Year 12 Mathematics

IAS 2.11

Statistical Reports

Robert Lakeland & Carl Nugent

Contents

MuLake Ltd
Innovative Publisher of Mathematics Texts

NCEA 2 Internal Achievement Standard 2.11 – Statistical Reports

This achievement standard involves evaluating a statistically-based report.

Achievement	Achievement with Merit	Achievement with Excellence
• Evaluate a statistically based report.	• Evaluate a statistically based report, with justification.	• Evaluate a statistically based report, with statistical insight.

- This Achievement Standard is derived from Level 7 of The New Zealand Curriculum and is related to the achievement objective
  - evaluate statistically based reports:
    - identifying sampling and possible non-sampling errors in surveys, including polls

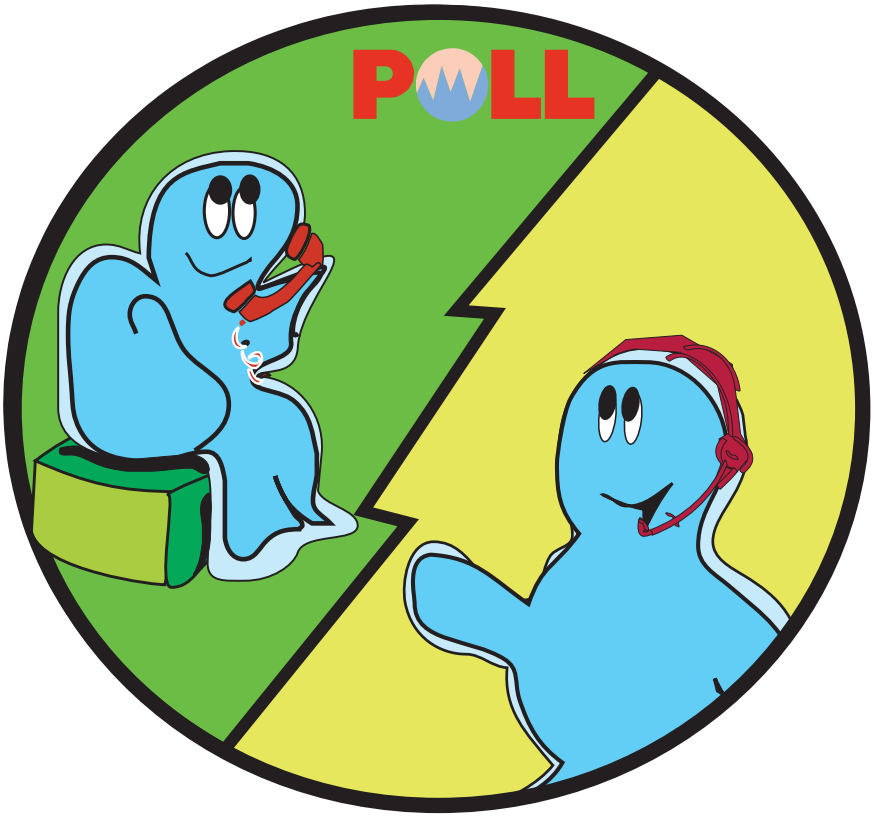
  in the Statistics strand of the Mathematics and Statistics Learning Area.

- Evaluate a statistically-based report involves identifying and commenting on features and findings of a survey relevant to its purpose.

  Evaluate a statistically-based report, with justification involves supporting the comments on the features and findings with reference to statistical evidence and the statistical processes used to carry out the survey.

  Evaluate a statistically-based report, with statistical insight involves integrating statistical and contextual information to assess the quality of the report in terms of its purpose.

- Features of a survey include:
  - population measures and variables
  - sampling methods
  - survey methods
  - sampling and possible non-sampling errors
  - sample size.



Evaluating a Report

Features of a Report

This Achievement Standard is focussed on critically evaluating a statistically based report. Essentially you are required to comment on the features and findings of a report giving relevant statistical evidence of the processes used.

You may be provided with the report you have to evaluate or choose a suitable report yourself. If you choose a report ensure you have access to detailed background information as well as the source of the data or even the data itself, perhaps included as an appendix at the end of the report.

If you are unsure whether a report you choose is suitable for this Achievement standard show it to your teacher first to get their opinion.

There are many sources of statistically based reports e.g. printed newspapers, magazines, journals, internet and so on.

When you undertake your evaluation you need to describe and evaluate a range of features relevant to the purpose of the report. These include different types of variables.

Variables

All statistically based reports quote different types of statistical variables. A variable is essentially an object, event, idea, feeling etc. that we are trying to measure.

An *independent* variable is one that stands alone and isn't changed by the other variables you are trying to measure, e.g. a person's age would be an independent variable.

A *dependent* variable is one that depends on other factors, e.g. a result in a test is a dependent variable because it depends on other factors.

A *categorical* variable (or nominal variable) is one that has two or more categories but cannot be ordered, e.g. hair colour (blonde, red, brunette, black etc.).

A *dichotomous* variable is where there are two possible answers. A dichotomous variable is a special example of a *categorical* variable.

An *ordinal* variable is similar to a categorical variable (non-numerical), but can be ordered, e.g. homework grades (unsatisfactory, satisfactory, good, excellent).

A *quantitative* variable is one that can be expressed in numerical form and can be either discrete or continuous, e.g. height, weight, age, salary etc.

In an experimental situation a *response* variable is often called the dependent variable or predicted variable and an *explanatory* variable is often called the independent variable or predictor variable.

Consider an experiment that investigates the relationship between hours spent studying and a student's grade average.

The explanatory variable is the hours spent studying and the response variable the resulting grade average. Both the variables are quantitative.

Another variable type is a *lurking* variable which is a variable that may affect the response variable but which cannot or has not been measured. In some situations there may be a correlation between a lurking variable and the explanatory variable in a study.

Consider, for example, if we were investigating the relationship between years of education and a person's future income.

A lurking variable in such an investigation could be a person's level of motivation.

In such a study it is unlikely that we could measure the level of motivation of a person, but instead we focus on the number of years' education and a person's income.

Motivation would be regarded as a lurking variable, after all you might expect highly motivated people to earn higher incomes, perhaps regardless of their education level.

Lurking variables can often be associated with outliers in the dataset and can be picked up during the data cleaning phase of an investigation.

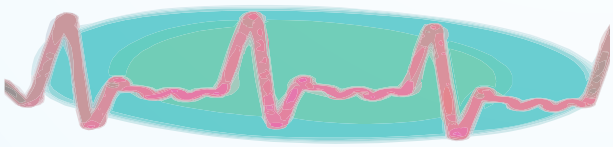
5. For each of the following identify the two variables and determine whether they are categorical, ordinal or quantitative. Also identify which variable is the response one and which the explanatory one.

a) Height of a person in centimetres and their favourite music genre.

b) Amount donated to charities per year and the tax bracket a person is in.

c) The amount of time a student spends on their homework in hours and the grade they get (poor, below average, average, above average, excellent).

d) Resting heart rate in beats per minute and the distance a person runs each day in kilometres.



6. For each of the following identify the two variables and determine whether they are categorical, ordinal or quantitative. Also identify which variable is the response one and which the explanatory one.

a) Daily intake of vitamin C in mg and life expectancy in years.

b) Number of beers consumed by a person in 60 minutes and their percentage blood alcohol level.

c) Likelihood of contracting lung cancer (below average, average, above average) and the number of cigarettes smoked per day.

d) Smoking during pregnancy (none, low, medium, high) and child's subsequent IQ level (poor, below average, average, above average, high).

Different Sampling Methods

In selecting a sampling method it is necessary to take into account how representative of the population the sample is likely to be, and the cost and ease of sampling.

Systematic Sample

In a systematic sample every *n*th member of the population is selected until the desired sample size is achieved. For a systematic sample the population needs to be ordered in some way (e.g. in alphabetical order, seating order, or the order they walk around a corner). It is often easy to systematically sample a population, but if the population has a natural pattern it is important that in selecting every *n*th member you do not select elements which are in some way not typical of the population.

Cluster Sampling

In a cluster sample a whole group is selected to represent the population. Hopefully the group should be similar in composition to the population. It could be all people whose names start with T or an entire form class at each level. It is very easy to cluster sample, but if the group is together for some reason they are likely to have something in common and may not therefore be typical of the population.

Stratified Sample

In an attempt to get a sample to better reflect the population, a research organisation sometimes extracts a stratified sample. In a stratified sample, the research organisation identifies the significant characteristics for the population and the researcher randomly selects sufficient people in each category to reflect the proportions in the population. Stratified samples have increased credibility by making sure minority groups are sampled in proportion, but it is more expensive and time consuming.

Simple Random Sample

One of the most effective techniques for obtaining an unbiased sample from a population is to use random numbers tables or the random number generating function on your calculator. To do this we

1. obtain a list of the population.
2. number each member on the list making sure each comprises the same number of digits i.e. 001 to 300.
3. use either the random number tables or your calculator to produce a 3 digit random number. If you are using the tables, start at a random place and examine groups of 3 digits moving systematically in a predetermined direction.
4. use the number to select the appropriate member from the list. If the number generated is too large, it is ignored. If it is a repeat it is also ignored.
5. repeat the process from Step 3 on, until the desired sample size is obtained.

In a simple random sample, every element of the population has the same probability of being selected.

Person in the Street

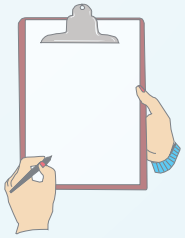
In this sample, a sample of individuals in the street are approached about their opinions. There is little credibility in this method of sampling as people approached are usually at one location at a particular time and the interviewer usually approaches people who they believe will have something to contribute. They might avoid people who they believe are busy or not newsworthy.

Quota Sampling

In a quota sample the researcher or interviewer is given a quota of minority groups (race, age groups, employment status and sex) to make sure relevant groups get sampled. It has now been discredited, as it was shown that researchers tended to select individuals who fulfilled their quota as quickly as possible (a young Maori unemployed disabled woman for example).

Self-Selected Sample

If the sample requires individuals to do something to be selected it is a self-selected sample. Examples include a phone-in-poll or a questionnaire in the local paper. Self-selected samples have little or no credibility as the only people who complete them tend to be those people with strong opinions.



26. The table below gives the number of assaults in New Zealand in 2014 by selected police regions.
Source: www.police.govt.nz

District	Recorded	Population	Per 10 000 population	Resolved	Resolution Rate
Northland	1 778	163 119	109	1 274	71.7%
Waitemata	2 960	565 966	52.3	2 011	67.9%
Auckland	3 135	452 381	69.3	2 025	64.6%
Counties/ Manukau	5 719	528 558	108.2	4 548	79.5%
Waikato	3 894	354 968	109.7	2 682	68.9%
Bay Of Plenty	3 641	340 918	106.8	2 950	81.0%
Eastern	3 446	205 854	167.4	2 312	67.1%
Central	3 192	356 250	89.6	2 609	81.7%
Wellington	4 204	483 218	87	2 565	61.0%
Tasman	1 613	f)	90.4	1 321	81.9%
Canterbury	3 726	568 855	65.5	2 499	67.1%
Southern	2 636	309 753	85.1	2 112	d)
Total NZ	**39 944**	**4 508 352**	**88.6**	**28 908**	**72.4%**

a) What is the absolute risk of a person living in Wellington being a victim of assault?

b) Using the figures for all of New Zealand as your base, what is the Relative Risk of a person living in Auckland or Eastern regions of being assaulted?

c) What does the term 'Resolved' mean?

d) Calculate the Resolved Rate for the Southern region.

e) What is the Absolute Risk of a criminal who commits an assault in Wellington of being convicted (or warned)?

f) Use the figures in the table to calculate the population of Tasman in 2014.

g) Using the figures for all of New Zealand as your base, what is the Relative Risk of a criminal who commits an assault in both Tasman and Wellington regions of being convicted?

h) Which police region in New Zealand do these figures suggest the population is most at risk? Justify your answer by using figures of Relative Risk of assault and the Relative Risk of a criminal being convicted (or warned).

Reducing Non-sampling Errors

A lot can be done to reduce non-sampling errors although it is virtually impossible to eliminate them entirely.

Ways of reducing non-sampling errors include:

Keeping questionnaires, surveys and interviews as short as possible. As a general rule the more questions you ask the less likely you are to get accurate information. Surveys or questionnaires comprising large numbers of questions put respondents off.

Avoiding questions that are sensitive or threatening.

When a person is concerned about the consequence of answering a question, e.g. on a sensitive subject, there is a good possibly that their response will be untruthful. By making the questionnaire confidential a person is more likely to fully respond.

Avoiding questions that result in ambiguous answers. A question that asks people whether they are happy with the quality of the food and level of service at a restaurant may evoke the response no. Does the 'no' refer to the food or the level of service or both?

Offering incentives for respondents to complete surveys. A store may conduct a survey on its level of service and offer all respondents that complete the survey a 10% discount on their next purchase.

Advertising a survey or questionnaire often helps with credibility and reducing non responders. It lets people know that they are not the only one being surveyed.

Making questionnaires or surveys easy to answer by using multichoice questions. Multichoice questions assist the respondent and are easier to analyse. It is important however in multichoice type questionnaires that they accommodate all possible answers, for example,

What brand of computer do you currently own?

a) Apple

b) PC (Compaq, Dell, Acer etc.)

c) Other

d) Don't own a computer

Avoiding telephone polls as they have a high non-response rate and are potential sources of non-sampling bias because they exclude people, because today many people only have a cell phone and not a land line.

If you have to use a telephone poll make sure you call at times when people are likely to be home. Most telephone polls are conducted between 6 pm and 8 pm.

In 1936, Franklin Roosevelt ran for his second term, against Alf Landon for the presidency of the United States. Most people expected Roosevelt to beat Landon easily but not the Literary Digest, an influential weekly magazine, which predicted that Roosevelt would get only 43% of the vote. In the election itself Roosevelt gained 62%.

The Digest prediction was based on an enormous sample, of 2.4 million respondents. Sampling error was not the problem in this poll, it was non-sampling error.

The Digest mailed out 10 million questionnaires and got 2.4 million responses. However the questionnaires were sent to people on mailing lists compiled from car ownership lists and telephone directories, among other sources.

In 1936, cars and telephones were not as common as they are today, and the Digest mailing list was overloaded with people who could afford what were luxury goods in the depression era.

Obviously the Digest's non-sampling error was one of coverage or lack of. A specific group, the poor, had been under represented or not included in the poll.

Types of Survey Methods

Face to Face Interview

A face to face interview is where an interviewer asks the questions directly to the respondent and records the answers. The interviewer does not need to be the researcher but must understand the questions and be able to answer questions seeking explanations. In a face to face interview more complex questions can be asked as they can be interpreted. The interviewer can also show diagrams and other visual aids. A face to face interview is likely to be completed once started as the respondent will feel a commitment to carry on. A disadvantage is that the presence of the interviewer could bias the response. The respondent may assume that confidentiality may not be respected or alternatively they may want to impress the interviewer. Face to face interviews are costly on time and resources.

Telephone Survey

A telephone survey is when an interviewer rings up the respondent, asks the questions of the respondent and records the answers, over the phone. This is the main type of survey done by large research organisations to get national opinions such as how the country is likely to vote in an election or who is the preferred prime minister.

The main advantage is that it is easier to get a more representative sample when sampling the community particularly if a filtering question is asked first. A filtering question is asked to check if the respondent is in the research population. The respondent is likely to feel a telephone survey is more anonymous and therefore they are more likely to be honest. It is quicker and cheaper than face to face interviews. A disadvantage is that all questions must be said orally with nonvisual aids and the respondent tends to be the first person to answer the phone which could bias the results. Also not all sectors of the population own phones particularly landlines.

Face to face interviews have the advantages that

- **the questions can be more complex**
- **the respondent is less likely to give up (completion rate).**

Disadvantages include

- **the respondent may exaggerate or reduce their answer to impress the interviewer**
- **it takes a lot more time.**

Telephone surveys have the advantages that

- **they can reach a widely spread sample**
- **less personal so more anonymous**
- **they are very quick.**

Disadvantages include

- **only oral questions and answers**
- **little control over who answers the phone**
- **some people do not have landlines**
- **survey may be confused with telemarketing and therefore the respondent declines to cooperate.**

Types of Surveys cont...

Paper Questionnaire

With a paper questionnaire the respondent has as much time as they need to answer. Diagrams and visual aids can be included. Disadvantages include that the results must be coded into a computer for analysis and the respondent can read ahead which may provide the respondents with additional information and affect their answers. Often the first response is what is wanted and this is impossible to manage with self-administered questionnaires. Non-completion rates are high as many people are not motivated to complete the survey which means many must be followed up.
Paper questionnaires delivered to the respondent should include a self addressed envelope complete with stamp to help the researcher get the completed surveys back.

Web Based Questionnaire

Rather than send a paper questionnaire it is becoming very common for an email to be sent to the sample members and in the email is a link to an online questionnaire. The respondent still must enter their email address so that a record is kept as to which members of the sample have completed the survey.
The advantages of online surveys are that they are quick to complete, they do not have to be returned and as the responses are recorded there is no coding required for the researcher to do to get the results into a computer for the analysis.
Web based questionnaires can be tailored to skip irrelevant questions, randomise the order and analysis of answers. Some of these templates are free but usually there is a fee. A good example is

SurveyrMonkey (www.surveymonkey.com)
SurveyMonkey has a free version that is useful for very small and informal surveys, and allows some customisation of the look of the survey, but no downloads of reports or data, and can only collect 10 questions and 100 responses per survey.

Paper questionnaires have the advantages that

- **they can be done at the respondent's leisure**
- **supporting diagrams can be included**
- **they are likely to feel non-threatening.**

Disadvantages include

- **the researcher cannot control the order that the questions are read**
- **the completion rate can be low**
- **the competed surveys must be entered into a computer for analysis.**

Invited online surveys have the advantages that

- **they can be flexible**
- **supporting diagrams can be included in paid versions**
- **they are quick to complete**
- **often they can do some analysis**
- **they are likely to feel non-threatening.**

Disadvantages include

- **the respondents must have access to an online computer.**

Answers

Page 4

1. a) Quantitative
b) Quantitative
c) Categorical
d) Categorical
e) Quantitative
f) Quantitative
g) Categorical
h) Quantitative

2. a) Ordinal
b) Categorical (Dichotomous)
c) Ordinal (A, M, E)
d) Categorical
e) Ordinal
f) Ordinal
g) Quantitative

3. a) Continuous
b) Discrete
c) Continuous
d) Discrete (assuming it has been rounded to the nearest %).
e) Discrete

4. a) Explanatory – time spent at the gym.
Response – level of aerobic fitness.
b) Explanatory – gender.
Response – like/dislike action movies.
c) Explanatory – suburb located.
Response – price sold for.

Page 5

5. a) Height – Quantitative, Explanatory.
Favourite music genre – Categorical, Response.
b) Tax bracket – Ordinal, Explanatory.
Amount donated – Quantitative, Response.

Page 5 Q5 cont...

c) Time spent – Quantitative, Explanatory.
Grade – Ordinal, Response.
d) Dist. run per day – Quantitative, Explanatory.
Resting heart rate – Quantitative, Response.

6. a) Vitamin C intake – Quantitative, Explanatory.
Life expectancy – Quantitative, Response.
b) Number of beers – Quantitative, Explanatory.
% blood alcohol level – Quantitative, Response.
c) No. cigarettes per day – Quantitative, Explanatory.
Likelihood of contracting lung cancer – Ordinal, Response.
d) Smoking – Ordinal, Explanatory.
IQ Level – Ordinal, Response.

Page 8

7. This may be biased as
- from 3pm to 5pm very few people with full-time jobs will be near the supermarket.
- you may approach some people who do not live in Auckland.
- you may only approach friendly looking people.
- one suburb only.

8. This may be biased as
- a significant section of the population either does not have a phone or has an unlisted number.
- Dunedin people are unlikely to be representative of New Zealand as a whole.

Page 8 Q8 cont...

- you have no control on who answers the questions. They may not be of voting age. A lot of teenagers will answer the phone.

9. This may be biased as
- this form class may spend more (or less) time on the internet than other form classes.
- the students are likely to underestimate the amount of time spent on the internet as that is what they think the Principal may want to hear.
- the students may lie to impress each other.
- may be a streamed class and therefore not representative of all students.

10. This may be biased as
- different students may be more or less serious about filling in the questionnaire.
- some racial groups (e.g. Chinese) will have less chance of being selected, yet may spend different amounts of time on the internet.
- not all students have access to the internet at home.
- bigger classes would be under represented.

Page 9

11. Population. All students in the school.
Method of sampling. Systematic sampling. Select every nth member of the school roll by going through the form registers of the entire school. Each person selected is asked to complete a questionnaire no matter whether they regularly take books out of the school library or not. The school roll divided by 30 is how n is calculated.