

SUPERVISOR'S USE ONLY

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Draw a cross through the box (X) if you have NOT written in this booklet



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	Score
ONE	
TWO	
THREE	
FOUR	
TOTAL	

ASSESSOR'S USE ONLY

**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.

- (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.

- (b) Read the report below.

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



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

**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.

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- Comment on whether the Poisson distribution is an appropriate model for this data. Support your answer with calculations or numerical evidence.

- 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.

## 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>



Discuss any reservations you have about this claim.

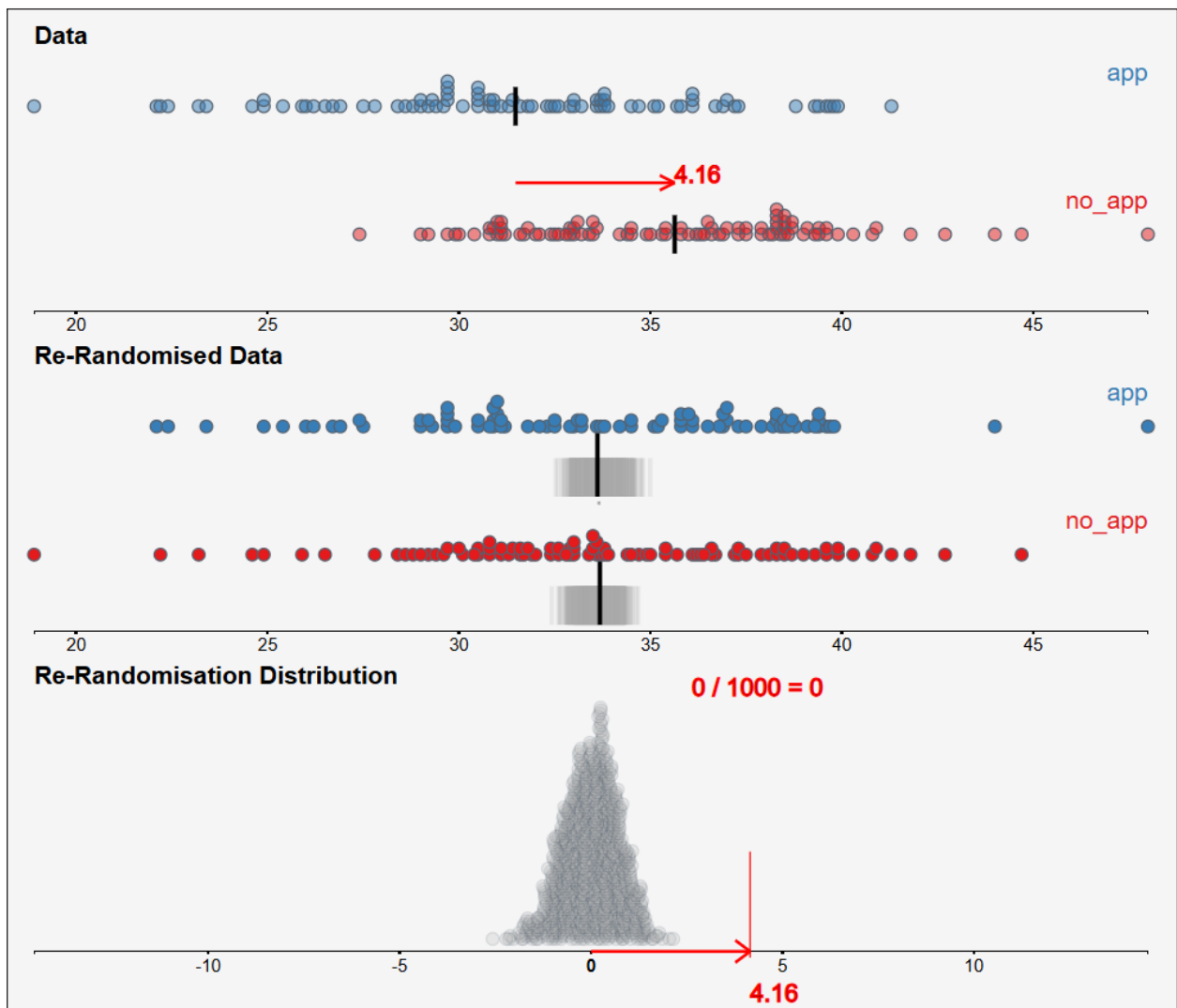
- (b) A student observed that many packaging products in New Zealand were only partially recyclable. For example, Dove body wash comes in a plastic bottle with a plastic plunger cap, but the plunger cap is non-recyclable and must be removed before recycling the bottle.

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.**

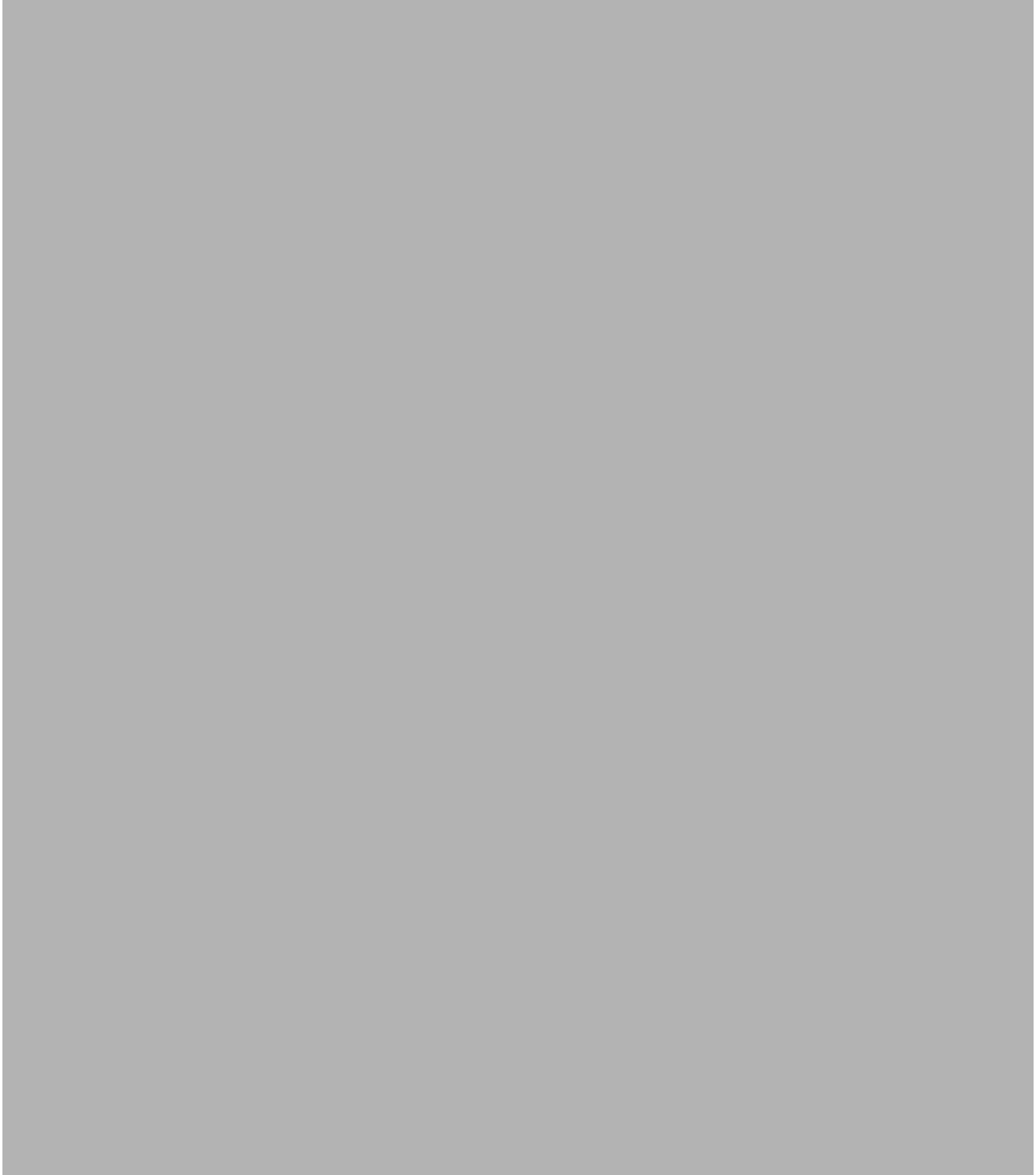




- (c) The Ministry for the Environment surveyed 1000 New Zealanders who were given a list of lifestyle ‘tweaks’ and asked to pick the three that they believed would have the biggest positive impact on the climate crisis.

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/>

- 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.

- 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.

Study A	Study B
<p>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.</p> <p>The results of the study are analysed and a bootstrap confidence interval constructed.</p>	<p>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.</p> <p>Energy usage is calculated and weighted to take into account the size of the house and the number of occupants living in it.</p> <p>The results of the study are analysed and a re-randomisation test conducted.</p>

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### 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**.

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- (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  $149\text{ }\mu\text{m}$  (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  $149\text{ }\mu\text{m}$  (micrometres) that were extracted from the 17 salt brands.
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- (ii) Suggest two suitable probability distribution models, including any additional relevant parameters, to model the size of microplastics in commercial salts from different countries.
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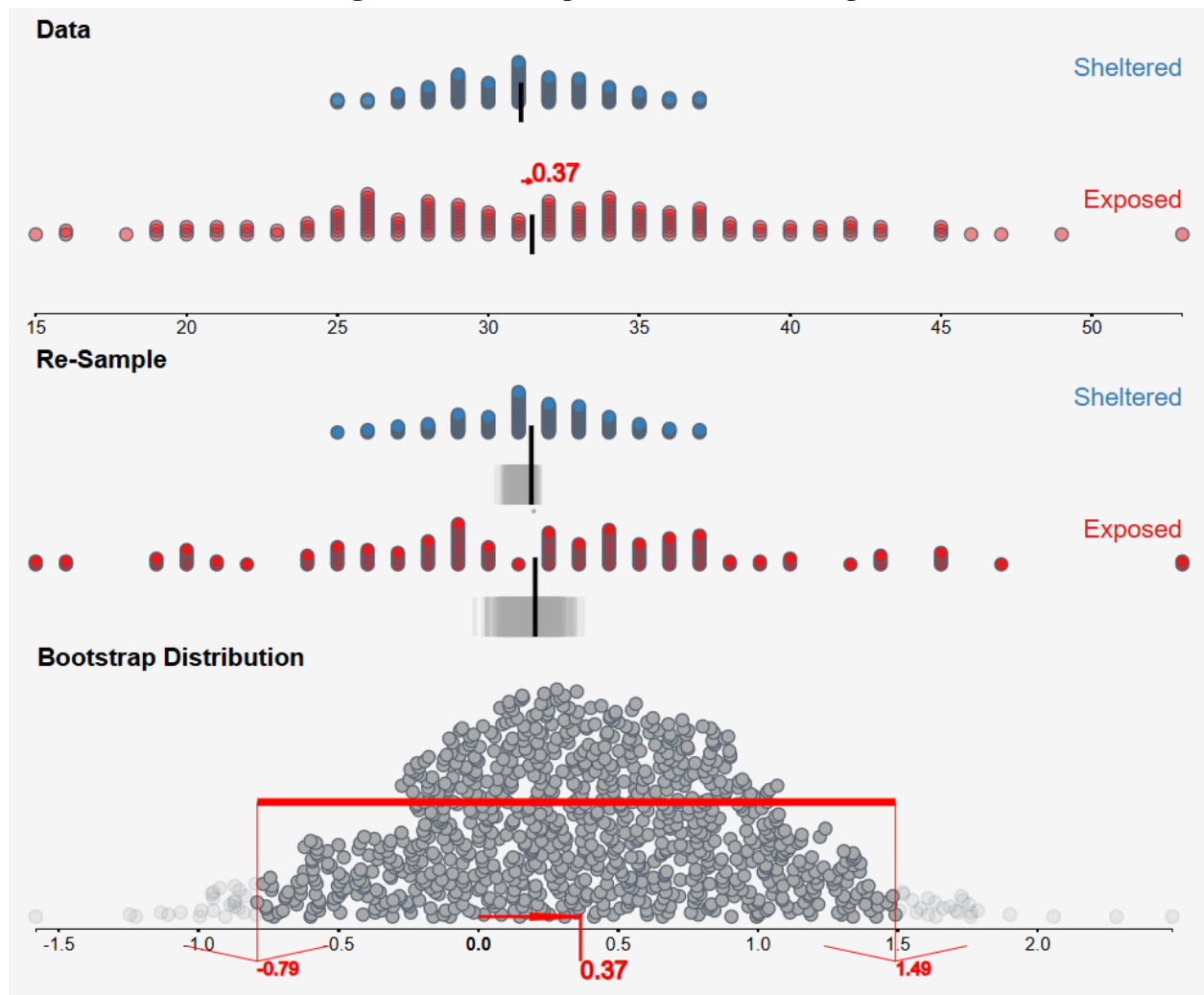


- (c) Macroplastics are pieces of plastic that are over 5 mm in size. They may include waste such as bottles, bags, packaging materials, discarded fishing equipment, and other plastic items. Macroplastics are a major contributor to environmental pollution, particularly in marine and freshwater ecosystems, 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<sup>2</sup> 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.

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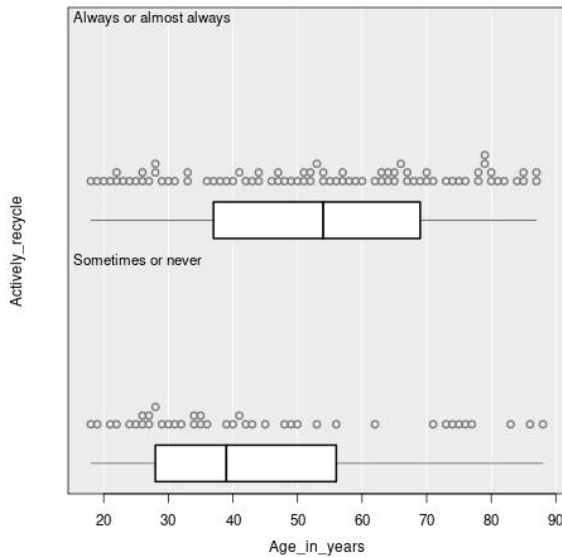
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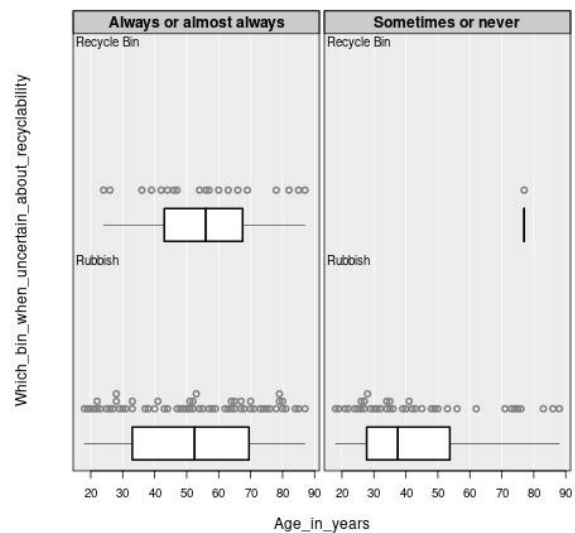
## QUESTION FOUR

- (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.

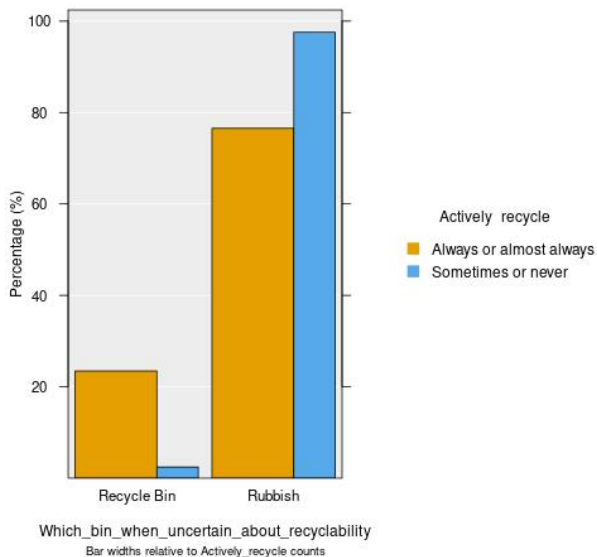
**Figure 9: Age in years by actively recycle**



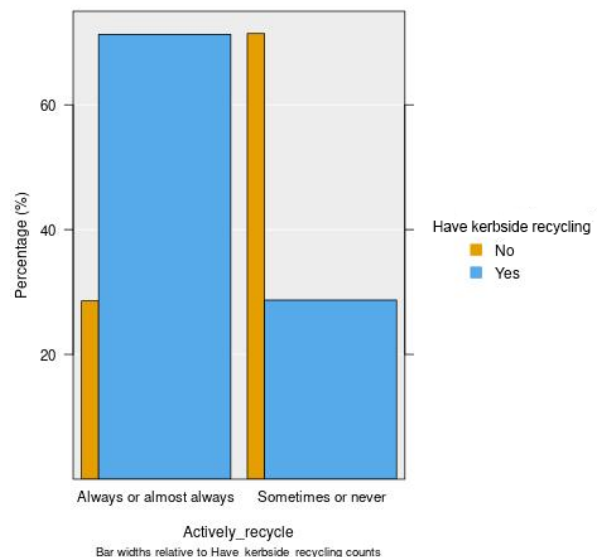
**Figure 10: Age in years by which bin when uncertain about recyclability, subset by actively recycle**



**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.

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Statistics 93201, 2025

- (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
<b>Rubbish</b>	Fortnightly	83%	1522 tonnes
<b>Recycling</b>	Fortnightly	73%	936.1 tonnes
<b>Organics</b>	Weekly	60%	92.7 tonnes

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.



- (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.

- (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.

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

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

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