallest to largest, the distribution of populations is:



A bar chart of the estimated resident populations of the eight states and territories, with the median and mean marked

- **Median:** the mean of the two middle values, (1,910.6 + 3,076.5) ÷ 2 = 2,493.55 thousand, that is 2,493,550 people.
- **Mean:** the eight values sum to 27,796.0 thousand, so the mean is 27,796.0 ÷ 8 = 3,474.5 thousand, that is 3,474,500 people. (The national total is 27,801,023 — slightly more, because it also includes the territories not listed here.)
- **Range:** 8,641.1 − 267.5 = 8,373.6 thousand, that is 8,373,600 people.
- **Shape:** strongly skewed to the right. The mean sits well above the median, and five of the eight values lie below the mean — the large states pull the mean up.

The growth rates tell a different story:



A dot plot of the annual growth rates of the eight states and territories, with the median and mean marked

- **Median:** (1.3 + 1.6) ÷ 2 = 1.45%; **mean:** 11.1 ÷ 8 ≈ 1.39%; **range:** 2.2 − 0.5 = 1.7 percentage points.

- **Shape:** close to symmetric — the mean and the median nearly agree — with WA the fastest-growing (2.2%) and Tas the slowest (0.5%).

Reporting a distribution

To *analyse* a distribution is to work out its shape, centre and spread; to *report* it is to write up what those things mean, in the context, for a reader who has not seen the data. A complete report has five parts:

Reporting a distribution — what to include

1 Source and method	where the data came from, and how the sample was chosen
2 Shape	clustered or spread out; symmetric, or skewed to one side
3 Centre	the median and the mean, and which better shows a typical value
4 Spread	the range, from the smallest value to the largest
5 Outliers and conclusion	values apart from the rest; the finding in context

finish with what the result cannot tell you — the limits of the sample

A card listing the five parts of a report on a distribution: source and method, shape, centre, spread, outliers and conclusion

Model report — the travel times. A Year 8 class surveyed all 25 of its students about the time each takes to get to school; the data is primary, collected as a class exercise. The times are skewed to the right: most students take between 2 and 15 minutes, but a few take far longer. The median is 9 minutes and the mean is about 13.4 minutes; the median better shows a typical time, because the long tail pulls the mean up. The range is 53 minutes (2 to 55), and the values 40 and 55 sit apart from the rest. Because the class is one single year level at one school, the result describes that class and cannot be taken as true for a whole school or a whole city.

Key idea. A good report tells the reader what the data shows — and, just as clearly, what the sample cannot show. Section 6C looks at how much random samples vary, and 6D has you plan, run and report your own investigation.

Worked examples

Example 1 — scaffolded

Name the sampling method in each case, and say whether it is random or non-random.

a) A library numbers its 400 returned books, picks a book by drawing a number from a hat, then checks every 20th book after it for damage.
b) The names of all 30 members of a club go into a hat, and 6 names are drawn without looking.
c) A reporter asks the first 15 people who walk past the station exit.
d) A factory splits its workers into day-shift and night-shift groups and takes a random sample from each group.

Item	Method	Random or non-random	Why
a	Systematic	Random	A random start, then a fixed interval (every 20th) along the list.
b	Simple random	Random	Every member has the same chance; the draw is by chance alone.
c	Convenience	Non-random	Whoever is easiest to reach; people who use other exits have no chance.
d	Stratified	Random	The groups (strata) are set first, then a random share is taken from each.

Example 2 — scaffolded

A school of 1,200 students has 360 in Year 7, 340 in Year 8, 280 in Year 9 and 220 in Year 10. The council wants a stratified sample of 60 students.

a) What fraction of the school is in the sample? b) How many students from each year level? c) How should the students be chosen within each year level?

Step	Comment
60 ÷ 1,200 = 1/20	The sample takes 1 student in every 20, the same fraction from every year level.
Year 7: 360 ÷ 20 = 18	Each stratum gives the same share of its members.
Year 8: 340 ÷ 20 = 17	
Year 9: 280 ÷ 20 = 14	
Year 10: 220 ÷ 20 = 11	
Check: 18 + 17 + 14 + 11 = 60	The shares add up to the sample size.
Within each year level, number the students and choose by chance — hat draw or random numbers.	A stratified sample is random *inside* each stratum; without that it would be a quota sample.

Example 3 — scaffolded

Using the ABS growth rates in the table above, write a report on the distribution, covering source and method, shape, centre, spread and conclusion.

Part of the report	Working or text
Source and method	The ABS published growth rates for each state and territory to 31 December 2025; the data is secondary and is cited. All eight states and territories are included — this part is a census of the eight, not a sample.
Centre	Median = (1.3 + 1.6) ÷ 2 = 1.45%; mean = 11.1 ÷ 8 ≈ 1.39%.
Spread	Range = 2.2 − 0.5 = 1.7 percentage points.
Shape	Close to symmetric — mean and median nearly agree.
Report text	“Growth rates ranged from 0.5% (Tasmania) to 2.2% (Western Australia), with a median of 1.45% per year. The distribution is close to symmetric, so the mean and the median tell much the same story. Most states and territories grew by between 1.0% and 1.7%, while WA grew fastest. As the data covers only one year, a single fast or slow year for one state would change the

Part of the report	Working or text
	picture.”

Example 4 — unscaffolded

A sports club keeps a numbered list of its 400 members. Design a systematic sample of 20 members, using a random start of 7. Name the first four members chosen and the last one.

The interval is $k = 400 \div 20 = 20$. Starting at 7, the chosen members are 7, 27, 47, 67, … and so on, adding 20 each time: the first four are members 7, 27, 47 and 67. The last member chosen is $7 + 20 \times 19 = 387$. The 20 chosen members are spread evenly over the whole list, and the only choice made by chance is the starting number.

Example 5 — unscaffolded

A council wants to know whether residents support a new bus route.

- Method A asks 120 people at the shopping centre on Saturday morning; 85% support the route.
- Method B asks 40 residents chosen at random from the city’s whole list of residents; 52% support it.

a) Which method gives the more reliable conclusion? b) Explain why the other result may be wrong, even though its sample is three times larger.

b) Method B. Its sample is random — every resident on the list had the same chance of being asked — so its 52% is a fair estimate for the whole city.

c) Method A is a convenience sample: it only reaches people who go to that centre on a Saturday morning. Residents who work on Saturday, or shop in other places or at other times, have no chance of being asked, so the sample misses whole parts of the city. Size does not fix this — 120 people drawn from one place at one time still describe that place and time, not the city.

Practice questions

Scaffolded

Q1. Complete each sentence in your own words.

- When a sample is chosen ______, chance decides who is in it.
- The sample space is ______.
- The sample is ______.
- The sample distribution is ______.

Q2. Say whether each sample is **random** or **non-random**. If it is non-random, name the method (convenience, quota or judgement).

a) Every student’s name goes into a drum, and 25 names are drawn without looking.
b) A reporter asks the first 20 people to walk past the station exit.
c) A survey team keeps asking people at the market until 10 men and 10 women have answered.
d) A coach picks the 5 players she believes are most typical of the team.

Q3. A chess club has 40 members. Describe a way to choose a simple random sample of 8 members.

Q4. A club of 320 members keeps a numbered list from 1 to 320. A systematic sample of 16 members is wanted.

a) What is the sampling interval? b) If the random start is 12, name the first four members chosen.

Q5. The club in Q4 has 120 junior members, 160 senior members and 40 life members. The council wants a stratified sample of 40 members. How many members of each kind should be in the sample?

Q6. A council splits the residents of a city into age groups, then chooses the same fraction of residents at random from each group. Which sampling method is this?

A. cluster sampling B. convenience sampling C. stratified sampling D. quota sampling

Q7. A student stands at the basketball courts at lunch and asks everyone there whether the school should buy new basketballs. Give two reasons why this sample is biased.

Q8. Match each situation to the best sampling method: **simple random**, **systematic**, **stratified** or **cluster**.

a) A factory checks every 25th bottle on a filling line.
b) A school has 30 home groups; the principal chooses 2 home groups at random and surveys every student in them.
c) A school has three year levels of very different sizes, and the council wants a fair share from each.
d) All 250 raffle tickets go into a drum, and 5 are drawn.

Unscaffolded

Q9. Name the sampling method used in each case.

a) Every 8th house on the street list is visited.
b) Three streets are chosen at random, and every house in those streets is surveyed.
c) The names of all 200 staff go into a drum, and 25 are drawn.
d) A market researcher chooses 4 shoppers she judges to be typical customers.

Q10. Explain why a convenience sample can mislead even when it is very large.

Q11. A school has 30 home groups of 24 students each. The student council wants to ask 48 students about the new uniform.

a) Describe how to choose a cluster sample of 48 students. b) Give one reason why the council might choose a cluster sample instead of a simple random sample of 48 students.

Q12. At the bike shed, a student asks the first 11 students there how long they take to get to school. Their times, in minutes, are: 2, 3, 3, 4, 5, 5, 5, 6, 7, 7, 8.

a) Find the mean and the median of these 11 times. b) The median for the whole class of 25 students is 9 minutes. Explain why the bike-shed sample gives a lower result.

Q13. Use the ABS table in the theory section.

a) Find the median population. b) Find the mean population of the eight states and territories. c) Which states and territories have a population above the mean? d) Explain why the mean is so much larger than the median.

Q14. Use the growth-rate column of the same table.

a) Find the median, the mean and the range of the eight growth rates. b) Which state or territory grew the fastest, and which grew the slowest?

Q15. Fifteen students chosen at random from a school library's borrowing list were asked how many books each read last term. Their answers: 0, 1, 1, 2, 2, 2, 3, 3, 3, 3, 4, 4, 5, 6, 8.

Write a report of this distribution, covering source and method, shape, centre, spread and conclusion.

Q16. Two surveys ask residents the same question: "Do you support the new bus route?"

- Survey A asks 200 people at the train station on a Monday morning; 64% support the route.
- Survey B asks 50 residents chosen at random from the city's whole list of residents; 52% support it.

Which survey gives the more reliable conclusion, and why? In your answer, explain why the larger sample does not settle the question.

Q17. A bag contains 5 tickets numbered 1, 2, 3, 4 and 5. Tickets are drawn from the bag one at a time, without looking.

a) Write the sample space for the first draw. b) The three tickets drawn are 2, 4 and 5. What is this set of tickets called? c) A dot plot of the values 2, 4 and 5 is a picture of what? d) In your own words, what does *random* mean in “the ticket is drawn at random”?

Q18. A school of 900 students has 260 in Year 7, 240 in Year 8, 220 in Year 9 and 180 in Year 10. The student council wants a stratified sample of 45 students.

a) Find the number of students to sample from each year level. b) Explain why this method is fairer than asking whoever is in the canteen at lunch.

Answers

Q1. at random; the set of all possible outcomes of a random selection; the members actually chosen, from whom the data is collected; the distribution of the values in a sample.

Q2. a) Random (simple random). b) Non-random — convenience. c) Non-random — quota. d) Non-random — judgement.

Q3. Number the members 1 to 40, write each number on a slip of the same size, mix the slips in a bag, and draw 8 without looking; survey the members with those numbers.

Q4. a) 320 ÷ 16 = 20. b) 12, 32, 52, 72.

Q5. The sample is 40 of 320 members, 1 in every 8: juniors 120 ÷ 8 = 15, seniors 160 ÷ 8 = 20, life members 40 ÷ 8 = 5.

Q6. C — stratified sampling.

Q7. Any two of: only students at the courts are asked, and students who do not play or watch basketball never get a chance to answer; students who play basketball are more likely to want new basketballs; the survey is done at lunch, so students who are not at the courts then are missed.

Q8. a) Systematic. b) Cluster. c) Stratified. d) Simple random.

Q9. a) Systematic. b) Cluster. c) Simple random. d) Judgement.

Q10. The people easiest to reach are not like everyone else: members of the population who are harder to reach never have a chance of being in the sample, so the sample keeps showing the same part of the population — and a larger convenience sample repeats the same mistake, it does not fix it.

Q11. a) Number the 30 home groups, choose 2 of them at random, and survey all 24 students in each chosen group (2 × 24 = 48). b) Any one of: it is quicker and cheaper — the surveyor visits two rooms instead of finding 48 separate students from a school-wide list.

Q12. a) Mean = 55 ÷ 11 = 5 minutes; median = 5 minutes. b) The bike shed is used mostly by students who ride, and riders mostly live near the school; students who come from further away by bus, tram or car never pass the bike shed, so the longer times are missing from the sample.

Q13. a) 2,493,550 people. b) 3,474,500 people. c) Queensland, Victoria and New South Wales. d) The distribution is skewed to the right: the three large states are far above the rest and pull the mean up, while the median only uses the middle two values.

Q14. a) Median = 1.45%; mean ≈ 1.39%; range = 1.7 percentage points. b) Fastest: Western Australia (2.2%); slowest: Tasmania (0.5%).

Q15. A report should name the source and method (15 students chosen at random from the borrowing list; primary data), describe the shape (skewed to the right, most values between 0 and 4, a tail to 8), give the centre (median 3 books, mean about 3.1 books, mode 3), give the spread (range 8 books, 0 to 8), and end with a conclusion in context, noting the limits (15 students from one list give an estimate, not a census, of the school's reading).

Q16. Survey B. Survey A only reaches people at the station on a Monday morning; residents who are not there then have no chance of being asked, so the sample misses whole parts of the city. Size does not fix this: 200 people drawn from one place at one time still describe that place and time, not the city.

Q17. a) {1, 2, 3, 4, 5}. b) The sample. c) The sample distribution. d) Chance decides which ticket comes out; every ticket has the same chance, and nobody can pick the result.

Q18. a) 45 ÷ 900 = 1/20, so Year 7: 260 ÷ 20 = 13, Year 8: 240 ÷ 20 = 12, Year 9: 220 ÷ 20 = 11, Year 10: 180 ÷ 20 = 9 (check 13 + 12 + 11 + 9 = 45). b) At the canteen at lunch, only students who use the canteen at lunch can be asked, so whole groups may be missed; the stratified sample gives every year level its fair share and chooses at random within each one, so every student has a chance.

Fully-worked solutions

Q1. A sample chosen **at random** is one where chance decides who is in — nobody picks the members. The **sample space** is the set of all possible outcomes of a random selection: with one ticket in a bag, it is every ticket that could come out. The **sample** is the members actually chosen — the part of the population the data really comes from. The **sample distribution** is the distribution of the values in a sample: once the data is plotted, its shape, centre and spread are the sample distribution. The three differ: the sample space is what *could* happen, the sample is what *did* happen, and the sample distribution is what the resulting values look like.

Q2. Ask in each case: does chance decide who is in, or does a person? a) The drum draw gives every student the same chance — random, and the method is simple random sampling. b) The first 20 people past one exit are whoever is easiest to reach — non-random, convenience. c) The team sets group targets (10 men, 10 women) but fills them with whoever comes first — non-random, quota. d) The coach picks by her own judgement of "typical" — non-random, judgement.

Q3. A simple random sample needs every member to have the same chance. One way: number the 40 members 1 to 40, write each number on a slip of the same size, put all 40 slips in a bag and mix them, then draw 8 slips without looking. The members with those 8 numbers form the sample. (Choosing 8 different numbers from a table of random numbers would also do.)

Q4. a) The interval is the population divided by the sample: 320 ÷ 16 = 20. b) From the random start 12, add 20 each time: members 12, 32, 52 and 72 are the first four.

Q5. A stratified sample takes the same fraction from each group. The fraction is 40 ÷ 320 = 1/8, so take 1 member in every 8 from each kind: juniors 120 ÷ 8 = 15, seniors 160 ÷ 8 = 20, life members 40 ÷ 8 = 5. Check: 15 + 20 + 5 = 40. Within each kind, the members are then chosen at random.

Q6. The residents are first split into groups (age groups), then a random share is taken from each group — that is **stratified sampling, C**. It is not quota sampling (D) because the selection inside each group is random; it is not cluster (A) because whole groups are not taken; it is not convenience (B) because nobody is picked for being easy to reach.

Q7. Two reasons: first, only students at the courts at lunch are asked, and students who never go there — most of the school — have no chance of answering. Second, the students at the courts are the ones who play or watch basketball, and they are more likely to want new basketballs, so the sample is pulled toward "yes". (Either reason earns a mark; any two valid reasons do.)

Q8. a) A fixed interval along the line — systematic. b) Whole groups (home groups) are chosen at random and everyone inside is surveyed — cluster. c) The year levels differ in size and each must give its fair share — stratified. d) Every ticket has the same chance in one draw — simple random.

Q9. a) A fixed interval down the list — systematic. b) Whole streets are chosen at random and every house inside is surveyed — cluster. c) Names drawn from a drum so every member has the same chance — simple random. d) The researcher picks who seems typical by her own judgement — judgement.

Q10. A convenience sample is biased by method: the people easiest to reach are not like the whole population, and the members who are harder to reach never have a chance of being in the sample. The sample therefore keeps showing the same part of the population. Making it larger does not help — a larger convenience sample is more of the same people, not more of the population — so it can give a confident-sounding answer about the wrong group.

Q11. a) Number the 30 home groups 1 to 30, choose 2 numbers at random, and survey all 24 students in each chosen group. Two groups × 24 students = 48 students, the sample size wanted. b) Any one of: it is much quicker — the surveyor only needs to visit two rooms; or it needs no school-wide list of all 720 students, only the list of home groups. The price is that the two chosen groups may not look like the whole school, which is why cluster sampling is traded for speed and cost.

Q12. a) The sum of the 11 times is 2 + 3 + 3 + 4 + 5 + 5 + 5 + 6 + 7 + 7 + 8 = 55, so the mean is 55 ÷ 11 = 5 minutes. The median is the 6th value in order, 5 minutes. b) The bike shed mostly serves students who ride to school, and riders mostly live near the school — so the shed is full of short times. Students who travel from further away come by bus, tram or car and never pass the shed, so the long times that the whole-class data shows (up to 55 minutes) cannot appear in the bike-shed sample. That is sampling bias: some members of the class had no chance of being in the sample.

Q13. a) With the eight values in order, the median is the mean of the 4th and 5th: (1,910.6 + 3,076.5) ÷ 2 = 2,493.55 thousand, that is 2,493,550 people. b) The eight values sum to 27,796.0 thousand, so the mean is 27,796.0 ÷ 8 = 3,474.5 thousand, that is 3,474,500 people. c) Above the mean are Queensland (5,712.1), Victoria (7,121.9) and New South Wales (8,641.1) — three of the eight; five values lie below the mean. d) The distribution is strongly skewed to the right: NSW and Victoria (and to a lesser degree Queensland) are far larger than the other five, and large values pull the mean up while the median only uses the two middle values. A mean well above the median is the mark of a right-skewed distribution.

Q14. a) In order the rates are 0.5, 1.0, 1.2, 1.3, 1.6, 1.6, 1.7, 2.2. The median is the mean of the two middle values: (1.3 + 1.6) ÷ 2 = 1.45%. The sum is 11.1, so the mean is 11.1 ÷ 8 = 1.3875, about 1.39%. The range is 2.2 − 0.5 = 1.7 percentage points. b) The fastest-growing was Western Australia at 2.2% per year; the slowest was Tasmania at 0.5%.

Q15. A model report: *Source and method:* 15 students were chosen at random from the school library's borrowing list and each was asked how many books they read last term; the data is primary. *Shape:* the distribution is skewed to the right — most students read between 0 and 4 books, with a tail running out to 8. *Centre:* the median is 3 books and the mean is 47 ÷ 15 ≈ 3.1 books; the mode is 3. *Spread:* the range is 8 − 0 = 8 books, and the value 8 sits a little apart from the rest. *Conclusion:* a typical student on the list read about 3 books last term; because only 15 of the borrowers were asked, this is an estimate for borrowers, not a count for the whole school, and it says nothing about students who never borrow. A report that names the source and method, describes shape, centre and spread with the right numbers, and ends by saying what the sample cannot show, earns full marks.

Q16. Survey B gives the more reliable conclusion. Its 50 residents were chosen at random from the city's whole list, so every resident had the same chance of being asked and the 52% is a fair estimate for the city. Survey A is a convenience sample: it only reaches people at the train station on a Monday morning — commuters and early risers — and misses everyone else. The larger size does not settle the question because size cannot fix bias: 200 people drawn from one place at one time tell you more about that place and time, not more about the city. A small random sample beats a large convenience sample.

Q17. a) The first draw can give any of the five tickets, so the sample space is {1, 2, 3, 4, 5}. b) The tickets actually drawn — 2, 4 and 5 — are the **sample**: the members the data comes from. c) A dot plot of the sample's values is the **sample distribution** — the picture of the values that came out. d) *Random* means chance decides which ticket comes out: every ticket has the same chance of being drawn, and nobody looking in the bag can pick the result. It does not mean "any old how".

Q18. a) The sample takes the same fraction from each year level: 45 ÷ 900 = 1/20, so 1 student in every 20. Year 7: 260 ÷ 20 = 13; Year 8: 240 ÷ 20 = 12; Year 9: 220 ÷ 20 = 11; Year 10: 180 ÷ 20 = 9. Check: 13 + 12 + 11 + 9 = 45. Within each year level the students are then chosen at random. b) At the canteen at lunch, only students who use the canteen at lunch can be asked — students who bring lunch, play sport or leave the school then have no chance, and the sample is biased by method. The stratified sample fixes both problems: every year level gives its fair share, so no year level is missed or overdone, and within each year level chance decides, so every student has a chance of being in.

Variation between random samples and the effect of sample size

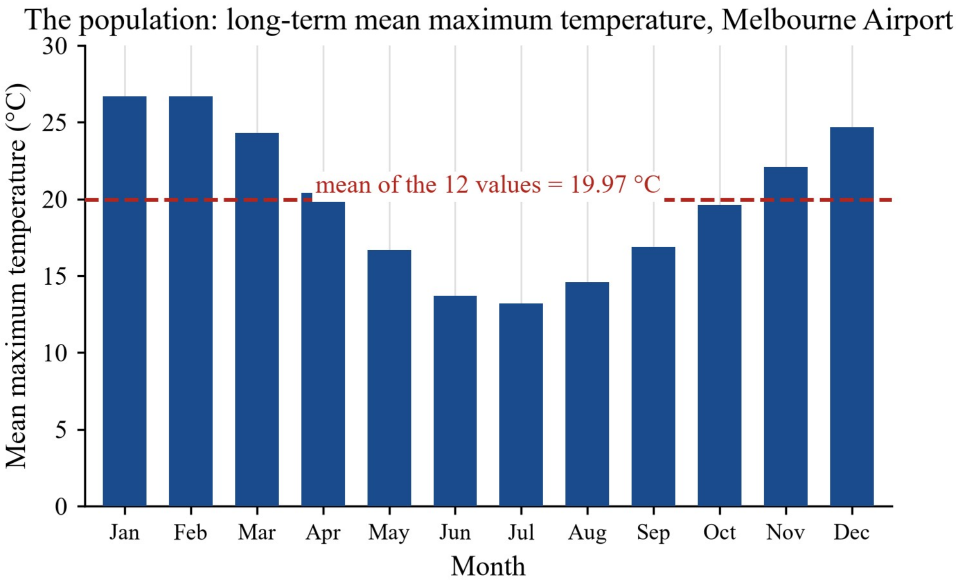
Curriculum: Victorian Curriculum F–10 Version 2.0, Mathematics, Level 8 — `VC2M8ST03` (Statistics): "compare variations in distributions and proportions obtained from random samples of the same size drawn from a population and recognise the effect of sample size on this variation." Achievement-standard extract: "They compare the variation in distributions of random samples of the same and different size from a given population with respect to shape, measures of central tendency and range."

In Year 7 you calculated the range, median, mean and mode, displayed numerical data on dot plots, and planned and conducted statistical investigations (`VC2M7ST01`–`VC2M7ST03`). That work is assumed here, not re-taught. Section 6A defined a population and a sample; Section 6B looked at how samples are chosen. This subtopic asks the next question: **if we take several random samples of the same size from one population, how much do they differ — and what does the sample size change?**

Theory

A population we can hold in our hands

To see how samples behave, we use a population small enough to hold: the twelve monthly mean maximum temperatures recorded at Melbourne Airport. Each value is the long-term average for that month, so the twelve values are fixed — this is our whole population.



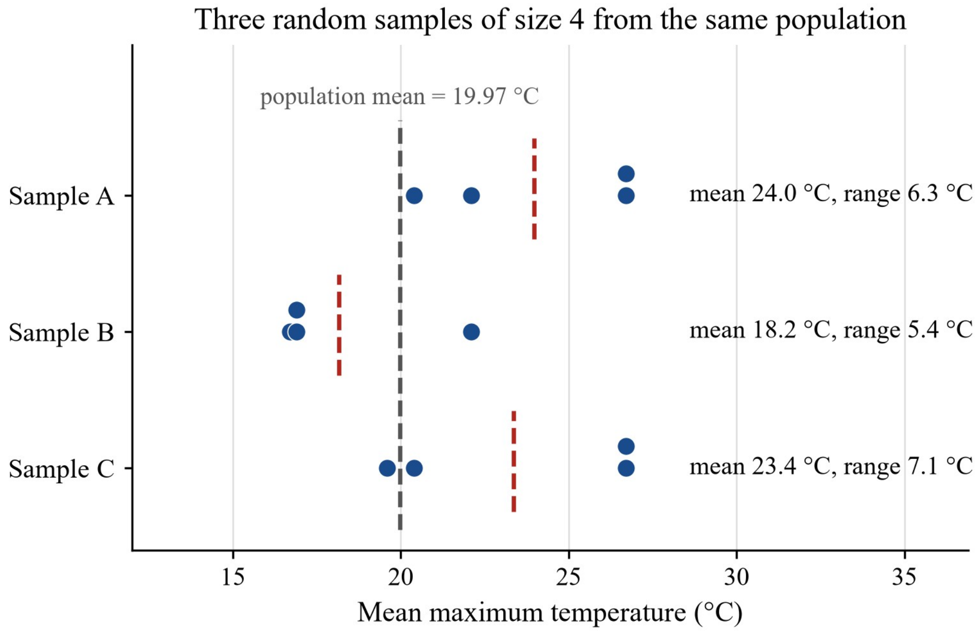
Bar chart of the long-term mean maximum temperature at Melbourne Airport for each month, with a dashed line at the mean of the 12 values, 19.97 degrees Celsius.

Source: Bureau of Meteorology, Climate statistics for Australian locations, Melbourne Airport (site 086282), long-term averages 1970–2026; retrieved 20 August 2026.

For this population: the mean of the 12 values is 19.97 °C, the median is 20.0 °C and the range is 26.7 − 13.2 = 13.5 °C. Imagine each month written on a card. Drawing a random sample then means mixing the twelve cards and drawing some of them without looking, so every card has the same chance of being drawn.

Samples of the same size vary

Three random samples of size 4 are drawn from the cards:

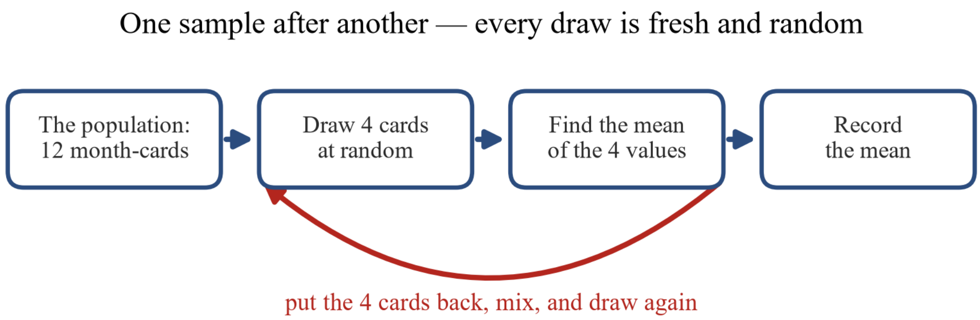


Dot strips for three random samples of size 4 from the same population, with the mean and range of each sample.

All three samples come from the **same** population and are the **same** size, yet they differ in shape, centre and spread: the means are 24.0 °C, 18.2 °C and 23.4 °C, and the ranges are 6.3 °C, 5.4 °C and 7.1 °C. None of the three means equals the population mean of 19.97 °C. This is the first idea in the content description: **random samples of the same size, drawn from the same population, vary from sample to sample.** A single sample is therefore only an estimate of the population — a lucky or unlucky draw can sit well above or below the population value.

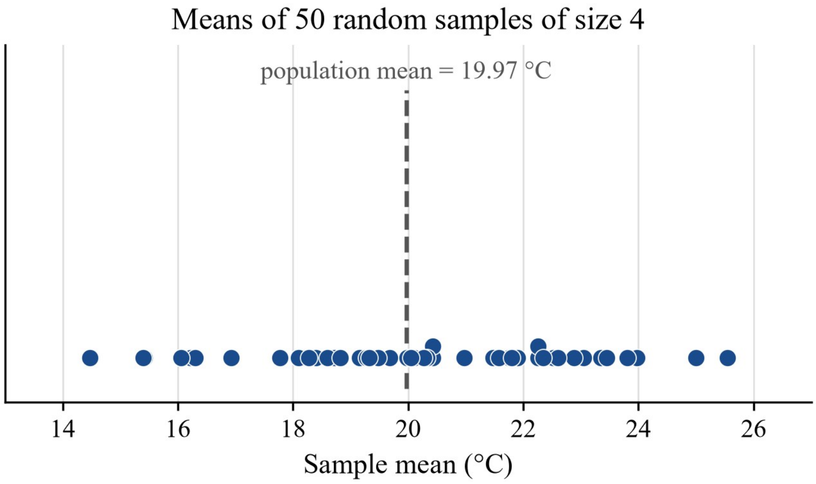
Repeated sampling

One way to see the whole pattern of that variation is to repeat the draw many times: take a sample, find its mean, record it, put the cards back, mix, and draw again.



Flow chart of repeated sampling: start with 12 month cards, draw 4 at random, find the mean, record it, then put the cards back and draw again.

Putting the cards back each time matters: it keeps every draw from the **same** population of twelve values. The same repeated sampling can be done with a digital tool (a spreadsheet or a simulator), which is what makes fifty or five hundred samples quick to collect — but the card version and the digital version are the same process. Doing it fifty times with samples of size 4 gives:

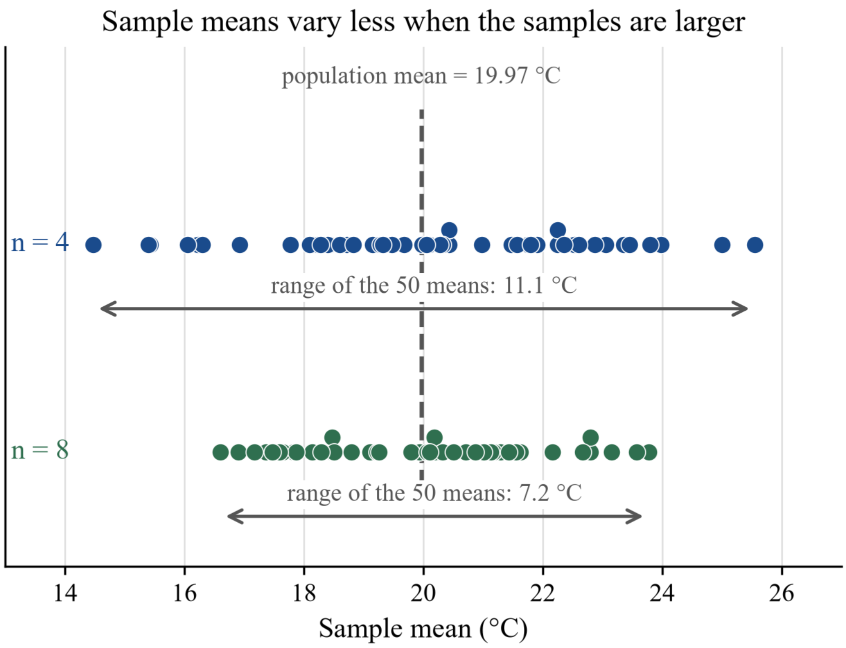


Dot strip of the means of 50 random samples of size 4, spread around the population mean.

The fifty means form a distribution of their own. It is centred close to the population mean — the mean of the fifty means is 20.1 °C, against the population's 19.97 °C — but individual sample means spread from 14.47 °C to 25.55 °C. Most sit within a few degrees of the population mean, and a few sit far away. That spread is the variation between samples, made visible.

The effect of sample size

Now repeat the same process with samples of size 8 instead of 4, and line the two distributions up:



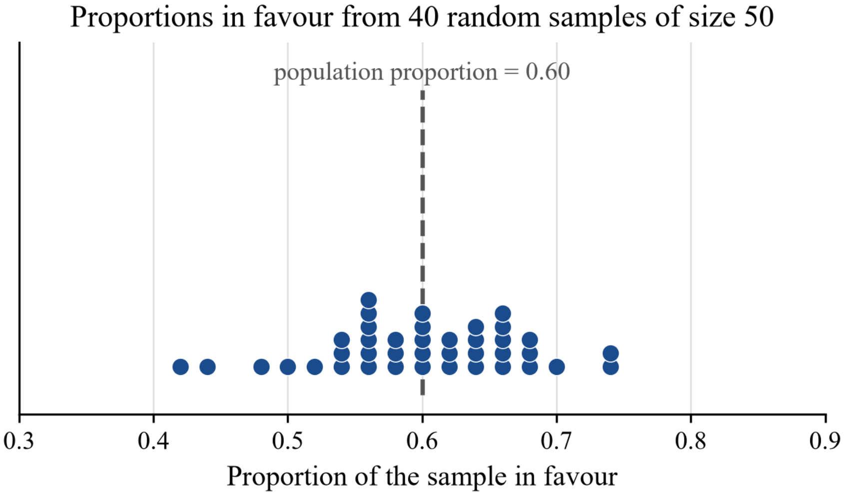
Dot strips of 50 sample means for samples of size 4 and size 8; the range of the means is smaller for the larger samples.

Both rows centre on the same population mean — changing the sample size does **not** change where the means centre. What changes is the spread: the fifty means of size 4 cover a range of 11.1 °C, while the fifty means of size 8 cover only 7.2 °C. Larger samples vary less.

> **Key idea.** Random samples of the same size vary from sample to sample in shape, centre and spread. As the sample size grows, that variation shrinks: sample means (and sample proportions) cluster more closely around the population value. This is why a bigger random sample gives a more trustworthy estimate — not a different centre, but a steadier one.

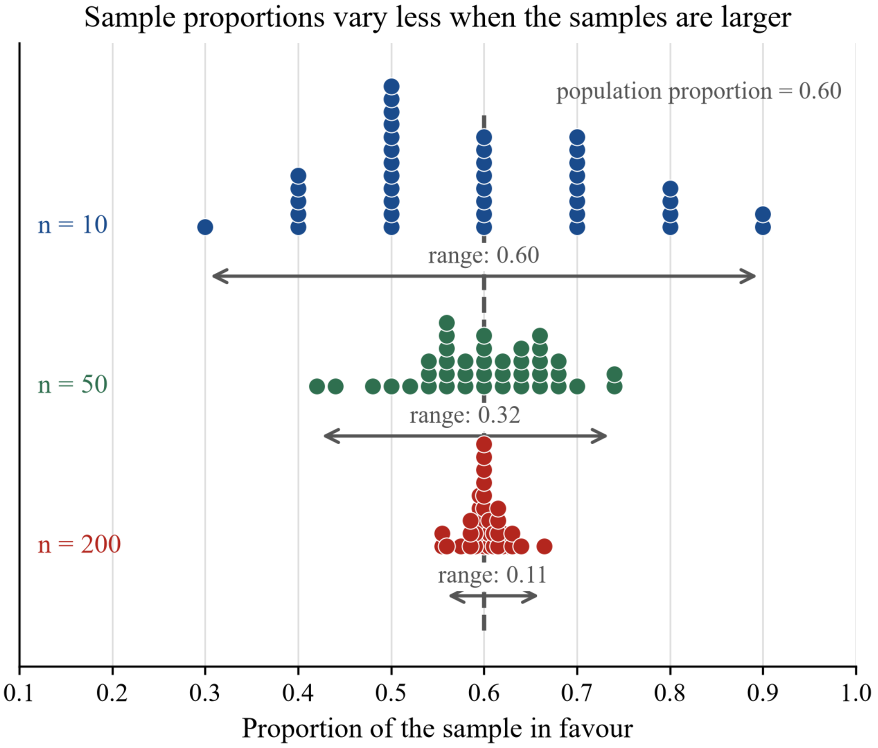
Proportions vary too

The same story holds for proportions, not just means. Suppose a school of 500 students is voting on a proposal for a change in school uniform, and 300 of the 500 are in favour. The population proportion in favour is 300 ÷ 500 = 0.60. Ask a random sample of 50 students instead, and the sample proportion will usually not be exactly 0.60:



Dot strip of the proportions in favour from 40 random samples of size 50, spread around the population proportion of 0.60.

Forty samples of size 50 give proportions from 0.42 to 0.74 — three of the forty even report less than half in favour, although 60% of the whole school is in favour. Now compare sample sizes 10, 50 and 200 from the same population:

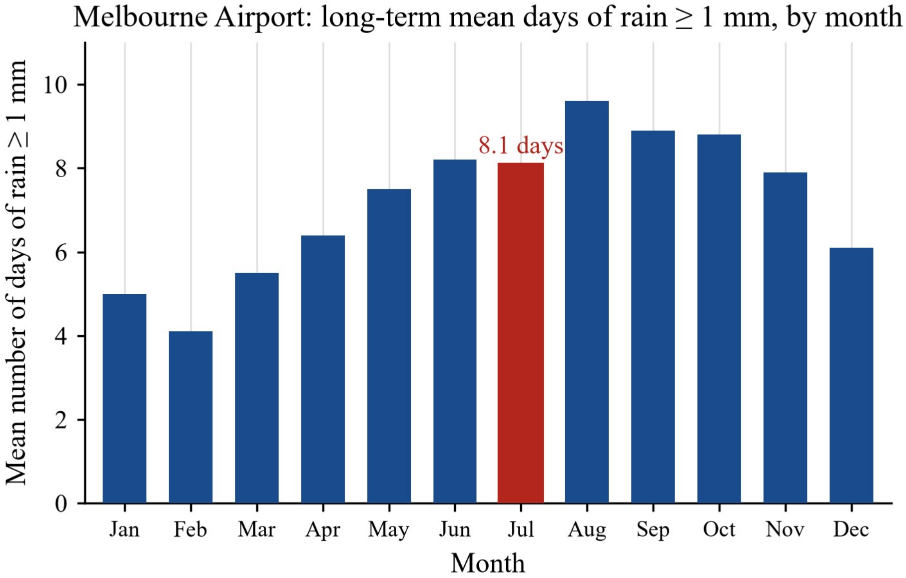


Dot strips of sample proportions for sample sizes 10, 50 and 200; the range shrinks from 0.60 to 0.32 to 0.11 as the sample size grows.

The ranges of the forty proportions are 0.60 for n = 10, 0.32 for n = 50 and 0.11 for n = 200. The larger the sample, the more closely the sample proportions cluster around 0.60. This is exactly why opinion polls use samples of a thousand or more people rather than fifty: the larger the random sample, the smaller the variation we should expect between samples.

Predicting from past data

Historical records give relative frequencies that we can use to predict proportions and likely counts. The Bureau of Meteorology's long-term record for Melbourne Airport includes the mean number of days each month with at least 1 mm of rain:



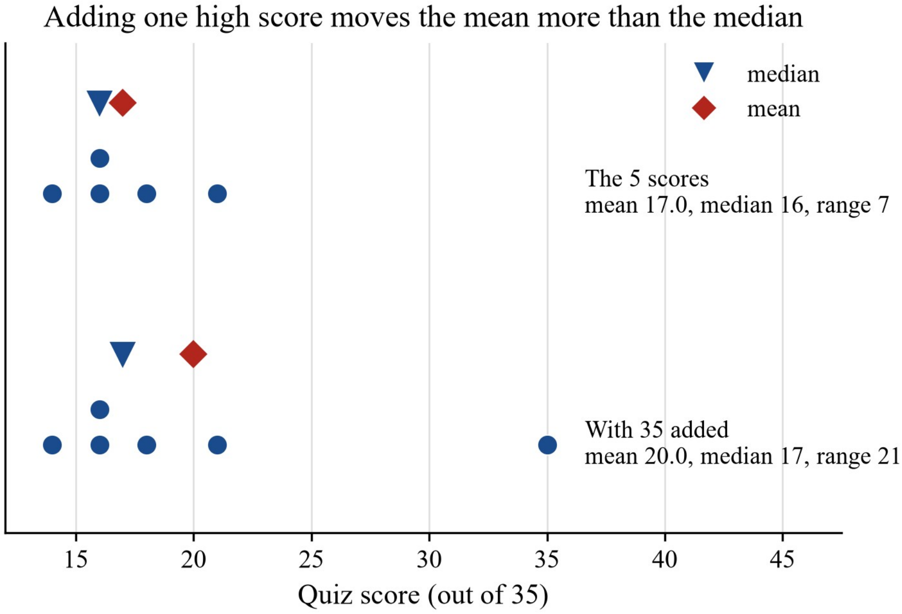
Bar chart of the long-term mean number of days of rain of at least 1 millimetre at Melbourne Airport for each month, with July in red at 8.1 days.

Source: Bureau of Meteorology, Climate statistics for Australian locations, Melbourne Airport (site 086282), long-term averages 1970–2026; retrieved 20 August 2026.

In July the long-term mean is 8.1 days out of 31, a relative frequency of $8.1 \div 31 \approx 0.26$. That relative frequency is our best single guide to a future July: we would predict about $0.26 \times 31 \approx 8$ days with at least 1 mm of rain. The prediction is a long-run guide, not a promise — any single July can be wetter or drier, just as any single sample can sit away from the population value.

Adding or removing data

A different way to see how a centre and a spread behave is to add or remove a value and watch what moves. Five quiz scores (out of 35) are 14, 16, 16, 18, 21. A student who missed the quiz later sits it and scores 35:



Dot strips of five quiz scores before and after adding a score of 35; the mean moves more than the median.

Before, the mean is 17.0, the median is 16 and the range is 7. After adding 35, the mean is 20.0, the median is 17 and the range is 21. The extreme value pulls the **mean** a long way (up 3.0), moves the **median** only one mark, and stretches the **range** from 7 to 21. Adding or removing an extreme value therefore changes the range and the mean most, and the median least — which is why the median is called a more stable centre when data contains extremes. Removing a value works the same way in reverse: taking an extreme value out pulls the mean back towards the rest of the data and can shrink the range a lot.

Worked examples

Example 1 — scaffolded

Three random samples of size 4 are drawn from the twelve month-cards (the population in the first figure). The draws are:

- Sample A: Nov, Apr, Jan, Feb → 22.1, 20.4, 26.7, 26.7
- Sample B: Nov, May, Sep, Sep → 22.1, 16.7, 16.9, 16.9
- Sample C: Oct, Feb, Jan, Apr → 19.6, 26.7, 26.7, 20.4

Find the mean and range of each sample and compare them with the population (mean 19.97 °C, range 13.5 °C). What does this show about samples of the same size?

Step	Comment
Sample A: sum = 22.1 + 20.4 + 26.7 + 26.7 = 95.9; mean = 95.9 ÷ 4 = 23.975 ≈ 24.0 °C.	The mean of a sample is found exactly as for any data set: sum ÷ count.
Sample A: range = 26.7 − 20.4 = 6.3 °C.	Range = largest value − smallest value.
Sample B: sum = 72.6; mean = 72.6 ÷ 4 = 18.15 ≈ 18.2 °C; range = 22.1 − 16.7 = 5.4 °C.	Same population, same size, and yet a quite different centre and spread from Sample A.
Sample C: sum = 93.4; mean = 93.4 ÷ 4 = 23.35 ≈ 23.4 °C; range = 26.7 − 19.6 = 7.1 °C.	A third sample gives a third answer again.
The three means (24.0, 18.2, 23.4 °C) differ from each other and none equals 19.97 °C; the ranges (6.3, 5.4, 7.1 °C) also differ.	Random samples of the same size from the same population vary in shape, centre and spread. Each sample mean is only an estimate of the population mean.

Example 2 — scaffolded

At the school of 500 students, 300 are in favour of the uniform proposal, so the population proportion is 0.60. The first three random samples of 50 students give 29, 30 and 32 students in favour. Find the sample proportions and compare them with the population.

Step	Comment
Sample 1: 29 ÷ 50 = 0.58.	A sample proportion is the count in favour ÷ the sample size.
Sample 2: 30 ÷ 50 = 0.60.	This sample happens to match the population proportion exactly.
Sample 3: 32 ÷ 50 = 0.64.	This sample overstates the population proportion by 0.04.
The three proportions (0.58, 0.60, 0.64) are all different, sitting below, on and above 0.60.	Sample proportions vary from sample to sample around the population proportion — the same idea as sample means varying around the population mean.

Example 3 — scaffolded

Use the two “effect of size” figures to complete the table, then state the rule they show.

What was repeated 50 or 40 times	Range of the sample results
Means of samples of size 4	11.1 °C
Means of samples of size 8	7.2 °C

What was repeated 50 or 40 times	Range of the sample results
Proportions from samples of size 10	0.60
Proportions from samples of size 50	0.32
Proportions from samples of size 200	0.11

Reading across each pair: when the sample size grows (4 → 8 for the means; 10 → 50 → 200 for the proportions), the range of the sample results shrinks (11.1 → 7.2 °C; 0.60 → 0.32 → 0.11). In every case the results still centre on the same population value. **Rule: the larger the random sample, the less the sample results vary.**

Example 4 — unscaffolded

The long-term record for Melbourne Airport shows a mean of 8.1 days with at least 1 mm of rain in July, and July has 31 days.

a) Show that the relative frequency of a July day with at least 1 mm of rain is about 0.26.

b) Use this relative frequency to predict the number of days with at least 1 mm of rain in a future July of 31 days.

c) Explain why your answer is a prediction, not a promise.

d) 8.1 ÷ 31 ≈ 0.26.

e) 0.26 × 31 ≈ 8, so about 8 days with at least 1 mm of rain.

f) The relative frequency comes from the long-term record (1970–2026). It describes what has happened on average, and any single July can be wetter or drier than the average — the variation between one "sample July" and the next is exactly the variation this subtopic studies.

Example 5 — unscaffolded

Five quiz scores (out of 35) are 14, 16, 16, 18, 21. A late student's score of 35 is added to the set.

a) Find the mean, median and range before and after the new score is added.

b) Which of the three measures changed the most, and which changed the least? What does this tell you about adding an extreme value?

c) Before: mean = (14 + 16 + 16 + 18 + 21) ÷ 5 = 85 ÷ 5 = 17.0; median = 16 (the middle of the five); range = 21 − 14 = 7. After: mean = 120 ÷ 6 = 20.0; median = (16 + 18) ÷ 2 = 17; range = 35 − 14 = 21.

d) The range changed the most (7 → 21) and the median changed the least (16 → 17, up only 1, while the mean jumped 17.0 → 20.0). Adding an extreme value pulls the mean a long way and stretches the range, but moves the median only a little — the median is the more stable centre when extremes are added.

Practice questions

Scaffolded

Q1. Use the population figure (mean maximum temperature at Melbourne Airport). a) Which two months share the highest mean maximum temperature, and what is it? b) Write down the median of the 12 values. c) Write down the range of the 12 values.

Q2. Use the figure of the three samples of size 4. a) Which sample has the highest mean? b) Which sample has the smallest range? c) Does any sample mean equal the population mean of 19.97 °C exactly?

Q3. A new sample of 4 cards gives May, Jun, Jul, Aug → 16.7, 13.7, 13.2, 14.6. a) Calculate the mean of this sample. b) Calculate its range. c) Compare the sample mean with the population mean of 19.97 °C and explain why they differ so much, even though the sample was drawn at random.

Q4. Another sample of 4 cards gives 24.3, 22.1, 20.4, 19.6. a) Calculate the mean and the range. b) Sample B in the worked example had mean 18.2 °C and range 5.4 °C. Both samples are size 4 from the same population. What do the two results show?

Q5. In the uniform vote (population proportion 0.60), a random sample of 50 students includes 27 in favour. a) Write the sample proportion as a decimal. b) Is it above or below the population proportion, and by how much?

Q6. One random sample of 10 students has 9 in favour; one random sample of 200 students has 133 in favour. a) Write both sample proportions as decimals. b) Which sample proportion is closer to the population proportion of 0.60? How does this agree with the figure showing sample sizes 10, 50 and 200?

Q7. Use the figure of sample proportions for n = 10, 50 and 200. a) Write down the range of the forty proportions for each sample size. b) Describe what happens to the range as the sample size grows.

Q8. Five scores in a game are 10, 12, 12, 14, 17. A sixth score of 35 is then added. a) Find the mean, median and range of the five scores. b) Find the mean, median and range of the six scores. c) Which of the mean and median moved more when 35 was added?

Unscaffolded

Q9. Explain, in your own words, why two random samples of the same size, drawn from the same population, will usually give different means.

Q10. True or false, with a reason: "Any random sample of 4 cards from the temperature population must have a mean between 15 °C and 25 °C."

Q11. Use the figure of the means of 50 random samples of size 4. a) Between what two values do the fifty means sit, and what is their range to one decimal place? b) The mean of the fifty means is 20.1 °C. Compare this with the population mean and comment.

Q12. A student looks at the figure comparing means of samples of size 4 and size 8 and concludes "larger samples give larger means". Use evidence from the figure to show why this is wrong.

Q13. The long-term record for Melbourne Airport shows a mean of 9.6 days with at least 1 mm of rain in August, and August has 31 days. a) Show that the relative frequency of an August day with at least 1 mm of rain is about 0.31. b) Predict the number of days with at least 1 mm of rain in a future August of 31 days. c) Why is this a prediction rather than an exact answer?

Q14. Scientists monitoring the biodiversity of a bird species take a random sample of 250 birds and find 140 are adults. a) Write the sample proportion of adults as a decimal. b) The region holds about 2,000 of these birds. Use the sample proportion to estimate the number of adults. c) Explain why a sample of 250 birds gives a more trustworthy estimate than a sample of 25.

Q15. A data set is 5, 7, 7, 8, 11. The value 20 is added. a) Find the mean, median and range before and after. b) Which centre changed more, the mean or the median? Why?

Q16. From the data set 5, 7, 7, 8, 11, the value 11 is removed instead. a) Find the mean, median and range of the four remaining values. b) Compare with the original set (mean 7.6, median 7, range 6) and comment on what removing the highest value changed.

Q17. You have twelve cards labelled with the monthly mean maximum temperatures from the first figure. Describe, step by step, how you would use the cards to collect fifty sample means of size 4, and explain why the cards must be put back after every draw. (A digital tool that does the same thing is equally acceptable.)

Q18. Opinion polls usually ask a random sample of 1,000–2,000 people rather than 50. Use what this subtopic has shown about the effect of sample size on variation to explain why.

Answers

Q1. a) January and February, 26.7 °C. b) 20.0 °C. c) 13.5 °C.

Q2. a) Sample A (24.0 °C). b) Sample B (5.4 °C). c) No — the means are 24.0, 18.2 and 23.4 °C; none equals 19.97 °C.

Q3. a) 58.2 ÷ 4 = 14.55 °C. b) 16.7 − 13.2 = 3.5 °C. c) The sample mean is far below 19.97 °C because all four cards happen to be from the coldest months (May to August); random samples can sit well away from the population mean.

Q4. a) Mean = 86.4 ÷ 4 = 21.6 °C; range = 24.3 − 19.6 = 4.7 °C. b) Same size, same population, different centre and spread — samples of the same size vary.

Q5. a) 27 ÷ 50 = 0.54. b) Below, by 0.06.

Q6. a) 9 ÷ 10 = 0.90; 133 ÷ 200 = 0.665. b) The sample of 200 (0.665 is 0.065 from 0.60, while 0.90 is 0.30 away) — agreeing with the figure, where the n = 200 proportions sit much closer to 0.60.

Q7. a) n = 10: 0.60; n = 50: 0.32; n = 200: 0.11. b) The range shrinks as the sample size grows — larger samples vary less.

Q8. a) Mean 13.0, median 12, range 7. b) Mean 100 ÷ 6 ≈ 16.7, median 13, range 25. c) The mean (up about 3.7, against 1 for the median).

Q9. Each draw is by chance, so each sample contains different members of the population; different members give different sums and therefore different means. (Any clear version of this idea.)

Q10. False. The figure of fifty means of size 4 shows means from 14.47 °C to 25.55 °C; for example the sample in Q3 (the four coldest months) has mean 14.55 °C, below 15 °C.

Q11. a) 14.47 °C to 25.55 °C; range 11.1 °C. b) 20.1 °C is very close to 19.97 °C — the sample means cluster around the population mean even though individual means vary widely.

Q12. Both rows centre on the same population mean (19.97 °C); what changes is the spread (range 11.1 °C at n = 4, 7.2 °C at n = 8). Larger samples give *steadier* means, not larger ones.

Q13. a) 9.6 ÷ 31 ≈ 0.31. b) 0.31 × 31 ≈ 9.6, so about 10 days (9–10 days acceptable). c) It is based on the long-term average; any single August can be wetter or drier.

Q14. a) 140 ÷ 250 = 0.56. b) 0.56 × 2,000 = 1,120 adults. c) Larger random samples vary less (the ranges shrink as n grows in the proportions figure), so a sample proportion from 250 birds is likely to sit closer to the true population proportion than one from 25.

Q15. a) Before: mean 7.6, median 7, range 6. After: mean 58 ÷ 6 ≈ 9.7, median 7.5, range 15. b) The mean (up about 2.1, against 0.5 for the median), because the mean uses every value and is pulled by the extreme 20.

Q16. a) Mean 27 ÷ 4 = 6.75, median 7, range 8 − 5 = 3. b) The mean fell (7.6 → 6.75), the median stayed 7, and the range more than halved (6 → 3): removing the highest value pulled the mean down and shrank the range, while the median did not move.

Q17. Mix the twelve cards face down; draw 4 without looking; find the mean of the 4 values and record it; put the 4 cards back and mix; repeat until fifty means are recorded. The cards go back so that every draw is from the same population of twelve values — without putting them back, the population would change with every draw.

Q18. Larger random samples vary less: the figures show sample proportions spreading over a range of 0.60 at n = 10 but only 0.11 at n = 200. A poll of 1,000–2,000 people therefore gives a sample result likely to sit much closer to the true population proportion than a poll of 50, so its estimate is more trustworthy.

Fully-worked solutions

Q1. a) The two tallest bars are January and February, both 26.7 °C. b) Ordering the 12 values, the middle two are 19.6 and 20.4, so the median is (19.6 + 20.4) ÷ 2 = 20.0 °C. c) Range = 26.7 − 13.2 = 13.5 °C.

Q2. a) Sample A, mean 24.0 °C. b) Sample B, range 5.4 °C. c) No: 24.0, 18.2 and 23.4 °C are all different from 19.97 °C, which is exactly the point — a random sample mean is an estimate, not the population value itself.

Q3. a) 16.7 + 13.7 + 13.2 + 14.6 = 58.2; 58.2 ÷ 4 = 14.55 °C. b) 16.7 − 13.2 = 3.5 °C. c) The sample mean sits 5.42 °C below the population mean. Nothing went wrong: the four cards drawn happen to be the four coldest months, May to August, and random drawing can produce samples like that. It is why one small sample is only an estimate of the population.

Q4. a) 24.3 + 22.1 + 20.4 + 19.6 = 86.4; 86.4 ÷ 4 = 21.6 °C. Range = 24.3 − 19.6 = 4.7 °C. b) This sample (mean 21.6 °C, range 4.7 °C) and Sample B (18.2 °C, 5.4 °C) are the same size from the same population yet disagree by 3.4 °C in the mean — random samples of the same size vary in centre and spread.

Q5. a) 27 ÷ 50 = 0.54. b) 0.54 is below 0.60 by 0.06 — a perfectly ordinary sample result, inside the 0.42–0.74 spread the figure shows for samples of 50.

Q6. a) 9 ÷ 10 = 0.90 and 133 ÷ 200 = 0.665. b) 0.665 − 0.60 = 0.065, while 0.90 − 0.60 = 0.30, so the sample of 200 is much closer. This matches the figure: the n = 10 proportions spread over a range of 0.60, the n = 200 proportions over a range of only 0.11.

Q7. a) Reading the brackets: 0.60 (n = 10), 0.32 (n = 50), 0.11 (n = 200). b) As the sample size grows, the range of the forty proportions shrinks — the larger the sample, the less the sample proportions vary, and the more closely they cluster around the population proportion 0.60.

Q8. a) Sum = 10 + 12 + 12 + 14 + 17 = 65; mean = 65 ÷ 5 = 13.0. Median = 12 (middle of five). Range = 17 − 10 = 7. b) Sum = 65 + 35 = 100; mean = 100 ÷ 6 ≈ 16.7. Ordered: 10, 12, 12, 14, 17, 35, so median = (12 + 14) ÷ 2 = 13. Range = 35 − 10 = 25. c) The mean moved about 3.7 and the median only 1 — the extreme score pulls the mean more than the median, and stretches the range from 7 to 25.

Q9. A random sample is drawn by chance, so each sample contains a different selection of the population's members. Different members mean different sums and spreads, so the means (and ranges) differ. The figures show this directly: three samples of the same size gave means 24.0, 18.2 and 23.4 °C.

Q10. False. A sample mean can only sit between the smallest and largest population values, 13.2 °C and 26.7 °C — not between 15 and 25. The figure of fifty means of size 4 shows means as low as 14.47 °C and as high as 25.55 °C; the Q3 sample (mean 14.55 °C) is a concrete example that shows the statement false.

Q11. a) The dots run from 14.47 °C to 25.55 °C; range = 25.55 − 14.47 = 11.08 ≈ 11.1 °C. b) The mean of the fifty means (20.1 °C) sits only 0.13 °C above the population mean of 19.97 °C. Individual sample means vary a lot, but they vary *around* the population mean — the sample means are not biased to one side.

Q12. If larger samples gave larger means, the n = 8 row would sit to the right of the n = 4 row. It does not: both rows centre on the grey population-mean line at 19.97 °C (mean of the fifty means: 20.1 °C at n = 4, 20.0 °C at n = 8). The difference between the rows is the spread — range 11.1 °C against 7.2 °C — so larger samples give *less variable* means, not larger ones.

Q13. a) Relative frequency = 9.6 ÷ 31 ≈ 0.31. b) Predicted count = 0.31 × 31 ≈ 9.6, so about 10 days with at least 1 mm of rain. c) The relative frequency is a long-term average over 1970–2026; a particular August is one "sample" from that pattern and can be wetter or drier, so the figure is a guide to what is likely, not an exact forecast.

Q14. a) 140 ÷ 250 = 0.56. b) 0.56 × 2,000 = 1,120 adults (an estimate, not a count). c) The proportions figure shows the range of sample proportions shrinking from 0.60 at n = 10 to 0.11 at n = 200. A sample of 250 sits at the tight end of that pattern, so its proportion is likely to be close to the true population proportion; a sample of 25 could easily be far off.

Q15. a) Before: sum = 38; mean = 38 ÷ 5 = 7.6; median = 7; range = 11 − 5 = 6. After: sum = 58; mean = 58 ÷ 6 ≈ 9.7; ordered 5, 7, 7, 8, 11, 20 gives median = (7 + 8) ÷ 2 = 7.5; range = 20 − 5 = 15. b) The mean rose about 2.1 while the median rose only 0.5. The mean uses every value, so the extreme 20 pulls it; the median only looks at the middle, so it moves only a little.

Q16. a) Remaining: 5, 7, 7, 8. Mean = 27 ÷ 4 = 6.75; median = (7 + 7) ÷ 2 = 7; range = 8 − 5 = 3. b) Removing the highest value lowered the mean (7.6 → 6.75), left the median unchanged at 7, and more than halved the range (6 → 3). Removing an extreme value, like adding one, changes the range and the mean most and the median least.

Q17. Step 1: write each of the twelve monthly values on a card and mix them face down. Step 2: draw 4 cards without looking. Step 3: find the mean of the 4 values and record it. Step 4: put the 4 cards back and mix again. Step 5: repeat steps 2–4 until fifty means are recorded. The cards must go back so that each draw starts from the same population of twelve values; keeping cards out would change the population for the next draw, and the fifty means would no longer be "the same size from the same population". A spreadsheet or simulator that draws with replacement does the identical process.

Q18. The effect of sample size on variation: at n = 10 the sample proportions in the figure spread over a range of 0.60, at n = 50 over 0.32, and at n = 200 over only 0.11. A poll is a sample used to estimate a population proportion, and a larger random sample gives a result likely to sit closer to the truth. With only 50 people, a poll could easily be out by 0.2 or more; with 1,000–2,000 people the likely error is far smaller — which is why serious polls pay for the larger sample.

Planning and conducting a statistical investigation from a sample

Content description `VC2M8ST04`: plan and conduct statistical investigations involving samples of a population; use ethical and fair methods to make inferences about the population and report findings, acknowledging uncertainty

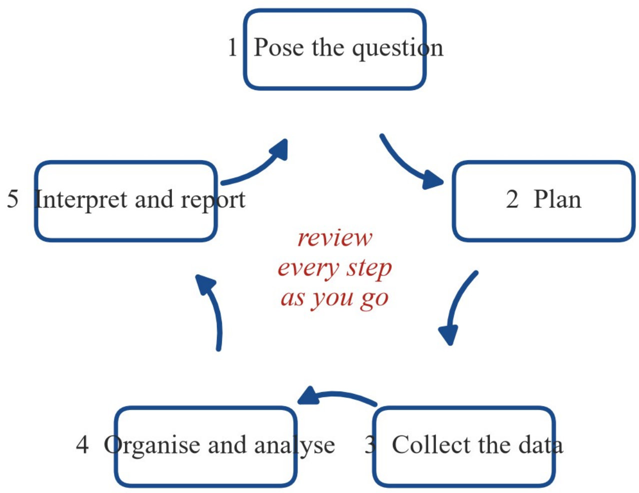
A sports store reads one week of sales and claims "students love our new shoes". A phone company asks only its own customers whether its prices are the best. A news site runs a poll that anyone can click. All three are using data to make a claim about a bigger group — and all three are doing it badly. By the end of this subtopic you will be able to plan and run a statistical investigation the right way: ask a question that data can answer, choose a sample in a fair way, treat the people in it ethically, and report what the data suggests — while honestly saying what it cannot.

Theory

The statistical investigation cycle

In the Level 7 book you planned and ran investigations, and in 6A–6C you met populations, samples and the way samples vary. This subtopic puts those pieces together into one full cycle. Every investigation in this subtopic — and in the extended task I1 — runs these five steps, and reviews every step as it goes.

The statistical investigation cycle



The statistical investigation cycle as five boxes joined in a loop by arrows: 1 pose the question, 2 plan, 3 collect the data, 4 organise and analyse, 5 interpret and report, with the loop returning to step 1; in the centre in red italic, review every step as you go

A statistical investigation does not start with data. It starts with a question, and the plan is written **before** anything is collected. The last step is a report that answers the question — and says how much trust the answer deserves.

Posing a statistical question

A **statistical question** is one whose answers vary across the group it asks about, so that data is needed to answer it. "How long does it take the students at our school to travel to school?" is statistical: different students will give different answers, and the spread of answers is exactly what we want to see. "What time does school start?" is not: it has one fixed fact for an answer, and no data about people is needed.

Is it a statistical question?

Statistical — answers vary, and data is needed

“How long does it take the students at our school to travel to school?”

Not statistical — the one fixed fact, no variation

“What time does school start?”

Statistical — answers vary, and data is needed

“How many hours of sport do Year 8 students at our school do each week?”

Not statistical — the one fixed count, no variation

“How many students are on the school roll?”

Four cards. Two green cards labelled statistical: how long does it take the students at our school to travel to school, and how many hours of sport do Year 8 students at our school do each week. Two red cards labelled not statistical: what time does school start, and how many students are on the school roll. Statistical questions expect answers that vary and need data; the others are one fixed fact

The group a question asks about is the **population**. For the travel question, the population is *all* the students at the school — not just the ones we end up asking. Keeping the population in mind is what stops an investigation answering an easy question instead of the one it set out to ask.

Census or sample

Collecting data from **every** member of the population is a **census**. Collecting it from part of the population, and using that part to stand for the whole, is a **sample**.

A census is the right choice when the whole population must be counted — the Australian Bureau of Statistics runs a Census of every household every five years for exactly this reason — or when the population is small enough that asking everyone is cheap and quick. But a sample is often necessary, and sufficient:

- **Efficiency and time.** Asking every household in Australia a question about sleep would take years; a well-chosen sample of a few thousand gives a usable answer in days.
- **Cost.** A census of millions of people costs millions of dollars.
- **Destruction.** To find how long a light globe lasts, you must run it until it fails. Testing every globe would leave none to sell — a census is impossible, so a sample is the only option.

A sample is sufficiently reliable when it is chosen in a fair way and is large enough — 6C shows that bigger samples vary less. When the method is fair, an inference from a sample to the population is good mathematics, not a guess.

The plan

The plan is written before any data is collected, so that the method cannot be bent to suit the results. A complete plan says seven things.

The plan — written before any data is collected

1. The question, and the population it asks about
2. Census or sample — and if a sample: how it will be chosen, and how large it will be
3. What will be measured or asked, in what units, with what instrument
4. How the data will be recorded
5. How the method will be ethical and fair
6. How the data will be organised, displayed and summarised
7. What will count as an answer to the question

A card listing the seven things a plan states before any data is collected: 1 the question and the population it asks about; 2 census or sample, and if a sample how it will be chosen and how large it will be; 3 what will be measured or asked, in what units, with what instrument; 4 how the data will be recorded; 5 how the method will be ethical and fair; 6 how the data will be organised, displayed and summarised; 7 what will count as an answer to the question

Writing "we will ask people and make a graph" is not a plan. Point 2 must say *how* the sample is chosen — a random draw from a full list is the gold standard at this level (6B) — and point 7 matters more than it looks: "what will count as an answer" decides, for example, whether a travel time given in hours gets changed into minutes before analysis.

Ethical and fair methods

VC2M8ST04 names ethical and fair methods as part of the mathematics. They are two different checklists.

Ethical and fair methods (VC2M8ST04)

Ethical — respect the people

- √ Consent: they are told what the data is for, and they agree
- √ Voluntary: they can say no, or skip any question
- √ Privacy: no names unless truly needed; results reported for groups, not individuals
- √ No harm: nothing that embarrasses, upsets or puts anyone at risk

Fair — give the answer a fair chance

- √ Every member of the population has a real chance of being included
- √ Data is not collected only where it is easiest to collect
- √ Questions are worded in a fair way — they do not push one answer
- √ Everyone compared is treated the same way, in the same conditions

Two cards side by side. Green card, ethical - respect the people: consent, they are told what the data is for and they agree; voluntary, they can say no or skip any question; privacy, no names unless truly needed and results reported for groups not individuals; no harm, nothing that embarrasses, upsets or puts anyone at risk. Blue card, fair - give the answer a fair chance: every member of the population has a real chance of being included; data is not collected only where it is easiest to collect; questions are worded in a fair way and do not push one answer; everyone compared is treated the same way in the same conditions

Ethical is about the people who give the data. Consent means they are told what the data is for *before* they agree; voluntary means they can skip a question or pull out; privacy means results are reported for groups, never in a way that points at one person.

Fair is about the answer. A method is fair when it gives every member of the population a real chance of being included, and when nothing in the method pushes the result one way. The sneakiest kind of unfairness is the wording of a question:

Wording: pushing an answer vs asking in a fair way

× Pushes one answer

"Don't you agree that the lunch break should be longer?"

√ Asks in a fair way

"Do you think the lunch break is the right length, too short, or too long?"

× Pushes one answer

"Most students love the new canteen menu. What do you think?"

√ Asks in a fair way

"What do you think of the new canteen menu?"

Four cards in two pairs. First pair: red, pushes one answer, don't you agree that the lunch break should be longer; green, asks in a fair way, do you think the lunch break is the right length, too short, or too long. Second pair: red, pushes one answer, most students love the new canteen menu, what do you think; green, asks in a fair way, what do you think of the new canteen menu

A question that begins "Don't you agree…" tells people what answer is wanted. A fair version lists the possible views neutrally, or asks openly. **Bias** is the tilt in a method — in the sample, the conditions or the wording — that pushes the result one way.

Collecting and recording the data

Data is recorded exactly as it is given, and problems are reported, not hidden.

Recording the data as it is collected

Student number	Travel time (min)
1	12
2	15
3	—
4	8
5	20

no answer given — record it as missing

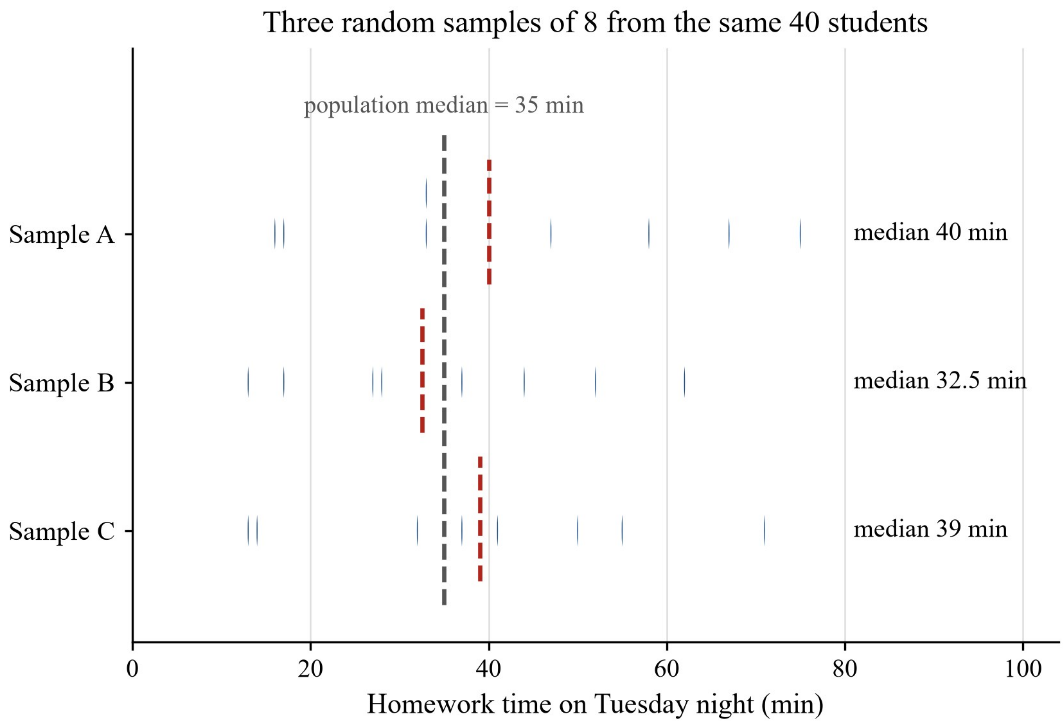
Never invent a value to fill a gap.
Report how many responses were missing,
and check that no value is impossible.

A small table of student number against travel time in minutes: 1 gives 12, 2 gives 15, 3 is a blank with an arrow saying no answer given, record it as missing, 4 gives 8, 5 gives 20; beside it the rules: never invent a value to fill a gap, report how many responses were missing, and check that no value is impossible

If a person skips a question, the entry stays blank and the report says how many were missing. Inventing a value to fill the gap is fabrication — the one unforgivable sin of data work. Values are also checked for sense: a travel time of 300 minutes is not a five-hour walk home; it is almost certainly a mistake to chase up, not a number to average. (Recall from 6A: record in the units the instrument gives, and to its precision — no more, no less.)

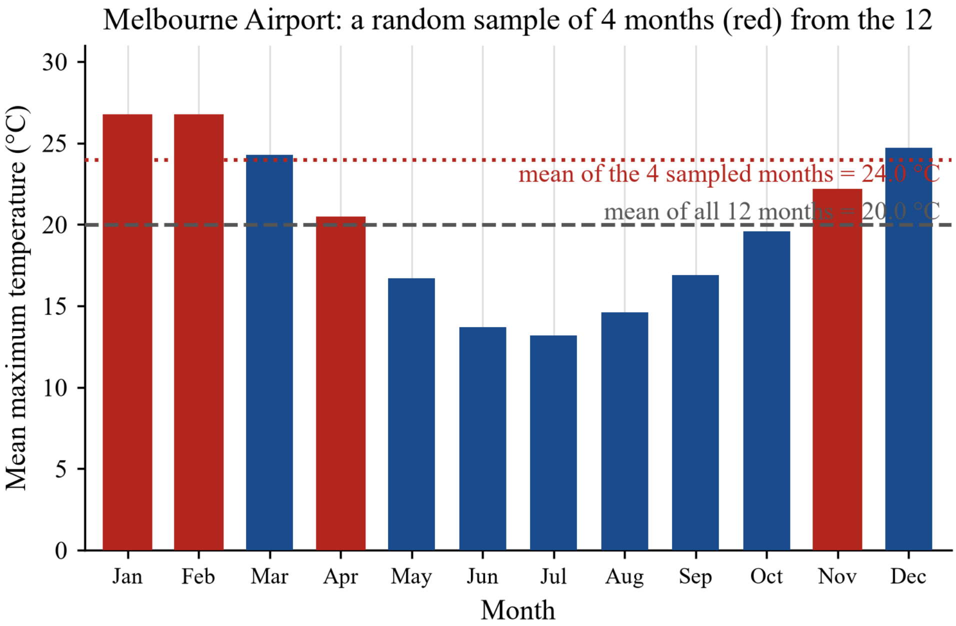
Organising, analysing and acknowledging uncertainty

The analysis uses skills you already have: order the data, display it (a dot plot or stem-and-leaf plot at this level), and summarise with the mean or median and the range. What is new is what the numbers are allowed to mean. A sample statistic is an **estimate** of the population figure — close, but not exact, and different samples give different estimates.



Three dot plots, samples A, B and C, each a random sample of 8 from the same 40 students' homework times in minutes; red dashed lines mark each sample median, 40, 32.5 and 39 minutes, while a grey dashed line marks the population median of 35 minutes; the three samples disagree with each other and with the population

The three samples above come from *one* population whose median is 35 min. Sample A says about 40, B says 32.5, C says 39. None of them is "wrong" — that spread is **uncertainty**, and it is why an honest report says "the median is about 35–40 min" rather than one exact number, and why the report names the sample size.



Bar chart of the mean maximum temperature for each month at Melbourne Airport, 12 blue bars; four bars in red mark a random sample of months, Jan, Feb, Apr and Nov; a grey dashed line at 20.0 degrees marks the mean of all 12 months and a red dotted line at 24.0 degrees marks the mean of the four sampled months

The red bars are a random sample of 4 of the 12 months of real Melbourne Airport data. The sample mean is (26.7 + 26.7 + 20.4 + 22.1) ÷ 4 = 95.9 ÷ 4 = 23.975, about 24.0 °C, while the mean of all 12 months is 20.0 °C. With only 4 months in the sample, a run of warm months lifts the estimate well above the population figure — the uncertainty is large, and the report must say so. (6C's rule of thumb: a bigger sample would have varied less.)

Reporting findings

The report closes the cycle. It is written for a reader who was not there, and it says what the data suggests *and* what it cannot say.

The report

1. The question that was asked
2. The population, the sample and how the sample was chosen
3. The ethical steps that were taken
4. The data: displays and summary statistics
5. The findings, in the context of the question, with the uncertainty stated
6. The limitations of the method
7. The review: what the data could not say, and what would be changed next time

A card listing what a report contains: 1 the question that was asked; 2 the population, the sample and how the sample was chosen; 3 the ethical steps that were taken; 4 the data, displays and summary statistics; 5 the findings in the *context of the question with the uncertainty stated; 6 the limitations of the method; 7 the review, what the data could not say and what would be changed next time*

"Inferences about the population… acknowledging uncertainty" is the CD's own ending. A sentence like "the sample suggests most students travel for 10–20 min, but the sample was only 15 of our 900 students, so the true figure could be a little different" is a *stronger* report than one that claims an exact answer — acknowledging uncertainty is mathematical honesty, not weakness. In Level 9, `VC2M9ST05` takes this further, comparing samples and populations more formally; the habit of saying how much trust a result deserves is what you carry up.

Planning and conducting an investigation — the key ideas

- A statistical question expects answers that vary, and needs data to answer
- The plan is written first: question, population, sample, method, recording, analysis
- Ethical: consent, voluntary, privacy, no harm
- Fair: everyone has a chance of being included, and the questions push no answer
- A sample gives an estimate, not an exact figure — different samples give different results
- Report findings with the uncertainty stated, and name what the investigation cannot say

Summary card of the key ideas of the subtopic: a statistical question expects answers that vary and needs data; the plan is written first and covers question, population, sample, method, recording and analysis; ethical means consent, voluntary, privacy, no harm; fair means everyone has a chance of being included and the questions push no answer; a sample gives an estimate not an exact figure and different samples give different results; report findings with the uncertainty stated and name what the investigation cannot say

Words of this subtopic

Word	What it means here
statistical question	a question whose answers vary across the population, so data is needed to answer it
population	the whole group a question asks about
census	collecting data from every member of the population
sample	data from part of the population, used to stand for the whole
random sample	a sample in which every member of the population has a real chance of being chosen
bias	a tilt in the sample, the conditions or the wording that pushes the result one way
ethical	respectful of the people who give the data: consent, voluntary, privacy, no harm
consent	people are told what the data is for, and agree to give it
fair method	a method that gives every answer a fair chance — no group left out, no push in the wording
inference	a reasoned statement about the population based on the

Word	What it means here
	sample — an estimate, not a fact
uncertainty	the spread in what different samples give; the reason a report says “about” and “suggests”
limitation	what the method could not show, or could have got wrong

Worked examples

Example 1 — with help

The Year 8 student council wants to find out how long students at their school take to travel to school on a normal day.

(a) Is this a statistical question? Give a reason.
(b) What is the population?
(c) Should the council use a census or a sample? Give one reason for your choice.
(d) Name two ethical steps the council must take.
(e) Name two ways the council can keep the method fair.

Working	Comment
(a) Yes — different students take different times, so the answers vary and data is needed.	A question with one fixed fact for an answer is not statistical.
(b) All the students at the school.	The population is the group the question asks about — not just the students the council manages to ask.
(c) A sample. The school has hundreds of students; a random sample of, say, 50 is much quicker and cheaper, and is sufficiently reliable if chosen in a fair way.	A census would also be possible here, but the point of a sample is that it is necessary or sensible when a census is slow or costly.
(d) Tell students what the data is for and let them say no (consent, voluntary); collect no names (privacy).	Any two of the four ethical checks.
(e) Draw names at random from the full school list so every student has a chance of being asked; word the question neutrally.	Any two of the fair-method checks.

∴ (a) yes, the answers vary; (b) all students at the school; (c) a sample — quicker and cheaper, and reliable enough if fair; (d), (e) any two checks from each checklist.

Example 2 — with help

Each question below pushes one answer. Say what is wrong with it, then rewrite it so it asks in a fair way.

(a) “Don’t you agree that homework should be banned?”
(b) “Most students already walk or ride to school. How do you travel to school?”
(c) “The canteen has spent a lot of money on a new menu. Do you like it?”

Working	Comment
(a) “Don’t you agree…” tells the reader which answer is wanted. Fair version: “Do you think homework should be banned, kept as it is, or changed in some other way?”	A fair question lists the possible views neutrally, or asks openly.
(b) “Most students already…” makes walking or riding sound like the expected answer. Fair version: “How do you usually travel to school?”	The lead-in sentence does the pushing — cutting it is enough.
(c) Mentioning the money spent makes “no” feel unkind. Fair version: “What do you think of the new canteen menu?”	Nothing about the canteen’s spending belongs in the question.

∴ each original wording carries a push — in the opening words or in a lead-in sentence — and the fair versions above ask the same thing with the push removed.

Example 3 — with help

How heavy are the school bags of Year 7 students at our school? A random sample of 11 bags is weighed. The masses, in kg, are:

2.4, 2.8, 3.0, 3.2, 3.5, 3.5, 3.8, 4.1, 4.5, 5.2, 6.0

(a) Find the mean, the median and the range.
(b) What does the sample suggest about the population?
(c) Would another random sample of 11 bags give exactly these numbers? What word names this fact?
(d) Give one limitation of the investigation.

Working	Comment
(a) Mean: the sum is 42.0, and 42.0 ÷ 11 = 3.818…, about 3.8 kg. Median: the 6th value, 3.5 kg. Range: 6.0 − 2.4 = 3.6 kg.	The data is already in order, so the median is the middle of the 11 values.
(b) The mean bag mass of all Year 7 bags is about 3.8 kg; a typical bag is about 3.5 kg.	The sample statistics stand in for the population figures — that is the inference.
(c) No — another sample would give slightly different values. That spread is uncertainty.	Different samples, different estimates; the report says "about".
(d) Sample: only 11 bags were weighed, and only Year 7 bags, on one day.	A limitation names what the method could not show.

∴ (a) mean about 3.8 kg, median 3.5 kg, range 3.6 kg; (b) the population mean is about 3.8 kg; (c) no — uncertainty; (d) any true limitation, such as the small sample.

Example 4 — on your own

The bar chart shows the mean maximum temperature for each of the 12 months at Melbourne Airport (Bureau of Meteorology, long-term statistics, site 086282, record 1970–2026). A random sample of 4 months — Jan, Feb, Apr and Nov — is marked in red.

Source: Bureau of Meteorology, *Climate statistics for Australian locations*, Melbourne Airport (site 086282). Retrieved 20 August 2026.

(a) The four sampled values are 26.7, 26.7, 20.4 and 22.1 °C. Calculate the sample mean.
(b) The mean of all 12 months is 20.0 °C. Compare it with your sample mean.
(c) Explain why the two means differ.
(d) Write one sentence reporting the finding, acknowledging uncertainty.

The sample mean is (26.7 + 26.7 + 20.4 + 22.1) ÷ 4 = 95.9 ÷ 4 = 23.975, about 24.0 °C.

(b) The sample mean is about 4 °C above the mean of all 12 months.

(c) The sample is only 4 of the 12 months, and three of the four drawn months are warm ones. With a small sample, chance can give a set of months that is warmer (or cooler) than the year as a whole — that is sampling variability, as seen in 6C.

(d) Sample: "The mean of the 4 sampled months is about 24.0 °C, which suggests the mean maximum for the whole year is around 20–24 °C; with only 4 months in the sample, the true mean of 20.0 °C is some way below the sample's figure, so the uncertainty is large."

∴ (a) 23.975, about 24.0 °C; (b) about 4 °C too high; (c) a small sample can miss the cool months; (d) any report sentence that says "about" or "suggests" and names the small sample or the uncertainty.

Example 5 — on your own

Write a complete plan for the question: *How many hours of sleep do students in Year 8 at our school get on a school night?* Your plan must cover the seven points of the plan card.

Sample plan:

1. **Question and population.** How many hours of sleep do Year 8 students at our school get on a school night? Population: all Year 8 students at the school.
2. **Census or sample.** A sample of 40 students, chosen by numbering the full Year 8 roll and drawing 40 numbers at random.
3. **What will be asked.** Hours of sleep last school night, to the nearest half hour.
4. **Recording.** A numbered table, one row per student, no names.
5. **Ethical and fair.** Students are told what the data is for and may skip the question (consent, voluntary); no names are collected (privacy); random draw from the full roll (fair); one neutral question (fair wording).
6. **Analysis.** A dot plot; mean and median; range.
7. **What counts as an answer.** The median of the sample, reported as an estimate of the population median with the uncertainty stated.

Check your own plan against the seven points: a plan that misses the sampling method, the ethical steps or "what counts as an answer" is not yet a plan.

Example 6 — on your own

In a recent year, total electricity consumption in Australia was 239 TWh, and households used 27% of it.

Source: Australian Energy Regulator, *State of the energy market* — figures as summarised in Wikipedia, *Electricity sector in Australia*. Retrieved 20 August 2026.

(a) Show that households used about 64.5 TWh.

(b) Now suppose that in a pandemic year, with many businesses closed, the total fell to 235 TWh while the household share rose to 29%. Calculate the household use. (These two numbers are a teaching example, not a quoted statistic.)

(c) Compare the two household figures, and suggest what the change says about the pandemic's effect on households.

(d) Give one thing these totals *cannot* tell us.

(e) 27% of 239 = $0.27 \times 239 = 64.53$, about 64.5 TWh.

(f) 29% of 235 = $0.29 \times 235 = 68.15$, about 68.2 TWh.

(g) Household use rose by $68.15 - 64.53 = 3.62$, about 3.6 TWh. With people at home during lockdowns, households used more electricity — the data is consistent with that story.

(h) Sample: the totals cannot say *which* households used more, whether the rise came from working at home or from something else entirely, or how much any one household's bill changed. An inference from totals is about the whole population of households, not about any one of them — and the uncertainty must be stated.

$\therefore$ (a) $64.53 \approx 64.5$ TWh; (b) $68.15 \approx 68.2$ TWh; (c) about 3.6 TWh more, consistent with people at home; (d) any true "cannot say".

Practice questions

Work these questions by hand. The skill in this subtopic is the investigating — the arithmetic is light.

With help

Q1. Say whether each question is statistical or not, and give a reason.

a. How many hours of sport do Year 8 students at our school do each week?
b. How many legs does a spider have?
c. How many minutes of homework did the students in your class get last night?
d. What is the highest mountain in Australia?

Q2. For each situation, state the population and say whether a census or a sample is the sensible choice, with one reason.

a. A factory wants to know how many times its folders can be opened before they break.
b. The Australian Bureau of Statistics wants the number of people in Australia on Census night.
c. A TV station wants to know what Australians watched on Tuesday night.
d. A teacher wants to know whether the 24 students in her class did the reading.

Q3. A draft plan reads: *"We will ask 20 students in our class how they travel to school, and make a dot plot."* Name three things the plan is missing, from the seven points of the plan card.

Q4. Each scenario breaks one of the four ethical checks (consent, voluntary, privacy, no harm). Name the check that is broken.

a. A survey about family income is read aloud in class, so every student hears every answer.
b. Survey forms say the data is for choosing an excursion day, then the results are used to rank the classes.
c. A student says "no, thanks" to a survey and is told they have to do it anyway.
d. A survey posts each student's result, with their name, on the notice board.

Q5. Each scenario breaks one of the fair-method checks. Name the check that is broken.

a. A survey about the library is only run in the library, at lunchtime.
b. A survey begins "Don't you agree that the uniform is too hot?"
c. In a running-time test, one group runs on a dry track in the morning and the other runs after lunch, into a strong wind.
d. To find the school's favourite sport, the survey forms are only handed to the netball team.

Q6. Rewrite each pushing question so it asks in a fair way.

a. "Most students love the new canteen menu. What do you think?"
b. "Don't you agree that the lunch break should be longer?"

Q7. A recording table of travel times (min) reads: 12, 15, —, 8, 300.

a. What should be done with the blank entry?
b. What should be done with the 300?

Q8. The travel times (min) of a random sample of 15 students are:

5, 7, 8, 10, 10, 12, 15, 15, 18, 20, 22, 25, 30, 35, 48

a. Find the mean, the median and the range.
b. What population figure does the median estimate?
c. Why should the report say "about" rather than giving the median as an exact fact?

On your own

Q9. Write a complete plan (all seven points) for the question: *What do students at our school think of the new canteen menu?*

Q10. A group plans to sample the school's travel times by standing at the front gate at 8.40 am and asking the first 10 students who walk in.

a. Give two reasons why this sample may not be fair.
b. Suggest a fairer way to choose 10 students.

Q11. A second random sample of 4 months from the Melbourne Airport data of Example 4 gives May, Sep, Sep and Nov. (Sep came up twice — drawing with replacement allows that, and it keeps every draw fair.)

a. The values are 16.7, 16.9, 16.9 and 22.1 °C. Calculate the sample mean.
b. Compare it with Example 4's sample mean (about 24.0 °C) and with the mean of all 12 months (20.0 °C).
c. What does the difference between the two samples tell you about estimates from samples?

Q12. The figure in the theory shows three random samples of 8 homework times drawn from the same 40 students, whose median is 35 min. The sample medians are 40, 32.5 and 39 min.

a. Which sample median is closest to the population median?
b. If sample B were the only sample you had, what would you report — and how far would you be from the truth?
c. In one sentence, state what this figure teaches about reporting from a sample.

Q13. A group reports: "We weighed 11 bags and the mean was 3.8 kg, so every Year 7 school bag weighs about 3.8 kg." Give two problems with this report.

Q14. A phone shop asks its own customers, "Do you agree that our prices are the best in town?" Give one ethical concern and two fairness concerns.

Q15. A class investigation ends when the group writes its findings on the poster. Which step of the cycle is missing, and what two questions would that step ask?

Q16. A short report reads: *"We asked the question and the mean was 18.7 min, so the answer is 18.7 min."* Name three things the report card says a report must include that this one is missing.

Maths in real life

Q17. The 2021 Census counted 25,422,788 people in Australia.

Source: Australian Bureau of Statistics, *2021 Census of Population and Housing*. Retrieved 20 August 2026.

a. What word names counting every member of the population like this?
b. Give one reason why the ABS does this once every five years rather than using a sample.
c. For the question "how many hours of sleep did Australians get last night?", explain why a sample is the sensible choice even though a census exists for counting people.

Q18. A factory makes light globes and wants to know how long they last. Testing a globe means running it until it fails.

a. Explain why a census is impossible here.
b. Describe a fair way to choose 50 globes from a batch of 2000 for the test.
c. Ethics is about people, so the ethical checklist does not apply to globes. Which fair -method check still matters for the test itself, and why?

Q19. The mean maximum temperatures at Melbourne Airport for the 12 months are:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
26.7	26.7	24.3	20.4	16.7	13.7	13.2	14.6	16.9	19.6	22.1	24.7

Source: Bureau of Meteorology, *Climate statistics for Australian locations*, Melbourne Airport (site 086282). Retrieved 20 August 2026.

a. Choose your own random sample of 4 months (different from Jan/Feb/Apr/Nov and from May/Sep/Sep/Nov), and calculate its mean.
b. Compare your sample mean with the mean of all 12 months, 20.0 °C.
c. In one sentence, acknowledge the uncertainty in your estimate.

Q20. In a recent year, Australia's total electricity consumption was 239 TWh and households used 27% of it — about 64.5 TWh. Suppose a pandemic year sees the total fall to 235 TWh while the household share rises to 29%.

Source: Australian Energy Regulator, *State of the energy market* — figures as summarised in Wikipedia, *Electricity sector in Australia*. Retrieved 20 August 2026. (The pandemic-year numbers are a teaching example.)

a. Calculate the household use in the pandemic year.
b. By how much did household use change?
c. Suggest one reason household use rose while the total fell.
d. Give one conclusion the totals cannot support.

Answers

Q1. a. Statistical — the answers vary between students, so data is needed. b. Not statistical — one fixed fact. c. Statistical — the answers vary between students. d. Not statistical — one fixed fact.

Q2. a. Population: all the folders the factory makes; sample — testing destroys the folder, so a census would destroy the stock. b. Population: every person in Australia; census — the official count must include everyone. c. Population: all Australians; sample — asking millions is too slow and too costly. d. Population: the 24 students in the class; census — the group is small, so asking everyone is quick.

Q3. Any three of: the population is not stated; how the 20 are chosen is not stated (only one class — not fair); sample size and method; ethical steps are not stated; what will count as an answer is not stated; how the data will be summarised beyond "a dot plot".

Q4. a. Privacy (and no harm). b. Consent — the data is used for a purpose people did not agree to. c. Voluntary. d. Privacy.

Q5. a. Data is collected only where it is easiest — people who never use the library are left out. b. The wording pushes one answer. c. The groups compared are not treated the same way, in the same conditions. d. Not every member of the population has a real chance of being included.

Q6. a. "What do you think of the new canteen menu?" b. "Do you think the lunch break is the right length, too short, or too long?"

Q7. a. Keep it blank, record it as missing, and say in the report how many responses were missing — never invent a value. b. Check it — 300 min (5 h) is almost certainly a mistake; chase it up, and do not put it into the analysis until it is checked.

Q8. a. Mean $280 \div 15 = 18.67$ (about 18.7 min); median 15 min; range $48 - 5 = 43$ min. b. The median travel time of all students at the school. c. Because it comes from a sample of 15 — another sample would give a different median, so it is an estimate with uncertainty.

Q9. Answers will vary. Check: all seven points are covered, the sample is chosen at random from the whole school, the ethical checks are named, and the question wording is neutral.

Q10. a. Sample: students who arrive before or after 8.40, or who come by bus to a different gate, are left out; students who say no are simply skipped and not replaced. b. Sample: number the roll and draw 10 numbers at random.

Q11. a. $(16.7 + 16.9 + 16.9 + 22.1) \div 4 = 72.6 \div 4 = 18.15$, about 18.2 °C. b. It is about 5.8 °C below the first sample's mean, and about 1.9 °C below the 12-month mean of 20.0 °C. c. Different random samples of the same size give different estimates — that spread is the uncertainty a report must acknowledge.

Q12. a. Sample B (32.5 min) — 2.5 min from the population median; A is 5 min away and C is 4 min away. b. About 32.5 min (or "32–33 min") — about 2.5 min below the true 35 min. c. Sample: a sample gives an estimate, not the exact population figure, so the report states the uncertainty.

Q13. Any two of: "every bag weighs about 3.8 kg" overstates it — the bags ranged from 2.4 to 6.0 kg, so one bag can be far from the mean; the report gives no uncertainty or limitation; a sample of 11 is small.

Q14. Ethical sample: customers may feel pushed to agree while being served (consent given under pressure). Fairness: only its own customers are asked, so people who shop at other stores are left out; the wording "do you agree" pushes one answer.

Q15. The review step. It would ask: does the answer make sense in context, and what could the data not say? / what would we change next time?

Q16. Any three of: the population, the sample and how it was chosen; the ethical steps; the uncertainty stated (it claims an exact answer); the limitations; the review.

Q17. a. A census. b. Sample: the count is used to plan hospitals and schools, and to fund states — decisions that need every person counted, not an estimate. c. Asking 25 million people one question about last night is far too slow and costly; a well-chosen sample of a few thousand is sufficiently reliable (E02).

Q18. a. Testing destroys the globe, so a census would leave nothing to sell. b. Sample: number the 2000 globes and draw 50 numbers at random; test those. c. Everyone compared is treated the same way, in the same conditions — same voltage, same room, same rules for calling a globe failed, so the results compare like with like.

Q19. Answers will vary. For the sample Mar, Jun, Sep, Dec: (24.3 + 13.7 + 16.9 + 24.7) ÷ 4 = 79.6 ÷ 4 = 19.9 °C — within 0.1 °C of the 12-month mean of 20.0 °C; other choices will land further away. c. Any sentence saying the sample mean is an estimate and the true mean could differ.

Q20. a. 0.29 × 235 = 68.15, about 68.2 TWh. b. 68.15 − 64.53 = 3.62, about 3.6 TWh more. c. Sample: with people at home during lockdowns, households used more electricity while closed businesses used less. d. Sample: the totals cannot say which households used more, or prove the pandemic caused the change — other explanations are possible.

Fully-worked solutions

Q1. A question is statistical when its answers vary across the group it asks about, so that data is needed; it is not statistical when one fixed fact answers it.

a. Different students do different amounts of sport — the answers vary, so data is needed: **statistical**. b. Every spider of the kind has the same number of legs — one fixed fact: **not statistical**. c. Different students got different amounts of homework — **statistical**. d. One fixed fact, looked up rather than measured across a group: **not statistical**.

Q2. The population is the whole group the question asks about; choose a census when everyone must be counted or the group is small, and a sample when a census is too slow, too costly, or impossible.

a. Population: **all the folders the factory makes**. **Sample** — the test opens a folder until it breaks, so testing every folder would destroy the stock.
b. Population: **every person in Australia**. **Census** — the official count is used for decisions that need everyone included.
c. Population: **all Australians**. **Sample** — asking millions of people is far too slow and costly; a fair sample is sufficiently reliable.
d. Population: **the 24 students in the class**. **Census** — with 24 people, asking everyone is quick, so there is no need to sample.

Q3. Read the draft against the seven points of the plan card. It states the question and part of the method, but (for example):

1. the **population** is not stated (all students at the school? only the class?);
2. **how the 20 are chosen** is not stated — asking one class is collecting where it is easiest, which is not fair;
3. the **ethical steps** (consent, voluntary, privacy) are not stated;
4. **what will count as an answer** is not stated.

Any three of these (or the missing recording/analysis detail) earn the marks.

Q4. Match each scenario to the ethical check it breaks.

a. Income answers heard by the whole class point at individuals — **privacy** (and the embarrassment makes it a **no-harm** issue too). b. People agreed to one use of the data and it was used for another — **consent**. c. A person who said no was made to answer — **voluntary**. d. Named results on a notice board identify individuals — **privacy**.

Q5. Match each scenario to the fair-method check it breaks.

a. Running the survey in the library only reaches people who use the library — **data is collected only where it is easiest**. b. "Don't you agree…" — **the wording pushes one answer**. c. Two groups run in different conditions — **everyone compared is not treated the same way**. d. Only the netball team is asked about sport — **not every member of the population has a real chance of being included**.

Q6. Remove the push, keep the question.

a. The lead-in "Most students love…" makes agreement the easy answer. Fair: **"What do you think of the new canteen menu?"** b. "Don't you agree…" tells people the wanted answer. Fair: **"Do you think the lunch break is the right length, too short, or too long?"** — listing the views neutrally.

Q7. a. A skipped question is a missing response, not a zero. **Keep the entry blank, record it as missing, and state in the report how many responses were missing.** Inventing a value is fabrication. b. 300 min is 5 hours — an impossible travel time here, so it is almost certainly a recording mistake. **Do not average it; chase it up and correct or remove it.** A report should also state that one value was checked.

Q8. a. Sum: 5 + 7 + 8 + 10 + 10 + 12 + 15 + 15 + 18 + 20 + 22 + 25 + 30 + 35 + 48 = 280. Mean = 280 ÷ 15 = 18.666…, **about 18.7 min**. The data is in order, so the median is the 8th value, **15 min**. Range = 48 − 5 = **43 min**.

b. The median estimates **the median travel time of all students at the school** — the population the sample was drawn from.

c. The 15 students are a sample, and 6C showed that different samples give different medians. So 15 min is an **estimate with uncertainty**; the report says "about" and names the sample size.

Q9. A complete plan covers all seven points. Sample:

1. Question and population: what do students at our school think of the new canteen menu? Population: all students at the school.
2. Sample: 60 students, chosen by numbering the full roll and drawing 60 numbers at random.
3. Asked: one neutral question — "What do you think of the new canteen menu?" — with the choices: like it, not sure, don't like it.
4. Recording: a numbered tally table, no names.
5. Ethical and fair: purpose explained, skipping allowed, no names (ethical); random draw and neutral wording (fair).
6. Analysis: a bar chart of the three choices, and the fraction of "like it".
7. Answer: the fraction of the sample that likes the menu, reported as an estimate of the whole school with the uncertainty stated.

Q10. a. Two reasons, sample: (1) students who arrive before 8.40, after 8.40, or at another gate never get a chance to be included — the sample is collected where it is easiest; (2) it only catches students who walk in the front gate, so bus, car and rider may be under- or over-represented. b. Number the full roll and **draw 10 numbers at random**, then ask those 10 students (by email or in class, so how they arrive is irrelevant).

Q11. a. 16.7 + 16.9 + 16.9 + 22.1 = 72.6; 72.6 ÷ 4 = **18.15, about 18.2 °C**.

b. The first sample (Jan, Feb, Apr, Nov) gave about 24.0 °C; this one gives about 18.2 °C — about 5.8 °C lower. The mean of all 12 months, 20.0 °C, sits between them: the first sample was too high by about 4 °C, this one too low by about 1.9 °C.

c. Two random samples of the same size, from the same 12 months, gave very different estimates. **Estimates from small samples vary a lot** — which is exactly the uncertainty a report must acknowledge (and why 6C's bigger samples are steadier).

Q12. a. Measure each sample median's distance from the population median of 35 min: A: 40 − 35 = 5; B: 35 − 32.5 = 2.5; C: 39 − 35 = 4. So **sample B** is closest, at 2.5 min.

b. With only sample B, the report would say "the median homework time is about 32.5 min" — **2.5 min below** the true population median of 35 min. With n = 8, that gap is expected; the report should say "about 30–35 min" rather than one exact number.

c. Sample sentence: **different random samples give different estimates, so a report from one sample must state its uncertainty and its sample size.**

Q13. Problem 1: the data ranged from 2.4 kg to 6.0 kg (range 3.6 kg), so saying *every* bag weighs about 3.8 kg is false — the mean describes the centre of the group, not each bag. Problem 2: the report gives **no uncertainty, no sample size and no limitation** — it reads the sample mean as an exact fact about the population, which an honest inference never does.

Q14. Ethical concern: customers are asked while being served, so they may feel pushed to agree — consent is not free, and saying "no" to the person selling to you is uncomfortable (a no-harm issue too). Fairness concern 1: **only its own customers** are asked — people who shop at other stores, and may not share the customers' view, have no chance of being included. Fairness concern 2: "**Do you agree…**" pushes one answer.

Q15. The missing step is the **review** (the loop back to step 1 in the cycle figure). It would ask, for example: (1) does the answer make sense in context, and what could the data **not** say? (2) what would we change about the method next time? Review is part of the mathematics, not a decoration — a report that skips it cannot say how much trust it deserves.

Q16. Against the report card, the short report is missing (any three): **the population, the sample and how the sample was chosen** (how many students? chosen how?); **the ethical steps taken**; **the uncertainty** — "the answer is 18.7 min" claims an exact fact instead of an estimate ("about 18.7 min, from a sample of …"); **the limitations of the method**; and **the review**.

Q17. a. Counting every member of the population is a **census**.

b. The Census count decides things like hospital and school planning and funding between states — decisions that need **every** person counted, not an estimate, so the ABS runs it every five years.

c. Counting people once every five years is one thing; asking all 25,422,788 of them a question about last night is far too slow and far too costly. For that question a well-chosen sample of a few thousand people is **sufficiently reliable** — this is exactly the efficiency/cost/time reasoning of `VC2M8ST04.E02`.

Q18. a. The test runs a globe until it fails, so a tested globe is destroyed. A census would test all 2000 and **leave none to sell** — a census is impossible, so a sample is necessary (E02).

b. Number the 2000 globes from 1 to 2000 and **draw 50 numbers at random**; test exactly those 50. Every globe then has the same chance of being tested — a random sample.

c. **Everyone (everything) compared is treated the same way, in the same conditions.** If some globes are tested at a higher voltage, in a hotter room, or with a looser rule for "failed", the results compare unlike with unlike and the estimate is biased.

Q19. a. Sample choice Mar, Jun, Sep, Dec: 24.3 + 13.7 + 16.9 + 24.7 = 79.6; 79.6 ÷ 4 = **19.9 °C**. (Your months will differ; add your four values and divide by 4.)

b. 19.9 °C is within 0.1 °C of the 12-month mean of 20.0 °C — this sample happened to balance warm and cool months. The book's two samples (about 24.0 °C and about 18.2 °C) miss by about 4 °C and about 1.9 °C, so a different choice can land further away.

c. Sample sentence: **"My sample of 4 months gives a mean of 19.9 °C as an estimate of the mean for the whole year; with only 4 of the 12 months, the true mean could be a degree or two away."** Any sentence that says "estimate/about" and names the small sample earns it.

Q20. a. 29% of 235 TWh = 0.29 × 235 = **68.15, about 68.2 TWh**.

b. 68.15 − 64.53 = **3.62, about 3.6 TWh more** household use in the pandemic year.

c. With lockdowns keeping people at home, households ran more heating, cooling, cooking and screens — household use rose — while closed shops, offices and factories cut the total. The data is **consistent with** that story.

d. Sample: the totals cannot say **which** households used more (or whether some used less), and they cannot **prove** the pandemic caused the rise — a different cause could be at work. An inference from two totals carries real uncertainty, and the report says so.

Test

Chapter test T6 — Statistics: samples, sampling and variation

Victorian Curriculum F–10 Version 2.0, Mathematics, Level 8 — Chapter 6: `VC2M8ST01` *(Section 6A),* `VC2M8ST02` *(Section 6B),* `VC2M8ST03` *(Section 6C) and* `VC2M8ST04` *(Section 6D).*

- **Time:** 25 minutes — 5 minutes reading time plus 20 minutes working time
- **Marks:** 20 (5 marks per subtopic)
- **Equipment:** none required
- **Calculator:** not permitted — none of the Chapter 6 content descriptions names a digital tool. All numbers are chosen so the working can be done by hand.

Answer all questions. Show your working where it is asked for. Marks are awarded for the reasons and explanations you give, not only for the answers.

Question 1 — Section 6A (5 marks)

A biscuit factory bakes 1,000 packets of biscuits in one day. The quality officer chooses 25 packets at random and checks each one for broken biscuits.

a) State the population for this investigation. (1 mark)

b) State the sample. (1 mark)

c) Name the collection technique the quality officer uses: census, sampling, experiment or observation. (1 mark)

d) Give one reason why the factory uses this technique instead of checking all 1,000 packets. (1 mark)

e) For each packet, the quality officer records the number of broken biscuits. Is this data qualitative or quantitative? (1 mark)

Question 2 — Section 6B (5 marks)

a) A factory has 800 day-shift workers and 200 night-shift workers. Management surveys 80 workers: 64 chosen at random from the day shift and 16 chosen at random from the night shift. Which sampling method is this? (1 mark)

A. cluster sampling

B. convenience sampling

C. quota sampling

D. stratified sampling

b) Name the sampling method used in each case.

c) The names of all 200 members of a club go into a drum, and 20 names are drawn without looking. (1 mark)

ii) A street directory numbers 300 houses from 1 to 300. A survey team picks a random starting number, then visits every 15th house after it. (1 mark)

iii) A student stands at the school gate at 8:30 am and asks the first 30 students who arrive whether the library should stay open after school. Explain why this sample may not represent the whole school. (2 marks)

Question 3 — Section 6C (5 marks)

The table shows the long-term mean maximum temperature for each month at Melbourne Airport. The mean of all 12 values is 20.0 °C, to one decimal place.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean maximum temperature (°C)	26.7	26.7	24.3	20.4	16.7	13.7	13.2	14.6	16.9	19.6	22.1	24.7

Source: Bureau of Meteorology, Climate statistics for Australian locations, Melbourne Airport (site 086282), long-term averages 1970–2026; retrieved 20 August 2026.

Two random samples of 3 months each are drawn from the 12 values in the table.

- Sample A: January, February, July
- Sample B: May, June, August

a) Calculate the mean of Sample A. (1 mark)

b) Calculate the mean of Sample B. (1 mark)

c) Both samples are the same size and come from the same population, yet their means are different. State what this shows about random samples of the same size. (1 mark)

d) Another student draws a random sample of 6 months from the same population. Is its mean likely to be closer to 20.0 °C than the means in parts a and b? Give a reason for your answer. (2 marks)

Question 4 — Section 6D (5 marks)

The student council wants to know how long students at their school take to travel to school. They ask 20 students from one Year 8 class. The median of the 20 answers is 12 minutes. The council's report reads: "Students at our school take 12 minutes to travel to school."

a) Is "How long do students at our school take to travel to school?" a statistical question? Give a reason. (2 marks)

b) Give two problems with this investigation — with the way it was done, or with the way it was reported. (2 marks)

c) Rewrite the report's sentence so that it acknowledges uncertainty. (1 mark)

Total: 20 marks

Solutions

Question 1

a) The population is the whole group the question is about: **all 1,000 packets of biscuits baked that day** (1 mark).

b) The sample is the part of the population the data comes from: **the 25 packets chosen** (1 mark).

c) **Sampling** (1 mark) — data is collected from part of the population only, so it is not a census; nothing is changed on purpose, so it is not an experiment; and the officer is not only watching what happens, so it is not an observation.

d) Any one of (1 mark): checking all 1,000 packets would take too long; it would cost too much; opening a packet to check it spoils the packet, so it could not be sold. The reason must explain why a census of the batch is not sensible — "a sample is easier" with nothing more is not enough.

e) **Quantitative** (1 mark) — the number of broken biscuits is a number found by counting.

Question 2

a) **D — stratified sampling** (1 mark). The workers are first split into two groups (the shifts) that differ in a way that may matter for the question; the same fraction is then taken from each group — 64 ÷ 800 = 16 ÷ 200 = 1 in every 12.5 — and members are chosen at random within each group. It is not quota sampling (C) because the choice inside each group is random; it is not cluster sampling (A) because whole shifts are not taken; it is not convenience sampling (B) because chance, not ease, decides who is in.

b)

  i) **Simple random sampling** (1 mark) — every member has the same chance of being drawn, and chance alone decides.

ii) **Systematic sampling** (1 mark) — a random start on a numbered list, then a fixed interval (every 15th house).

iii) Two marks, one for each point:

- Only students who arrive at that gate at that time can be chosen — students who arrive later, who come by another gate, or who are away that day have **no chance** of being in the sample (1 mark).
- The sample is a convenience sample: chance did not decide who was asked, and students who arrive early may feel differently about the library than the whole school does, so the result may be **biased** (1 mark).

Question 3

a) Sample A is January, February and July: 26.7 + 26.7 + 13.2 = 66.6, and 66.6 ÷ 3 = **22.2 °C** (1 mark).

b) Sample B is May, June and August: 16.7 + 13.7 + 14.6 = 45.0, and 45.0 ÷ 3 = **15.0 °C** (1 mark).

c) **Random samples of the same size, drawn from the same population, vary from sample to sample** (1 mark). Each sample mean is only an estimate of the population mean: Sample A sits 22.2 − 20.0 = 2.2 °C above it, and Sample B sits 20.0 − 15.0 = 5.0 °C below it.

d) **Yes — it is likely to be closer** (1 mark). **Reason (1 mark):** as the sample size grows, the variation between random samples shrinks — sample means cluster more closely around the population mean. A sample of 6 months is therefore expected to give a mean nearer 20.0 °C than the two samples of 3 months. A "yes" with no reason scores 1 mark only.

Question 4

a) **Yes** (1 mark). Different students take different times to travel to school, so the answers **vary** and data must be collected to answer the question — a question with one fixed fact for an answer is not statistical (1 mark).

b) Two marks, one for each valid problem. Any two of:

- the sample is only one Year 8 class — students in other year levels have no chance of being included, so the sample may not represent the school;
- the 20 students were not chosen at random (they are a convenience sample);

- 20 students is a small sample for a whole school;
- the report gives “12 minutes” as an exact fact — no “about”, no uncertainty and no mention of the sample.

c) Model response (1 mark): *“A sample of 20 students from one Year 8 class suggests the median travel time for students at our school is about 12 minutes; the true median may differ.”* To earn the mark, the sentence must use “about”/“suggests” (or similar) and refer to the sample or to the uncertainty — a rewrite that still states 12 minutes as an exact fact scores 0.

Answer key

Q	Part	Answer	Marks
1	a	All 1,000 packets baked that day	1
1	b	The 25 packets chosen	1
1	c	Sampling	1
1	d	Any valid reason (time, cost or destruction)	1
1	e	Quantitative	1
2	a	D — stratified sampling	1
2	b i	Simple random sampling	1
2	b ii	Systematic sampling	1
2	c	Who misses out + why that can bias the result	2
3	a	22.2 °C	1
3	b	15.0 °C	1
3	c	Same-size random samples vary	1
3	d	Yes — larger samples vary less	2
4	a	Yes — answers vary, so data is needed	2
4	b	Any two valid problems	2
4	c	“about/suggests” + sample or uncertainty named	1
		Total	**20**