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SCHOLARSHIP

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Scholarship 2025
Statistics

Time allowed: Three hours
Total score: 32

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should answer ALL the questions in this booklet.

Pull out Formulae and Tables Booklet S–STATF from the centre of this booklet.

Show ALL working.

Check that this booklet has pages 2–28 in the correct order and that none of these pages is blank.

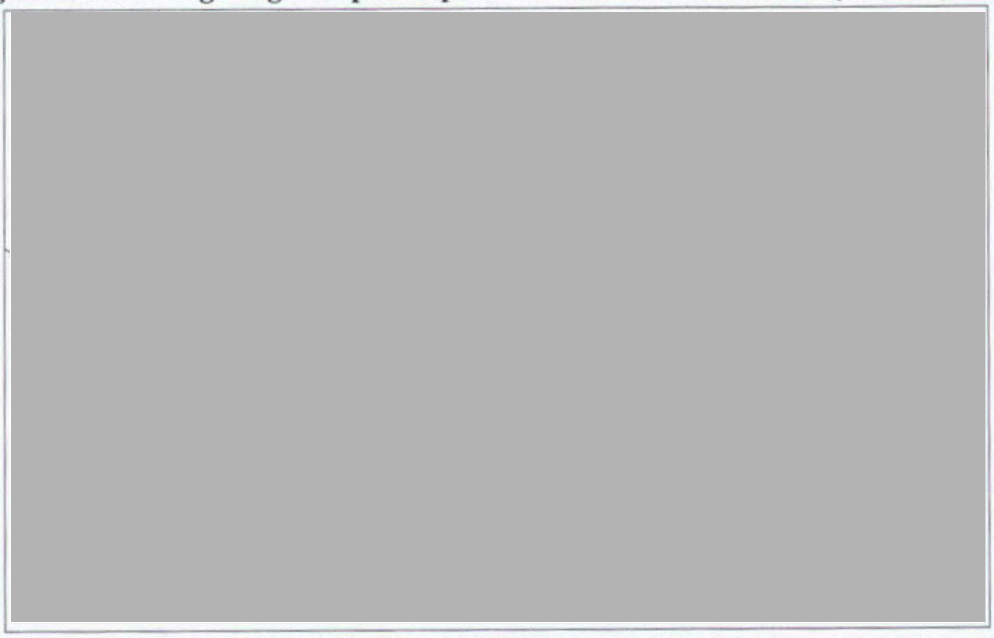
Do not write in the margins. This area will be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

QUESTION ONE

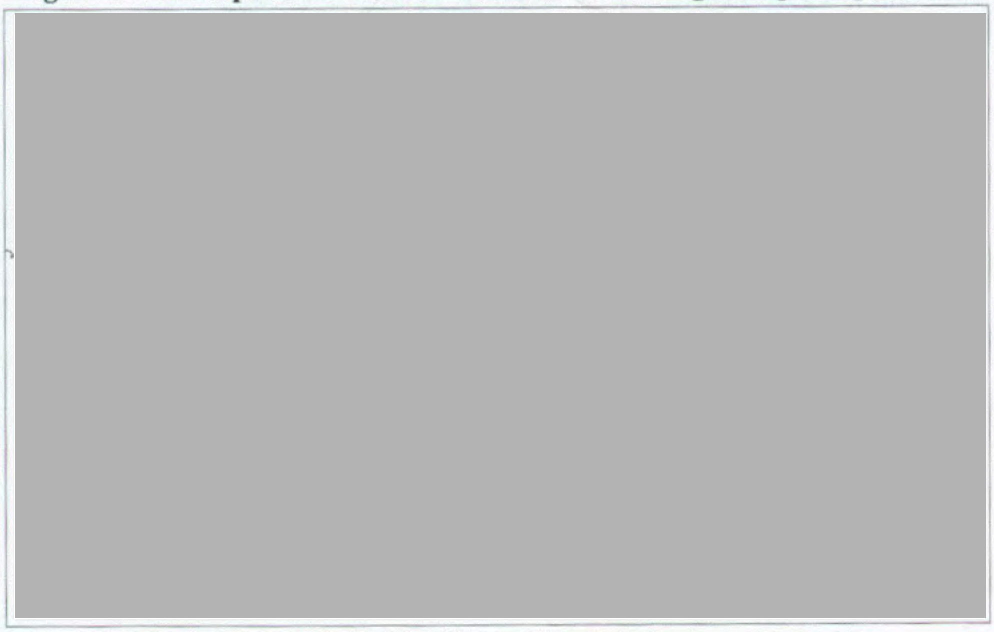
(a) Plastics in our oceans pose a severe threat to marine ecosystems and human health. Plastic pollution damages coastal habitats, disrupts ecosystems, and contributes to the decline of endangered species. Most ocean plastic comes from land-based sources, with an estimated 70 – 80% carried to the sea via rivers or coastlines. Research shows that wealthier countries contribute very little to this plastic pollution, meaning domestic policies in these countries alone will do little to curb this pollution. Instead, wealthier countries can help by supporting waste management improvements in lower-income countries, which is seen as a key solution to reducing global plastic pollution.

Figure 1: Percentage of global plastic pollution emitted to the ocean by country, 2019



Source: https://ourworldindata.org/ocean-plastics

Figure 2: Plastic pollution emitted to the ocean in kilograms per capita, 2019



Source: https://ourworldindata.org/grapher/per-capita-ocean-plastic-waste

(i) Explain the graphical techniques that have been used to visualise the data.

colour intensity has been used to visualise a high percentage of pollution with >10% in Figure 1 being dark blue / purple and 0.1% > or < 1% being lighter blue. Similarly, in Fig 2, dark red was used to show a high weight of >1kg and light yellow was used to show between 0.001 kg and 0.01kg.

(ii) *Our World in Data* suggests that there are multiple factors which may increase a country's contribution of plastics to the ocean. One of these contributing factors is the location of most of the population in relation to the coast. For example, countries that consist of smaller islands may be more likely to contribute to ocean waste.

Using information from Figures 1 and 2, discuss whether the visualisations support this claim.

~~In Fig 1, India with >10% of global plastic pollution emitted to the ocean is surrounded by mostly water. This, along with its high population along the coast means it is one of the top polluters by ocean. This is one exception~~

The Islands of the Southeast asia region namely Indonesia, ~~Mag~~ Malaysia and the Cook Islands all have dark shadings of colour in both figures, suggesting that they all pollute plastics into the ocean at high rates of ~1% to 10%+ ~~per~~ globally and 0.1kg to 1kg + per capita. Another ~~ps~~ visualisation that supports this is the islands below the U.S, with ~~>10~~ greater than 0.1% of global plastic pollution and nearly a 1kg of plastic pollution per capita. Another country that supports this is Japan, with nearly 1% global plastic pollution with a teal colour visualized, as well as the same shade of orange as China indicating ~~a~~ the same ~~kg~~ 0.01 kg + ~~per~~ of plastic pollution per capita, even though Japan is a smaller country. This shows that the visualisations do support the claim, as many small islands often have similar strength / intensity of colour as bigger nations that would

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(b) Read the report below.

Report 1: The deep ocean contains a mountain of microplastic pollution

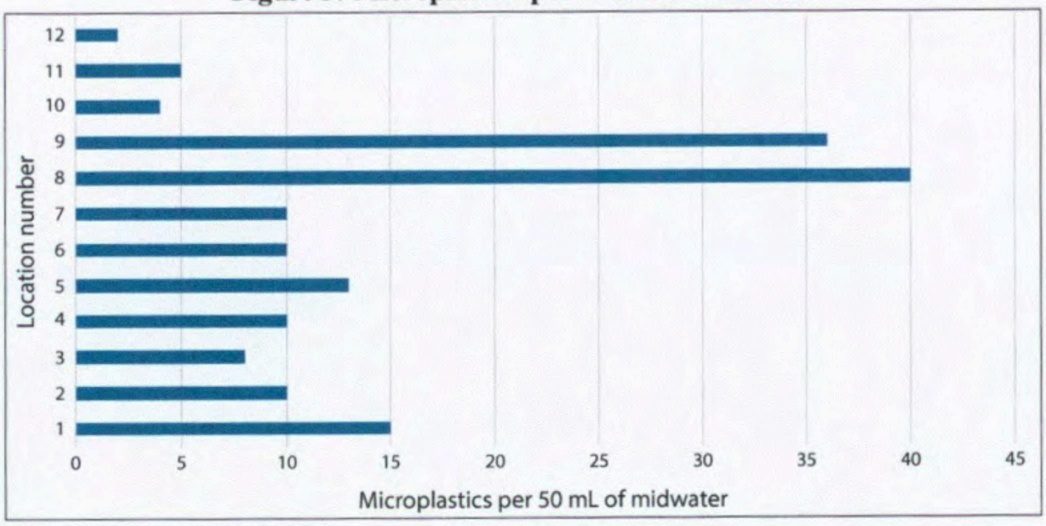
In the first study to systematically comb a section of ocean from top to bottom for microplastics, researchers have found that the midwater region (located 180–460 metres below the surface) contains significantly greater plastic pollutant loads than surface water does. They expected to find the greatest amount of plastic in surface water, because plastic is less dense than water. However, the surface water contained some of the lowest concentrations of microplastics. The highest concentrations of microplastics were found in the midwater region. Results from the study found that the midwater region generally contained four times as much microplastic waste as the surface water.

Source: www.scientificamerican.com/article/the-deep-ocean-harbors-a-mountain-of-microplastic-pollution/

A marine biologist is studying the presence of microplastics in samples of both surface water and midwater from around the world. 60% of the samples collected are surface water and 40% are midwater. For this study, high levels of microplastics are defined as 10 or more pieces of plastic per 50 mL. The results from the 12 midwater samples are shown in Figure 3.

mid = 4 surface

Figure 3: Microplastics per 50 mL of midwater



Using information provided in Report 1 and Figure 3, answer the following questions.

(i) The biologist selects a sample at random from the midwater and surface water samples.

Given that a sample contains a high level of microplastics, estimate the probability that it is a midwater sample.

$P(\text{Midwater} \mid \text{high level}) = \dfrac{P(\text{mid} \cap \text{high})}{P(\text{high level})}$

n(total) ~~n(surface)~~ = 12/0.4 = 30 samples   n(high ∩ mid) = 8

n(surface) = ~~8~~ 18 samples   n(high ∩ surface) = 2

P(high level ∩ mid) = ~~4/12 = 1/3~~ 8/12 = 2/3

P(high level ∩ surface) = ~~1/3 ÷ 4 = 1/12~~ 4×4/18 = 8/9

$\rightarrow \frac{\cancel{8} \div 4}{18} = \cancel{\frac{4}{18}} = 1/9$

$P(\text{midwater} \mid \text{high level}) = \frac{1/3}{4/9} = \cancel{\frac{4}{7}}\ 3/4$

$P(\text{high level}) = \frac{1}{9} + \frac{1}{3} = \cancel{\frac{7}{18}}\ \frac{4}{9}$

$= \cancel{0.857}\ 3/4$

$= 0.75$

(ii) Discuss any assumptions you have made when calculating this estimate.

- Assuming that the no. of high level samples found in midwater was exactly ~~15~~ 4 times ~~as~~ the no. found in surface water. ie. the samples ~~as~~ are taken from the same area, so that the proportions still match.
- the samples represent all of the samples collected, ie, the samples are all representative of the area they are collected from and no rounding was done on the percentages of samples
- that the number of samples with microplastics that is 10 above 10 ~~holds true~~ at midwater level is the only factor that determines ~~whe~~ how many samples of surface water is above 10 pieces of plastic, ie, the actual number of pieces doesn't matter, but only the number of sample that had 10 or more pieces.

(iii) The marine biologist also samples ocean water from 500 different deep water locations (defined as more than 460 metres below the surface) and counts the number of microplastic pieces per 50 mL. They model the distribution of microplastics using a Poisson distribution with an average of 2 pieces per 50 mL. The marine biologist finds that 98 of the 500 deep water samples contain exactly 1 microplastic piece.

Comment on whether the Poisson distribution is an appropriate model for this data.

Support your answer with calculations or numerical evidence.

$\lambda = 2$ $\quad \frac{98}{500} = P(X=1) = 0.196$

$P(X=1) = \frac{2^1 e^{-2}}{1!}$ $\quad P(X=1)$ actual $= 0.196$

$= 0.271$ prob estimate

The probability that there is exactly 1 microplastic piece modeled by the ~~the~~ Poisson ~~dist~~ distribution is 0.271, while the observed was 0.196. These probabilities do not match, and aren't close, so the Poissen isn't a good model for this.

-1. Poissen models events that are rare, random, and independent. Micro Plastics are ~~me~~ normally split from macro plastics, meaning it is likely that a group of microplastics is likely to be found in an area, meaning the apperance of 1 piece is likely not independent of the other pieces.

2. Microplastics don't occur randomly in different locations. As plastics pollution comes from land based use, areas like coastal cities or beaches that are near deep water locations are more likely to have microplastics than areas like the Mariana Trench, where no one goes, as fishing, pollution, or dumping of plastics is a lot more common, making the distribution of plastics not random.

(iv) In part (b)(iii) the distribution of microplastics was modelled using a Poisson distribution, with an average of 2 pieces per 50 mL.

Using this model, explain why the probability of finding 2 microplastic pieces in one 50 mL sample is equal to the probability of finding a total of 2 microplastic pieces in two independent 25 mL samples.

Use calculations to support your explanation.

$P(X=2) = \frac{2^2 e^{-2}}{2!} = 0.677$ in one sample of 50ml

$\cancel{P(X=2) = P(X=1) \times P(X=1) + P(X=0) \times P(X=2) \times 2}$

$\cancel{= \left(\frac{2^1 e^{-2}}{1}\right)^2}$ *

~~P(X=2) in 25ml = 1~~ X in 25ml = 1 = λ_2

$P(X=2) = (P(X=1))^2 + (P(X=0) \times P(X=2)) \times 2$

$= \left(\frac{1 e^{-1}}{1}\right)^2 + \frac{1^2 e^{-1}}{2} \times \frac{1^0 e^{-1}}{0!} \times 2$

$= (0.736)^2 + 0.368 \times 0.900 \times 2$

$= 0.677$

- Becuse the Poissen assumes the pieces are independent, so halfing the size of the semple should half the pieces in said semple, meaning finding 1 piece in a 25ml sample should be the same as finding a piece in another 25ml semple, so the probability stays the same

QUESTION TWO

(a) New Zealand participated in a global assessment to examine the recyclability of product packaging. Consumer organisations in 9 countries assessed packaging recyclability and labelling on 11 popular products.

Consumer NZ participated with organisations in Australia, Brazil, France, Hong Kong, India, Malaysia, Portugal, and the United Kingdom, coordinated by Consumers International. Combined, these consumer organisations represent 1.8 billion people.

In this assessment, a 'recyclable' product is 'recyclable in practice'. This means there is an existing collection, sorting, and recycling system in place that recycles the packaging which is readily accessible nationwide. In other words, the majority of consumers can actually recycle these products in their home countries – it is not just a theoretical possibility.

Table 1: Global recyclability of product packaging

Product	Approximate volume or weight*	Packaging recyclability in practice – New Zealand	Packaging recyclability in practice – international average
Coca-Cola mini 6 pack	200 ml x 6	100%	98%
Dove body wash	1 L	68%	82%
Heinz tomato ketchup	250 g	77%	81%
KitKat chocolate bar	50 g	0%	36%
M&M peanut chocolates	100 g	0%	33%
Nescafé original coffee	300 g	95%	88%
Nutella Ferrero hazelnut spread with cocoa	300 g	77%	84%
Pringles chips	200 g	0%	16%
San Pellegrino sparkling water	1 L	0%	77%
Toblerone chocolate bar	60 g	0%	64%
Whiskas mixed favourites 12 pack	85 g x 12	51%	60%

** Sometimes the packaging volume varied between countries.*

Source: https://www.consumer.org.nz/articles/media-release-new-zealand-ranks-second-to-last-in-international-packaging-recyclability-trial

Use the information from Table 1 to evaluate the claim that 57% of the packaging used in New Zealand is not recyclable in practice.

Discuss any reservations you have about this claim.

11 products = 1100%

100 + 77   408   0.425

P(recyclable design) = 68 + 77 + 95 + 51 ~~+~~ $\frac{291}{1100}$ = 0. = $\frac{~~304~~}{1100}$ = ~~0.355~~

P(not recyclable) = 1 − 0.425 = ~~0.645~~ ~~57.~~ 0.575

So ~~64.5~~ 57.5 % of of packaging used in NZ isn't recyclable in practice, which is higher than 57% claimed. However, it only is 0.5% higher which means the claim is valid.

Reservations: Some products have a zero % recyclability rate, which seem like it could be a misrepresentation compared to other companies.

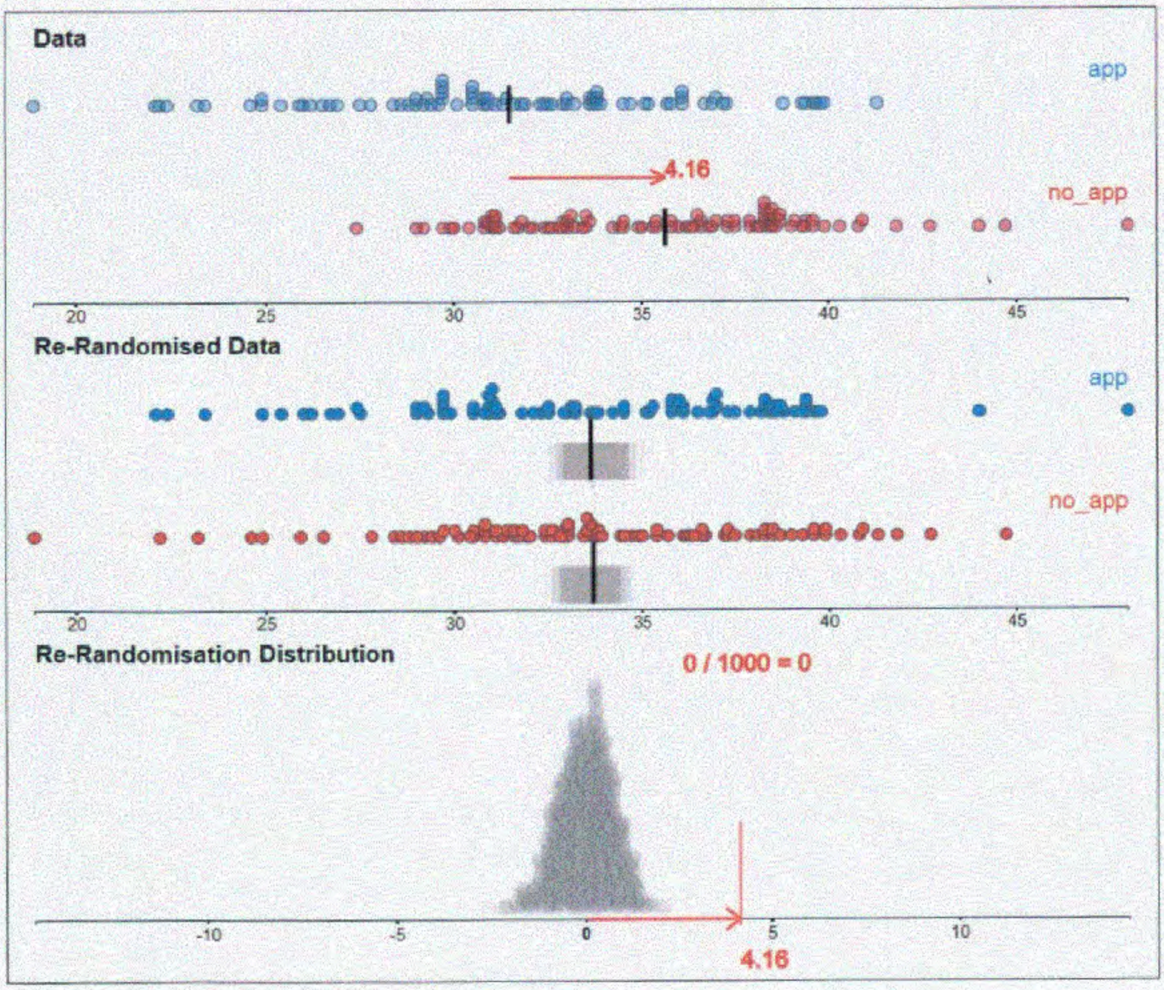
– ~~So~~ Even if packaging is recyclable in practice, in real life factors such as degradation, dirty plastics, faulty factory lines, or ~~water~~ costs could render even more of the recyclable packaging not recyclable.

(b) A student observed that many packaging products in New Zealand were only partially recyclable. For example, Dove body wash comes in a plastic bottle with a plastic plunger cap, but the plunger cap is non-recyclable and must be removed before recycling the bottle.

The student questioned whether partially recyclable packaging might reduce overall recycling rates, as consumers may not always know which parts of the packaging can be recycled.

The student developed an app that scans product barcodes and shows consumers which parts of the product's packaging are suitable for recycling. The student recruited 176 volunteer households from around New Zealand. These volunteer households agreed to separate their discarded packaging into recycling and landfill each week for three months. The households were randomly allocated into one of two groups: separating discarded packaging with the use of the app or without the use of the app. Participants' discarded packaging (both landfill and recycling) was collected and analysed and the percentage of recyclable packaging sent to landfill was recorded, with the mean percentage for each group calculated. The data was then used to create a re-randomisation distribution (Figure 4).

Figure 4: Test output for the percentage of recyclable packaging sent to landfill.



Discuss what can be concluded from both the features of the sample data distributions and the re-randomisation test output, including any reservations you may have about extending any findings from the results.

From the sample data, we can conclude that the mean percentage of recyclable packaging sent to landfill of the "no-app" group is 4.16% higher than the mean percentage of recyclable packaging sent to landfill of the "app" group. So in general, more packaging that was recyclable was sent to the landfill by those who didn't use the app, compared to those who did. From the re-randomisation test, we see that 0 out of 1000 re-samples would have got the ~~Sample~~ same difference in means that the sample data showed or higher. This 0% probability is less than the 5% significance level, so we can be 95% sure that chance was not acting alone. This means there is significant evidence to suggest that the difference in mean percentages was due to the treatment variable of using the app, which decreased the mean percentage of recyclable packaging going to the landfill.

- Reservations: volunteer households were recruited to test a pre-recycling app, meaning its likely that these households are already engaging in recycling more than the average household, so they aren't representative of the whole population.

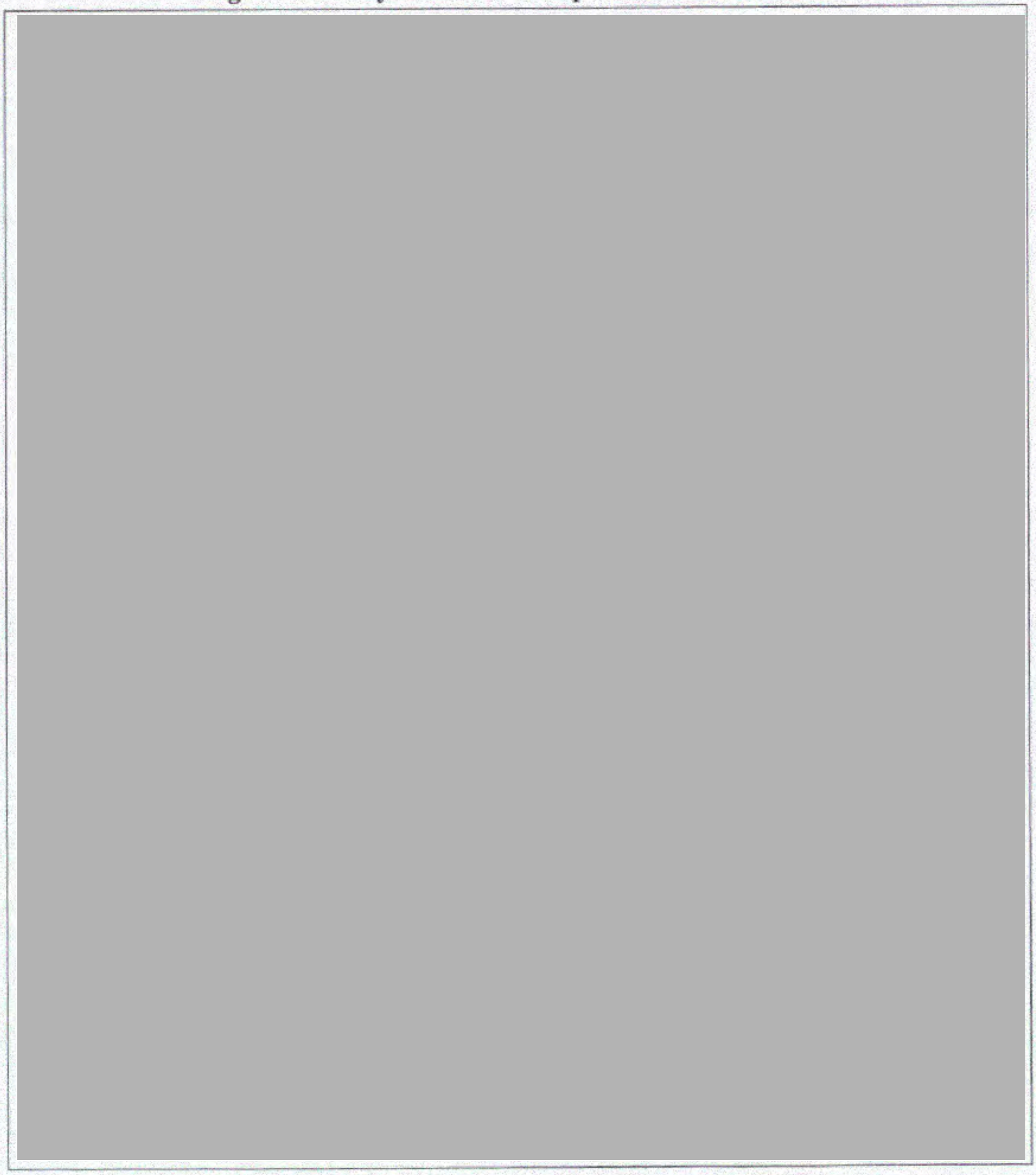
- Reservations: volunteer households, app / tech fluency

→ continued on page 26

(c) The Ministry for the Environment surveyed 1000 New Zealanders who were given a list of lifestyle 'tweaks' and asked to pick the three that they believed would have the biggest positive impact on the climate crisis.

Figure 5 shows the top 13 answers with the proportions below. The correct order of effectiveness is shown on the right of the figure.

Figure 5: Lifestyle 'tweaks' to improve the climate crisis



Source: https://www.nzgeo.com/stories/the-great-recycling-delusion/

(i) According to the Ministry for the Environment, buying products with less packaging will have more of an impact on reducing the effects of the climate crisis than recycling will.

Use the information provided in Figure 5 to construct a 95% confidence interval, and evaluate the claim that a higher proportion of New Zealanders consider recycling to be more effective at reducing the effects of the climate crisis than buying products with less packaging.

$n = 1000$ less packaging 4th is better than recycling 2nd

38th out of 59 59th of 59

~~0.33~~ 33% of NZer's think recycling

28% think packaging

difference = $33 - 28 = 5\% = 0.05$

$MoE = \frac{1}{\sqrt{1000}} \times 2 = 0.063$

$C.I = 0.05 \pm 0.063$

- The confidence interval for the difference in proportion of NZer's that consider recycling to be better than less packaging on reducing the effects on climate crisis is between -0.013 to 0.113. As zero lies within the interval we can not conclude there is any difference between the proportion of NZer's that think recycling is better at reducing the effects of climate crisis than less packaging on products. This is b/c zero lies in the interval and the true difference could be zero.

(ii) When investigating the results shown in Figure 5, a student argues that the effect that renovating your house for efficiency will have on your environmental impact is dependent on a number of confounding variables, such as how energy efficient the house was in the first place, the types of renovations being made, or how effective the efficiencies are in different environments. The student also argues that efficient renovations may even result in less desirable changes in occupants' behaviour, such as spending more time indoors with air-conditioning during warmer weather or choosing not to purchase energy-efficient appliances because of the effect of the renovations on finances.

They suggest that the Ministry for the Environment conducts a study to see how effective energy-efficient house renovations are at reducing household energy usage. They suggest two methods for an investigation. These are outlined in Table 2 below.

Table 2: Two possible studies to investigate the effectiveness of energy-efficient house renovations

Study A	**Study B**
A sample of New Zealand households recently renovated for efficiency is selected at random. Each household is categorised based on the pre-renovation energy efficiency of their home, into 'energy efficient' and 'not energy efficient'. Each household is observed for a year; their energy usage is calculated and weighted to take into account the size of the house and the number of occupants living in it. The results of the study are analysed and a bootstrap confidence interval constructed.	Volunteer participants are randomly allocated into one of two groups: renovations and no renovations. The renovations group each undertake an energy-efficient renovation, the no renovations group do not renovate at all. Energy usage is calculated and weighted to take into account the size of the house and the number of occupants living in it. The results of the study are analysed and a re-randomisation test conducted.

Discuss the impact of each study design on any conclusions that could be made.

observational vs experiment

Study ~~A~~ (A) is an observational study, where researchers can't control all the variables in place and are only searching for correlation and not causation. This means ~~that~~ no claims can be made about how energy efficient renovations affect energy usage, as an enormous amount of confounding variables such as energy usage patterns, household occupants, and materials of the house that affect the energy usage haven't been considered. Since not all the variables can be taken into account, no causal claim can be made about whether the renovation helped energy usage in A. In Study B, while it is an experiment, a volunteer sample was used, which isn't representative of a population as these households likely want to renovate anyway. This experiment consists of 2 independent groups, with the treatment variable being renovating and control: not renovating. The response variable is energy usage and is weighted the same as Study A, However, this time a causal claim can be made, as all variables can be controlled and if the re-randomisation test concludes that ~~there~~ the difference between ~~the~~ renovating and not renovating affected energy usage, the study B can claim there is indeed a reduction in energy usage due to the energy efficient renovations.

QUESTION THREE

(a) Figure 6 shows a scatterplot comparing the gross domestic product (GDP) per capita (in international dollars at 2021 prices, adjusted for inflation and differences in living costs between countries) and the plastic waste generation per person per day (in kg). Additionally, colour has been used to indicate the continent each country belongs to, while size denotes the population size of each country.

Figure 6: Per capita plastic waste vs. GDP per capita

Adapted from: https://ourworldindata.org/grapher/per-capita-plastic-waste-vs-gdp-per-capita

Identify at least three key features of the scatterplot shown in Figure 6, including a brief discussion of how per capita plastic waste compares for two different **continents**.

The trend is generally increasing, as you increase GDP per capita you also increase the per capita waste. The scatter about the trend line is substantiall, suggests a weak or moderate r-coefficient of 0.3 to 0.5. The trend appears to be ~~no~~ linear, with a gradient of $\frac{\cancel{0.2\ kg}}{\$45000} = 4.4\times10^{-6}$ non-linear, with the scale on GDP per capita axis being exponentially increasing. This means even as GDP per capita increases by \$10000, the per capita waste only increases by 0.1 kg, so the change in gradient appears exponential.

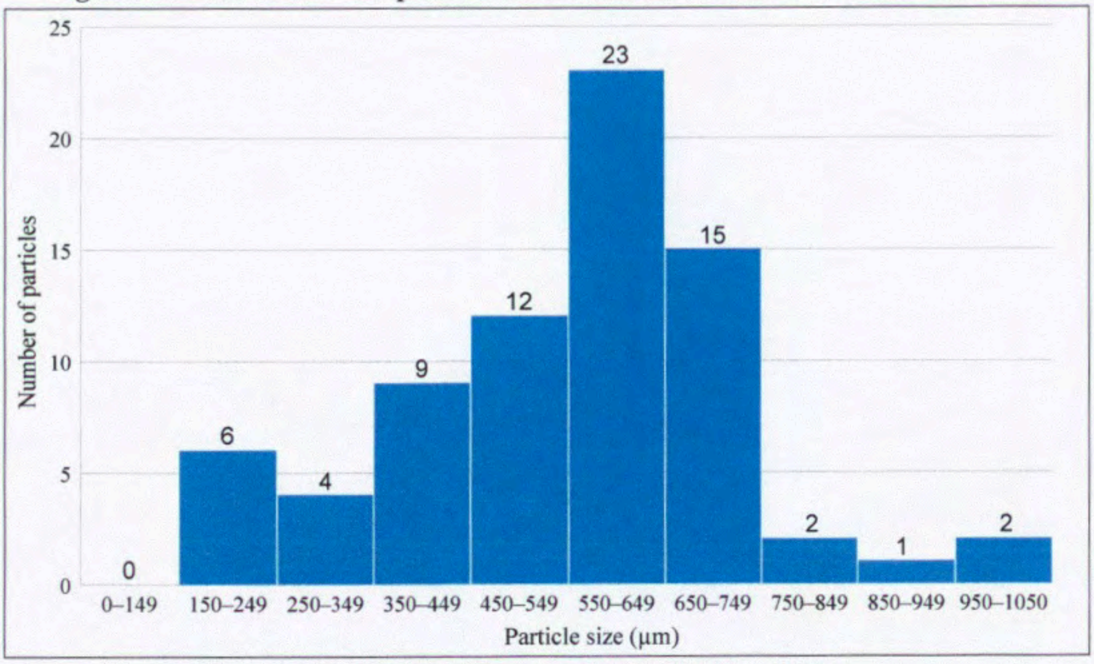
Another feature ~~of the~~ are the outliers in the top right of the plot, these countries have middle - GDP per capita but extremely high per capita waste, all around 0.5kg to 0.7kg. These outliers bring up the trend line.

Europe tends to be on the higher end of the GDP scale, while having ~~to~~ a ~~higher~~ similar ~~range~~ level of waste per capita while ~~[illegible]~~ North and Central America have extreme variance in their ~~capita~~ per capita waste, while being lower than Europe on the GDP scale.

Another key feature is the 2 largest plots/dots, China and India both have extremely low per capita waste compared to the other big dots like the U.S, ~~even though~~ maybe because China and India have a greater population.

(b) The occurrence of microplastics in saltwater bodies is relatively well studied, but little is known about their presence in most of the commercial salts that are widely consumed by humans across the globe. Researchers extracted 74 microplastic particles larger than 149 µm (micrometres) from 17 salt brands, originating from 8 different countries.

Figure 7: Presence of microplastics in commercial salts from different countries



Adapted from: https://www.nature.com/articles/srep46173

(i) Using information from Figure 7 calculate the mean size of microplastic particles larger than 149 µm (micrometres) that were extracted from the 17 salt brands.

$(6 \times 200 + 4 \times 300 + 9 \times 400 + 12 \times 500 + 23 \times 600 + 15 \times 700$

$+ 2 \times 800 + 900 + 2 \times 1000) \div 74 =$ ~~558~~ µm

551 µm

(ii) Suggest two suitable probability distribution models, including any additional relevant parameters, to model the size of microplastics in commercial salts from different countries.

Normal : $\mu = 600$ ~~551~~ , $\sigma =$ ~~200~~ 150

Triangular: $a = 200$, $b = 1000$, $c = 600$, $h = \frac{1}{400}$

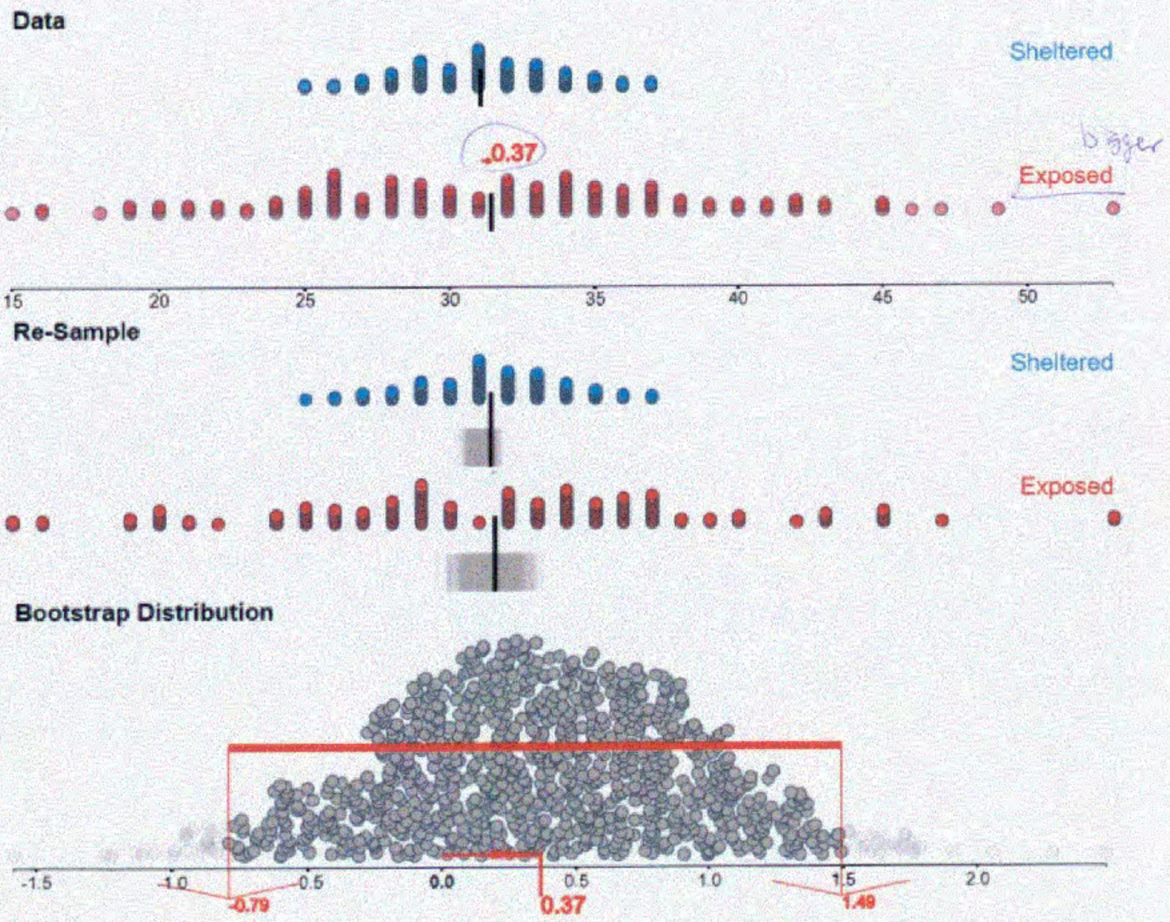
(iii) Use probability calculations to evaluate the fit of each model you have suggested in (b)(ii).

(c) Macroplastics are pieces of plastic that are over 5 mm in size. They may include waste such as bottles, bags, packaging materials, discarded fishing equipment, and other plastic items. Macroplastics are a major contributor to environmental pollution, particularly in marine and freshwater ecosystems, where they can break down into smaller microplastics over time.

An environmental group has been studying the prevalence of macroplastics on sheltered and exposed beaches on the Coromandel Peninsula. They use software to generate random points on these beaches where they survey a 20 m^2 area and count the number of macroplastics found. Their data has been used to construct a bootstrap confidence interval for the difference in the mean number of macroplastics found on sheltered beaches in comparison to exposed beaches.

The output from this analysis is shown in Figure 8.

Figure 8: Bootstrap distribution test output



Discuss the conclusions that can be made from both the sample data and the confidence interval constructed using the sample data.

Based on the sample data, we see that the mean number of ~~micro~~ macro plastics found on exposed beaches is 0.37 pieces more than the mean number of pieces found on sheltered beaches. This suggests there are (slightly) more pieces of macroplastics found

on exposed beaches compared to sheltered beaches.
The bootstrap confidence interval (C.I) for the difference in mean number of macroplastics between sheltered and exposed beaches is from -0.79 pieces to 1.49 pieces. This means sheltered beaches could have up to 0.79 pieces more than exposed beaches, or exposed beaches could have up to 1.49 more pieces than sheltered beaches. Since zero lies within the interval, the true difference in mean number of macroplastics between beaches could be zero, meaning there is no evidence ~~dif~~ to suggest there is a difference between the number of macroplastics found at an exposed beaches compared to the number found at ~~at~~ a sheltered beach.

- Other things: Range of values of number of macroplastics at exposed beaches is extremely high, ranging from 55 to 15 pieces.
- while at the sheltered beaches the numbers found ~~were~~ are consistently ~~were~~ between 25 to 38 pieces.
- The large range of ~~sheltere~~ exposed beach data suggests a high variance, which can ~~skew~~ affect the mean number of pieces.

QUESTION FOUR

(a) In April 2025, a nationally representative sample of 122 respondents was asked questions about recycling and waste reduction. Respondents reported their age and the actions they took towards reducing their household recycling, including which bin they used when they were uncertain whether or not an item was recyclable, and whether or not they had kerbside recycling collection in their area. Figures 9–12 show four plots produced from this data.

Figure 9: Age in years by actively recycle

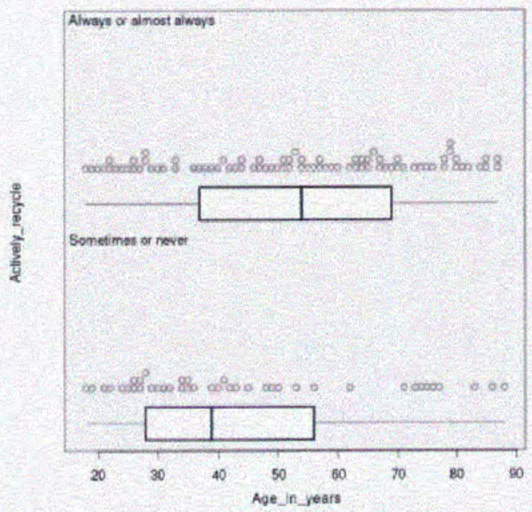


Figure 10: Age in years by which bin when uncertain about recyclability, subset by actively recycle

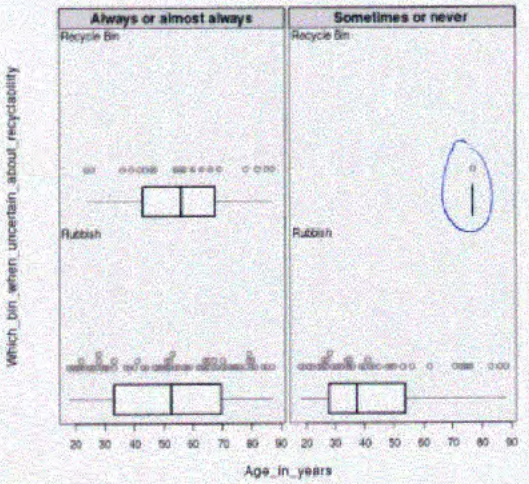


Figure 11: Which bin when uncertain about recyclability by actively recycle

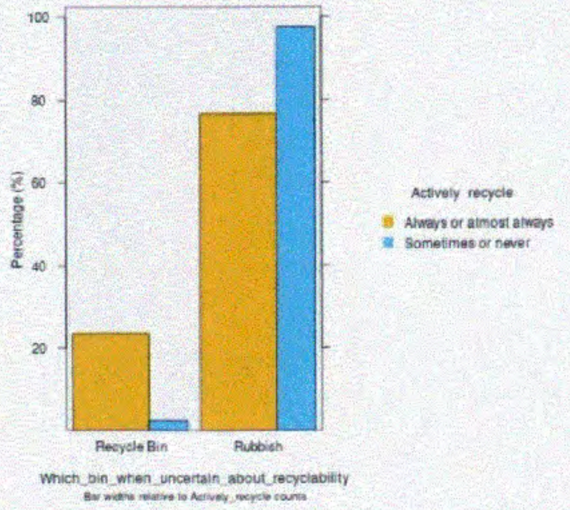
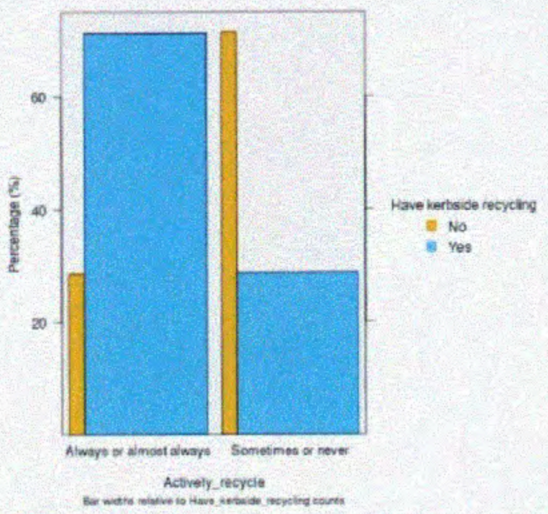


Figure 12: Actively recycle by have kerbside recycling



(i) Describe what the plots in Figures 9–12 reveal about respondents' recycling habits.

In Fig 11, ~~people~~ most people who always or almost always recycle ~~[illegible]~~ ~78% of the time put recycling into the rubbish when uncertain, ~~[illegible]~~ while nearly 100% of people who sometimes or never recycle put recycling into the rubbish when unsure. This reveals that most of the respondants put recycling in rubbish when unsure, regardless of whether they recycle or not. Fig 9, the median age of those who always recycle is 55 years, 15 years older than the median of those who never recycle at 39 years. This suggests older respondants recycle more often than younger respondents. ~~The~~ Fig 12, those who always recycle are a majority of those who have kerbside recycling and those who never recycle, a majority (65%) don't have kerbside recycling. This suggests respondants are very divided in their recycling habits, where those who do often recycle have the means to dipose of their recycling through kerbside recycling, while those who never recycle don't bother to get kerbside recycling b/c they likely don't need it.

(ii) Buller, Grey, and Westland district councils are exploring the introduction of kerbside collection for food and green waste. A councillor uses the information from Figure 12 to support their argument that the introduction of kerbside food and green waste collection will cause more people to appropriately discard their green waste.

Discuss the appropriateness of this extension of results.

This claim isn't appropiate as the figure shows that the majority of those who already have kerbside recycling recycle often anyways, while those who don't have kerbside recycling don't need it because they don't often recycle. By adding another optional ~~food~~ green waste collection, only those who are already inclined to appropriately discard their green waste will get green waste dispesal, while those who aren't inclined to ~~do~~ do so, won't get the green waste dispesal, as they won't use it.

Question Four continues on the following page.

(b) Christchurch City Council provides a kerbside waste collection service to all households. Each household has three bins: a red bin for general rubbish, a yellow bin for recycling, and a green bin for organic waste.

Table 3: Christchurch City Council waste statistics

	Collection frequency	% of bins presented at kerbside	Mean total weight of waste collected at each collection
Rubbish	Fortnightly	83%	1522 tonnes → 761
Recycling	Fortnightly	73%	936.1 tonnes → 468.05
Organics	Weekly	60%	92.7 tonnes ×2

Christchurch City Council suggests that the mean weekly combined weight of all recycling, rubbish, and organics produced by individual households is 11.46 kg.

Using the information from Table 3 and assuming that those households that do not present their bins at kerbside generate the same amount of waste as those that do, calculate an estimate for the number of households in the Christchurch City Council district.

Per house = 11.46 kg per week ×2 for fortnight

~~tot~~ 1522 + 936.1 + 92.7 × 2

~~total weight of all those who present bins = 761 + 468.05 + 92.7~~

~~weekly~~ fortnightly = 1321.75 ~~kg~~ tonnes

a household presents 2550.8 tonnes

~~X % of bins fortnightly = (83+73+60)/300 = 72%~~

~~total amount of waste generated = 2550.8/0.72 = 3542.8 tonnes~~

total for rubbish = 1522 ÷ 0.83 = 1833.7 tonnes

total for recycling = 936.1 ÷ 0.73 = 1282.3 tonnes

total for organics = 92.7×2 ÷ 0.6 = 309 tonnes

total = 3425.1 tonnes per fortnight

no. of households = $\frac{3425.1 \times 10^3}{11.46 \times 2}$ = 149435 ≈ 150000 households in Christchurch

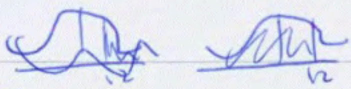
(c) At large events, recycling bins should be conveniently located to encourage recycling and reduce litter. As part of event planning, many city and district councils require recycling bins to be provided at set distances from each other. Current models of recycling bin location are mostly determined by distance – at one particular event in Hastings, event attendees were found to be on average 10.5 m from a recycling bin location, with a standard deviation of 2.75 m.

In general, a person will inappropriately discard their recyclable waste if the nearest recycling bin is more than 12 m away.

Source: https://www.hastingsdc.govt.nz/services/rubbish-and-recycling/waste-at-events/event-recycling-bins/

(i) Assuming that the variable 'distance from bin' is approximately normally distributed, estimate the probability that, out of 5 people attending this event in Hastings, all 5 people recycle their waste by using the recycling bin.

$\mu = 10.5$; $\sigma = 2.75$



$P(X < 12) = \cancel{0.293}\ 0.707$

$\cancel{P\ 0.293^5}\ 0.707^5 = 0.177$

(ii) Discuss any other assumptions you made when calculating your estimate in part (c)(i).

- 5 people attending the event didn't influence each other's decision to recycle their waste in anyway
- Everyone started out on average 10.5m from a recycling bin, with a variance of 2.75m
  - The 5 people weren't travelling as a group, otherwise they may have all gone and recycled together

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

2b) Second, the app may not be easy to use, especially for the more elderly or less tech-friendly. So the app may be getting misused, or the app may be wrong on the information it provides. This means the percentage of non-recyclable items getting sent to recycling could be higher as a result.

7a)

ii) pollute more. Meaning small island nations are more likely to contribute to plastic waste by ocean.

Scholarship

Subject: Statistics

Standard: 93201

Total score: 23

Q	Score	Marker commentary
1	5	This question provides evidence for 5s because the candidate has gained at least 5s grades overall. In Question One, the candidate interpreted how graphical techniques (e.g. colour intensity) were used to represent data in a visualisation and used this to evaluate a claim by identifying and comparing features in context. They did not calculate a suitable conditional probability using study data but did identify and explain an assumption made when using study data to estimate probabilities. The candidate also evaluated the suitability of a probability distribution by comparing expected values with observed data but did not use suitable probability calculations and reasoning about independence and combinations to compare equivalent probability scenarios.
2	6	This question provides evidence for 6s because the candidate has gained at least 6s grades overall. In Question Two, the candidate could not explain why a given sample was not representative of a population and the limitations of generalisation. They compared sample distributions in context and interpreted a tail proportion to evaluate a claim but did not discuss an appropriate reservation in context. The candidate calculated and interpreted a confidence interval for the difference between two proportions and used this to evaluate claim in context but did not recognise that the confidence interval would be over-estimated. They identified the type of conclusion that could be made from an experimental design but did not identify the type of conclusion that could be made from sample-to-population inference.
3	5	This question provides evidence for 5s because the candidate has gained at least 5s grades overall. In Question Three, the candidate described and compared relationships between variables and groups in multivariate data using contextual language. They calculated an expected value from a probability distribution but did not select the appropriate parameters for their suggested probability distribution models

		based on data characteristics. The candidate compared features of sample distribution and interpreted a bootstrap confidence interval but did not identify the appropriate population for which the findings applied.
4	7	This question provides evidence for 7o because the candidate has gained at least 6s grades and 1o grade overall. In Question Four, the candidate made evidence-based comparisons from data displays but did not identify the limitations of inferences from observational data, including causal and extension constraints. The candidate used summary statistics to calculate population quantities accurately. They selected and applied appropriate probability distribution models to calculate a required probability and identified the assumptions underlying a probability model in context.