

STAT 110: Week 11

University of Otago

Outline

- Where does the data come from?
- Up until now, we have assumed the data are representative of the population
 - ▶ What problems can arise if it isn't?
 - ▶ How can we sample to ensure that it is?
- Look at generalizing from one population to another
 - ▶ Example of what can go wrong

Case study: presidential election

- The *Literary Digest* was a general interest weekly American magazine
- In 1936 they ran a presidential election poll
 - ▶ Polled 10 million people
 - ▶ Received 2.38 million responses
- 57.08% of the respondents preferred Candidate A
 - ▶ If we were to find a confidence interval for p
 - 95% CI: (0.5702, 0.5714)
- This was not the first election the *Literary Digest* had run a poll
 - ▶ They had correctly predicted the winner every election since first polling in 1916
- Seems fairly conclusive evidence that Candidate A would win
 - ▶ Do you agree?

Outcome

- Candidate A was Kansas Governor Alfred Langdon
- The other candidate was incumbent Franklin D. Roosevelt
- The literary digest poll was wrong by nearly 20 percentage points
 - ▶ FDR received 60.8% of the popular vote
- How can a sample so large (2.4 million people) be so wrong?

Big picture

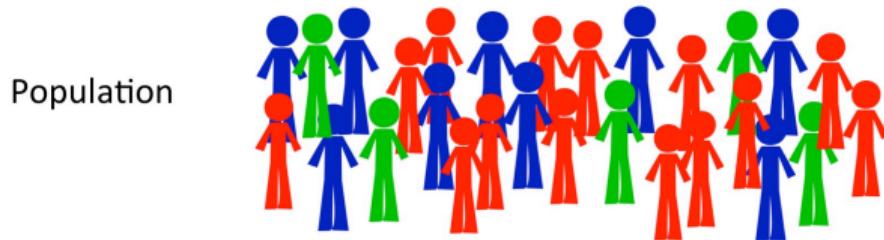
- Up until now, we haven't 'questioned the data'
 - ▶ Assumed it is reliable
 - ▶ Assumed it is representative of the population
- *Literary Digest*: the sample was not representative of the population
 - ▶ Even though the sample size is large
- Other (potentially) non-representative samples:
 - ▶ Measuring Otago Nuggets players (basketball) to learn about height in NZ population
 - ▶ Monitoring captive skinks to learn about movement in the wild
 - ▶ Using prisoners for a neuro study about brain response to stimuli for general population

Sampling

- Goal: to obtain a representative sample from the population
- Population: entire group of interest
- Sample: subset of the population
- A sampling frame is a list from which the sample is drawn
 - ▶ It ideally consists of the population

Simple random sampling

- Draw a sample of size n from the sampling frame such that each possible sample has the same probability of being selected.



Simple random
sample of 6
people



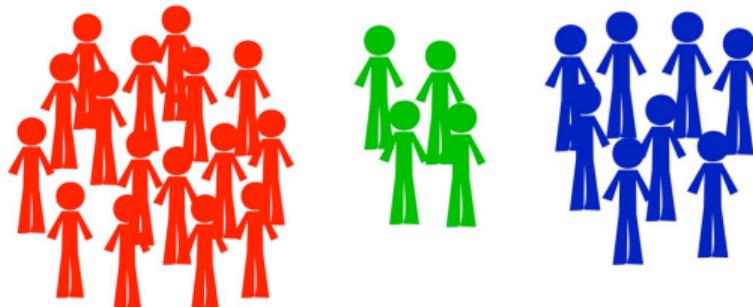
Every possible subgroup of 6 people has the same chance of selection
(you can think of it as every person having the same chance of selection)

Stratified sampling

- In many cases we may have certain groups within a population
 - ▶ e.g. ethnicity
- We can use stratified sampling in this situation
 - ▶ Define strata (or groups)
 - ▶ Take a simple random sample from within each stratum
- All strata are included in the sample

Stratified sampling: probability proportional to size

Population
stratified
(divided into
groups of
similar
people)



Stratified
random
sample

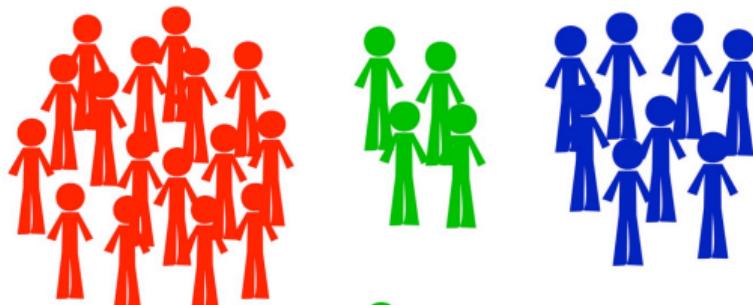


Sampled with probability proportional to size – everyone has the same chance of being selected

- This approach is useful if our interest is in the overall population
 - ▶ Ensuring each strata is represented
 - ▶ More precise than a simple random sample (of same size)

Stratified sampling: equal number from each strata

Population
stratified
(divided into
groups of
similar
people)



Stratified
random
sample



Sampled with equal numbers from each strata – those in smaller strata
are more likely to be selected

- This approach is useful if our interest is understanding the each stratum as well as the overall population
 - ▶ Ensuring accurate estimate within each strata (particularly small strata)

Cluster sampling

- Cluster sampling works using groups within the population
 - ▶ Single stage: take a simple random sample of groups and select all units in group
 - ▶ Two stage:
 1. Take a simple random sample of groups
 2. Take a simple random sample of all units in the group
- Cluster sampling is useful when clusters are easy to sample
 - ▶ e.g. sampling high school students by sampling schools
 - ▶ Usually cheaper but less precise than a simple random sample

One stage cluster sample

Population
divided into
clusters



Simple
random
sample of
clusters



Everyone in each sampled cluster is included in the study

Two stage cluster sample

Population
divided into
clusters



Simple
random
sample of
clusters



Simple random sample of one person from each cluster. Probability of someone being in the study depends on the number in their cluster

Sampling

- There are many, more complex, sampling designs
 - ▶ e.g. the sampling frame may not exist or may be otherwise difficult to find
 - Those in Dunedin addicted to drugs
 - Hedgehogs in the Dunedin Botanic Gardens
- How we analyze and interpret data may depend on how it has been sampled
- What can go wrong:
 1. Sampling error: the natural variation between statistic (sample) and parameter (population)
 - What we have been looking at: confidence intervals, etc
 2. Sampling bias: where systematic bias arises due to how the sample is collected

Sampling bias

- Selection bias: when the sample is not representative of the population
 - ▶ Sampling frame and population differ
 - ▶ *Literary Digest*: sampling frame telephone directories and car registrations
 - Predominantly wealthier people in 1936
 - Poorer voters were less likely to be sampled
- Non-response bias: those who don't participate in the study are systematically different from those who do
 - ▶ *Literary Digest*: empirical evidence was that working class were less likely to respond
 - Tended to favour FDR (Roosevelt)
 - 1936 was during the great depression
- Information bias: information obtained is not reliable
 - ▶ e.g. asking a participant about their diet in 1987
- There are many other possible sources of bias

Study design and interpretation

- We interpret the studies in light of the population of interest
- Care is required if we wish to generalize to other populations
 - ▶ Look at example

Case study: the 'warrior' gene

The screenshot shows the homepage of THE AGE website. At the top, there's a navigation bar with links for NEWS, MY CAREER, DOMAIN, DRIVE, and member centre. Below the header is the THE AGE logo with its URL theage.com.au. A horizontal menu bar below the logo includes links for NEWS, ENTERTAINMENT, BUSINESS, SPORT, TRAVEL, TECH, SECTIONS, and CLASSIFIEDS. Below this is a breadcrumb navigation showing the path: Home > National > Breaking News > Article. The main headline is 'Warrior gene' blamed for Maori violence' dated August 8, 2006, at 4:59PM.

'Warrior gene' blamed for Maori violence

August 8, 2006 - 4:59PM

- Research led by Dr. Rod Lea (ESR)
- General claim: a variant of the monoamine oxidase-A (MAO-A) gene is strongly associated with aggressive behaviour in Māori

Case study: the 'warrior' gene

- There were some controversial quotes in the media, e.g.
 - ▶ The MAO-A gene “*goes a long way to explaining some of the problems Māori have. Obviously, this means they are going to be more aggressive and violent and more likely to get involved in risk-taking behaviour like gambling.*” The Dominion Post, 9 August 2006¹
- Dr Lea subsequently claimed much of the controversy was unjustified because it stemmed from a combination of misquotes and misunderstandings ²
- Let's take a look at the science, study design and interpretation
 - ▶ Based on the work of Merriman and Cameron (2007; NZMJ; Vol 120–1250; 59–62)

¹ See Crampton and Parkin (2007; NZMJ; Vol 120–1250; 63–65)

² See Lea and Chambers (2007; NZMJ; Vol 120–1250; 5–10)

Case study: the 'warrior' gene

- There is evidence that low levels of MAO-A are associated with antisocial behaviour for males with a prior history of maltreatment
 - ▶ No evidence of association for those with no history of maltreatment
- This association may vary by ethnicity
 - ▶ The association was replicated in NZ (Dunedin study), UK, and USA (for white Americans)
 - ▶ No evidence of the association was found for US 'non-whites'
 - ▶ Consistent with evidence that many other genetic associations vary by ethnicity
- Summary: any association between antisocial behaviour and MAO-A does not appear to be strong, depends on the environment, and may vary by ethnicity

Case study: the 'warrior' gene

- To determine if the gene is associated with aggressive behaviour in Māori men, a study would need to be conducted that assess that
 - ▶ This is not what was done
- What was done: estimated the proportion of the specific MAO-A variant in the Māori male population
 - ▶ Based on a sample of $n = 46$ participants
 - ▶ Found it to be higher than some other ethnic groups (e.g. European ancestry)
- Very risky (at best) to use this and generalize / extrapolate the results of these previous studies

Case study: the 'warrior' gene

- So where does the term: 'warrior' gene, come from?
- It was termed by a scientific journalist
 - ▶ Based on a study of Rhesus macaque monkeys
 - ▶ Found that MAO-A gene was associated aggression
 - In a different way to that found in human studies
- Term 'warrior gene' had never been used for a human population before Dr Lea used it

Bias in AI

- Collecting more data does not solve the issues we have discussed today
 - ▶ *Literary Digest* is an example of that
- Application: Modern AI is backed by (often) huge datasets
 - ▶ If the data are biased (do not represent the population), the AI will be biased
 - Examples in [policing](#), [AI-assisted hiring](#), ...
- Bias in AI can also arise from generalizing from one population to another
 - ▶ Data used to train AI may come from a different population than where it is applied
 - Training data often preferential toward rich, white, male
- This is seen in healthcare, facial recognition, ...

The New York Times

[Artificial Intelligence](#) > [A.I. Forecast](#) [A.I.'s Super Bowl](#) [Google's Anthropic Investment](#) [What Is Vibecoding?](#) [Quiz](#)

*Facial Recognition Is Accurate, if
You're a White Guy*

Summary

- Where the data come from is critical
 - ▶ The fanciest statistical approach is useless if the data do not represent the population
- Look at some of the bias that can arise when sampling
- Looked at simple sampling designs
 - ▶ Simple random sample
 - ▶ Stratified sample
 - ▶ Cluster sample
- Looked at issues that can arise if we generalize to another population

STAT110 2025

Data and Interpretation II: Where do the data come from? (and why this matters...)

Phillip Wilcox

(Ngāti Rakaipaaka, Ngāti Kahungunu ki Wairoa, Rongomaiwahine, Pakeha)

Ahorangi Tuarua (= Associate Professor)

Department of Mathematics and Statistics

(Also: Affiliate Faculty, Bioethics Centre)



Current Roles...

- Associate Professor, Quantitative Genetics, Dept of Mathematics and Statistics
- Established Masters degree programme in Quantitative Genetics that started in 2017 -> now graduating students! See
<https://www.otago.ac.nz/sciences/study/applied-science/majors/otago619406.html>

Quantitative Genetics

[Home](#) / [Studying science](#) / [Applied Science programme](#) / [Majors](#) /

Quantitative Genetics uses statistical methods to understand the complexities of genetic inheritance, and can be applied in human medicine, population genetics and for selective breeding of plants and animals. So Quantitative Genetics is key in improving New Zealand's primary sector productivity and profitability as well as for understanding the genetic basis of a very wide range of diseases.

» Who is it for?
» What does it deliver?
» What is required?
» Contributors and Contacts



Current Roles...

- Kaikōkiri Māori in Genetics Teaching Programme – introducing te ao Māori content
- Kaiawhina Māori Math and Stat Dept + Genetics Teaching Programme
 - Oversee introduction of
- Current Research:
 - Genetic disease risk prediction in health-related characteristics in Māori and Pasifika
 - Co-lead *Aotearoa Variome* Project -> establish database of DNA sequence variation in contemporary Māori
 - Co-lead *Rakeiora* Pathfinder project -> pilot for personalised medicine involving Ngāti Porou Hauora
 - Māori-informed breeding objectives
 - Māori perceptions of gene editing



genomics
aotearoa

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Rakeiora: ground-breaking
research guides the path
to precision healthcare

Some of my Māori-related professional activities

- Involved in Māori-specific conversations/research regarding genetic technologies since 2001:
 - Established Te Arotūruki and co-developed TA Process (JRSNZ 2008)
 - Otago University ‘Full Circle Theme’
 - University of Waikato ‘Te Mata Ira’ & ‘Te Hau Mihi Ata’ projects
 - Various consultation with Māori communities
- Māori advisory roles
 - Scion (GE pine, kauri transcriptomics)
 - Royal Society of NZ Gene Editing expert panel
 - Reviewer for Te Tipu o te Wānanga
- Māori-specific education initiatives
 - Genetics modules in Science Wānanga for 11-14 year old Māori high school students
 - Summer Internship of Indigenous Peoples in Genomics (SING-Aotearoa)
 - Trained/ing 8 Māori graduate students in genetics
- Scientific Research
 - 24 years forestry-related genetics research
 - Genetics of gout in Maori and Pacific populations
 - GA-funded Aotearoa Variome project co-lead*
 - Co-led Māori components in successful NZ\$35M Genomics Aotearoa Proposal
 - Māori-specific roles in BioHeritage National Science Challenge and BioProtection CoRE
- Iwi (= tribal) roles
 - Previously mandated representative for Ngāti Rakaipaaka
 - Advisor for various iwi initiatives e.g. Ngāti Kohatu
 - Science advisor for various proposals in Wairoa/Mahia area
- University-specific activities
 - Maths and Stats Dept Kaiawhina
 - Sci Div Māori Leadership roopu
 - Overviewing & teaching UoO Science Wānanga Māori outreach
 - Teaching Māori ethical frameworks and consultation requirements in 300- and 400-level science courses



What we're covering...

Tuesday: Context and Rationale

- Why are we learning this?
- Indigenous peoples and knowledge... and some examples of how that impacts YOUR lives TODAY...
- Indigenous peoples and concepts of mathematics and data

Wednesday: Methods and tools

- Indigenous data sovereignty: key principles and tools
- Study design and conduct with Māori communities: tikanga-informed study design
- Co-design – an emerging area in conduct of research studies

Learning Outcomes...

By the end of these two lectures you should be able to describe:

- Examples of how indigenous peoples used data including use of mathematics
- What Māori and indigenous data sovereignty (IDS) are, why these exist, what are the underpinning principles, and what tools that can be used to implement IDS
- What is ethically appropriate (= tikanga informed) study design in an Māori context
- What ‘Co-design’ is (and why...)
- Why you need to know about all these things...

Why are we learning this?

- A broader understanding of indigenous knowledge and how this interfaces with application of modern statistical methods
- How data are collected impacts validity of study design and conduct – and utility of results...
- In Aotearoa/New Zealand, Māori knowledge, values and world views are increasingly important in all sector of our society...

Growing importance of the ‘Māori economy’

TE AO MĀORI / MONEY

New report highlights dramatic growth in Māori economy

5:39 pm on 11 March 2025

Share this

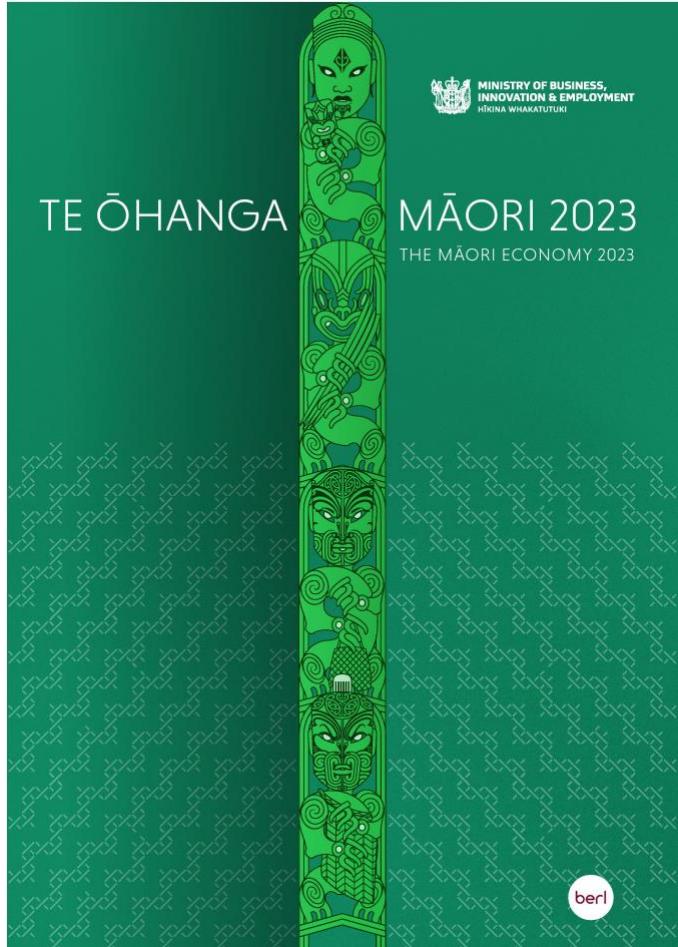


Emma Andrews, Henare te Ua Māori Journalism Intern
emma.andrews@rnz.co.nz



Māori entities have grown from contributing \$17 billion to New Zealand's GDP in 2018 to \$32 billion in 2023. Photo: 123RF

- Te ao Māori contribution to New Zealand society is increasing...
 - growing population (17% and increasing)
 - Cultural renaissance
 - Te Tiriti o Waitangi settlements
 - 23 000 Māori businesses*
 - Māori asset base



3 SNAPSHOT



Te Āhanga Māori is a strong, distinct, growing, and diversified component of the Aotearoa New Zealand economy.

MĀORI POPULATION

- The Māori population experienced substantial growth between 2018 and 2023, increasing by 14 percent from 775,800 to 887,500. This growth rate significantly outpaced the five percent increase observed in the non-Māori population during the same period.

MĀORI WORKFORCE

- The total number of Māori employed (including employers, employees, self-employed, and unpaid workers) totalled 390,700 in 2023, up 19 percent from 329,200 in 2018.
- More Māori were now employed in high-skilled jobs compared to those in low-skilled jobs.

MĀORI ASSET BASE

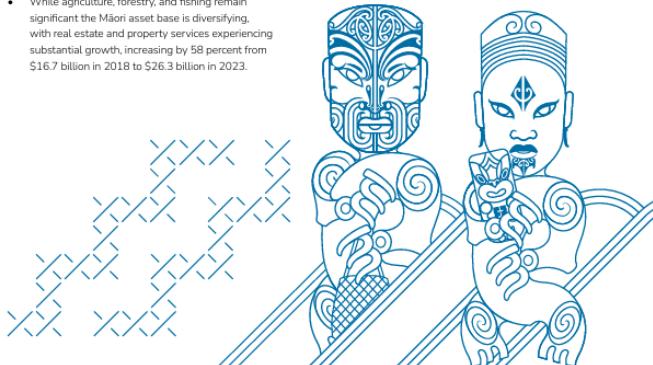
- In 2023, the asset base within Te Āhanga Māori was valued at \$1.26 billion, following an 83 percent increase from \$69 billion in 2018.
- While agriculture, forestry, and fishing remain significant the Māori asset base is diversifying, with real estate and property services experiencing substantial growth, increasing by 58 percent from \$16.7 billion in 2018 to \$26.3 billion in 2023.

MĀORI VALUE ADD (GDP)

- Value added (production GDP) from Te Āhanga Māori totalled \$32 billion in 2023, up from \$17 billion in 2018.
- The three largest sectors were professional, scientific, and technical services at \$5.1 billion; administrative, support, and other services at \$4.2 billion; and real estate and property services at \$4.1 billion.

MĀORI-OWNED BUSINESSES

- In 2023, there were nearly 24,000 Māori-owned businesses in Aotearoa New Zealand, an increase from 19,200 in 2018.
- The largest number of businesses, 5,934, was located in Tāmaki Makaurau followed closely by Waitaha with 4,215 Māori-owned businesses.



Māori contributions in all sectors of NZ society is growing...



WHAT IS CO-DESIGN IN A MĀORI SPACE?

KOTAHITANGA IN ACTION

Rita Estelle Wakefield
Kriki, British

Co-designing health research in Aotearoa New Zealand

// Lessons from the Healthier Lives National Science Challenge

Maori Data Experts Challenge Government Moves To Offshore New Zealand Data

Wednesday, 27 July 2022, 9:56 am
Press Release: Data Iwi Leaders Group

Data Iwi Leaders Group have challenged Government as it increasingly offshores New Zealand data, saying there are long-term benefits to investing in local data infrastructure instead.

Data Iwi Leaders Group Launches Revolutionary Iwi Data Platform - Te Whata

Thursday, 5 November 2020, 11:52 am
Press Release: Data Iwi Leaders Group

He whata kai, he whata idioro, īnhā he māramatanga

Tīhei Mauri Ora

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How to use and protect Māori intellectual property

Is whakapapa the answer to better health treatment?



Special Issue: Precision medicine

Rakeiora Genomics Platform: a pathfinder for genomic medicine research in Aotearoa New Zealand

Claire E Rye, Huti Puketapu-Watson, Helen Whongi, Ben Te Aika, Donia Macartney-Coxon, Joep de Ligt, ... show all

Received 14 Jun 2024; Accepted 13 Feb 2025; Published online: 24 Mar 2025

Cite this article | <https://doi.org/10.1080/03036758.2025.2469026>



Indigenous Branding- Creating an emotional connection.

Kellogg Rural Leadership Programme

Course 37 2018
Ashleigh Phillips



Māori in Governance of Agricultural Co-operatives in Aotearoa New Zealand.

Troy Hobson

Indigenous Branding – Creating a point of difference to the New Zealand Primary Sector



Kellogg Rural Leadership 2015
Stephen Thomson



Cultural Safety in Vocational Medical Training

Tipene-Leach D., Haggie-H., Potiki-M., Carter.M



Health Equity

Experiences perspectives and values of indigenous peoples regarding kidney transplantation: Systematic review and thematic synthesis of qualitative studies

Walker R., Tipene-Leach D., Abel.S., Reynolds.A., Palmer.S., Walker.C.



Health Equity

Understanding the experiences perspectives and values of indigenous women around smoking cessation in pregnancy: Systematic review and thematic synthesis of qualitative studies

Walker R., Graham.A., Palmer.S., Tipene-Leach D., Jagroop.A.



The Kaitiaki Intelligence Platform: conceptual foundations for an indigenous environmental sensing network

John Keoh, Katherine Rout, Dennis Wairere-Schulman, Corey Ruha & Jan Hanra

Received 30 Sep 2023; Accepted 17 Feb 2025; Published online: 25 Mar 2025

Cite this article | <https://doi.org/10.1080/03036758.2025.2470423>

Full Article | Figures & data | References | Citations | Metrics | Reprints & Permissions | View PDF | View EPUB



Sustainable Seas

How to Indigenise the Blue Economy in Aotearoa New Zealand

Rout.M., Mikा.J., Reid.J., Whitehead.G., Gillies.A., Wiremu.F., McLellan.G., MacDonald.T., Ruha.C.



Sustainable Seas

Indigenising the Blue Economy: A Case Study of the Moriori of Rēkohu

Gomes.D., Gillies.A.



Health Equity

Mahi a Atua: A Pathway Forward for Māori Mental Health?

Tipene-Leach D., Rangihuna D., Kopua.M.



Cultural Safety

Cultural Safety Training Plan for Vocational Medicine in Aotearoa

Simmonds.S., Carter.M., Haggie-H., Mills.V., Lyndon.M., Tipene-Leach.D.



Nourishing Hawke's Bay

Assessing the Potential for School Based Programmes Ka Ora Ka Ako to Enhance Education, Sustainability, and Health Goals

McKee-Sellizar.P., Swinburn.B., Rees.D., Glassay.R., Tipene-Leach.D., Garton.K.

Also... UoO graduate Attributes

- <https://www.otago.ac.nz/courses/the-university-of-otago-graduate-profile>



Cultural understanding

Knowledge and appreciation of biculturalism within the framework of the Treaty of Waitangi; knowledge and appreciation of multiculturalism; and an ability to apply such knowledge in a culturally appropriate manner.

Ethics

Knowledge of ethics and ethical standards and an ability to apply these with a sense of responsibility within the workplace and community

Todays lecture

- Some context:
 - Indigenous peoples
 - Indigenous knowledge and (some) contributions to our lives
 - Indigenous concepts of mathematics and data

Who are indigenous peoples? What differentiates indigenous from non-indigenous?

Source:

https://www.un.org/esa/socdev/unpfii/documents/5session_factsheet1.pdf



FACTSHEET

Who are indigenous peoples?

It is estimated that there are more than 370 million indigenous people spread across 70 countries worldwide. Practicing unique traditions, they retain social, cultural, economic and political characteristics that are distinct from those of the dominant societies in which they live. Spread across the world from the Arctic to the South Pacific, they are the descendants - according to a common definition - of those who inhabited a country or a geographical region at the time when people of different cultures or ethnic origins arrived. The new arrivals later became dominant through conquest, occupation, settlement or other means.

Among the indigenous peoples are those of the Americas (for example, the Lakota in the USA, the Mayas in Guatemala or the Aymaras in Bolivia), the Inuit and Aleutians of the circumpolar region, the Saami of northern Europe, the Aborigines and Torres Strait Islanders of Australia and the Maori of New Zealand. These and most other indigenous peoples have retained distinct characteristics which are clearly different from those of other segments of the national populations.

Understanding the term “indigenous”

Considering the diversity of indigenous peoples, an official definition of “indigenous” has not been adopted by any UN-system body. Instead the system has developed a modern understanding of this term based on the following:

- Self- identification as indigenous peoples at the individual level and accepted by the community as their member.
- Historical continuity with pre-colonial and/or pre-settler societies
- Strong link to territories and surrounding natural resources
- Distinct social, economic or political systems
- Distinct language, culture and beliefs
- Form non-dominant groups of society
- Resolve to maintain and reproduce their ancestral environments and systems as distinctive peoples and communities.

Indigenous People have always been 'scientists'



Polynesian
navigation



Plant and medicinal knowledge



Diné understanding of genetics

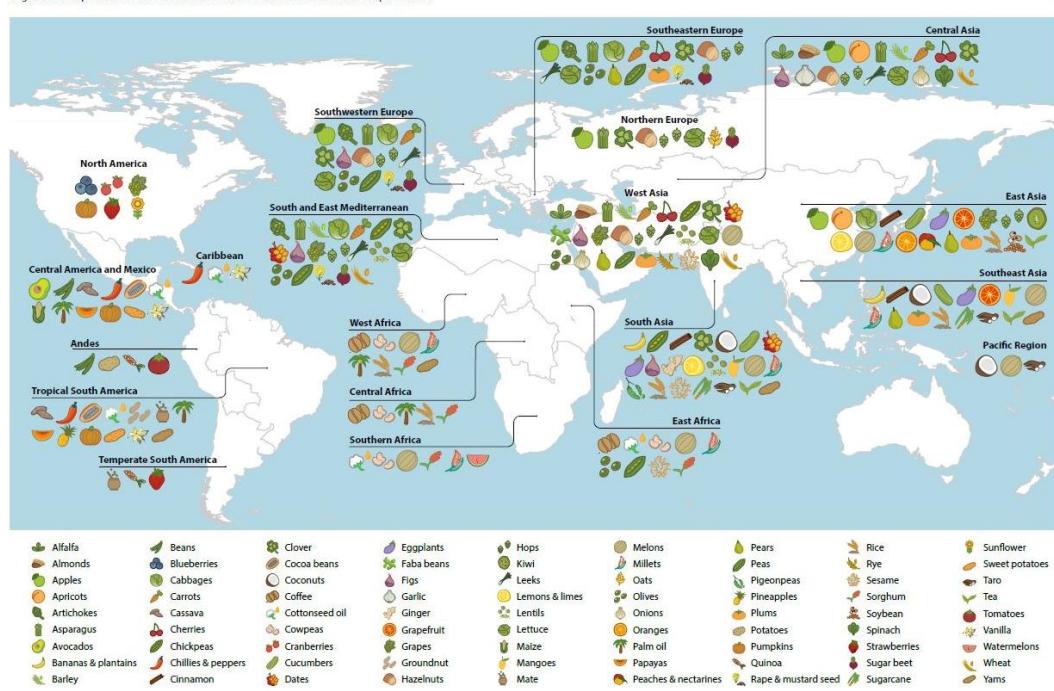
Indigenous people used traditional knowledge from generations of experiential learning, repeated observations and **experimentation** to understand the world around them.

Indigenous knowledge exist pre-dates universities.

Examples of indigenous knowledge applications that affect our everyday lives...

ORIGINS AND PRIMARY REGIONS OF DIVERSITY OF AGRICULTURAL CROPS

Khoury, C.H., Achucarro, H.A., Bjorkman, A.D., Navarro-Racines, C., Guarino, L., Flores-Palacios, X., Engels, J.MM., Wiessner, J.H., Dempewolf, H., Sotelo, S., Ramirez-Villagrasa, J., Castañeda-Alvarez, N.P., Fowler, C., Jarvis, A., Rieseberg, L.H., and Struik, P.C. (2016).



<https://blog.ciat.cgiar.org/origin-of-crops/>

- Domestication of plant species: **almost every food crop was domesticated by indigenous or ancient peoples**
 - **Modern-day breeding programmes use these domesticated varieties** (and modern statistical methods like ANOVA and regression to quantify and rank genotypes...)

Kumara Domestication led to Māori Cultural Evolution...

- Adaptation of kumara – a tropical species – to temperate climates...



Phase 1: Introductory

Introduced species grown using tropical-based production systems



Phase 2: Experimental

Development of agricultural methods like:

- Cold-protection for growing plants
- Long term storage methods
- Cultivation systems for indigenous species



Phase 3: Systemic/Stable

Production systems mature

Well-developed and systemized ceremonial rituals involving these species (*tapu*, *māramataka*)

Major contributions to pre-European Māori economy, especially kumara & harakeke



Evolution of ‘Classic’ Māori Culture

‘Archaic Eastern Polynesian’ (1150 → 1350-1500 AD)

- Aka ‘Moa-hunter’
- Nomadic, hunter-gatherer – based society
- Few permanent year-round settlements
- Widely travelled within Aotearoa
- Less war-like (?) – some evidence of peace traditions
- Some elements still exist today (e.g., southern parts of Te Waipounamu)



Classic Māori (1350 1500 → 1800 AD)

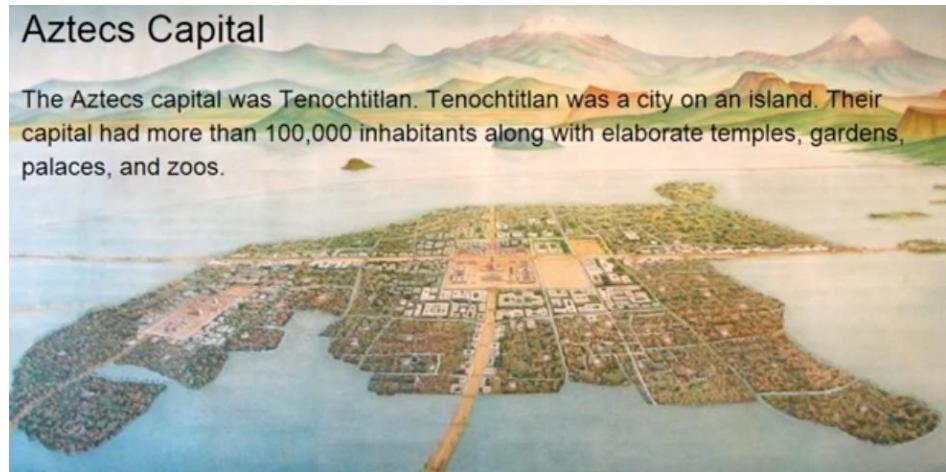
- Place-based permanent settlements
- **Agriculturalists** = role specialisation
- New forms of cultural expression: whakairo, religious developments (e.g., tuahu, local deities such as taniwha, etc.)
- New adaptations: pā (fortified villages)
- Sophisticated tribal structures and role specialisation: rangatira, tohunga, kaititaki, etc.
- Kaitiakitanga (environmental stewardship for the benefit of the tribe)



Indigenous mathematics... some examples

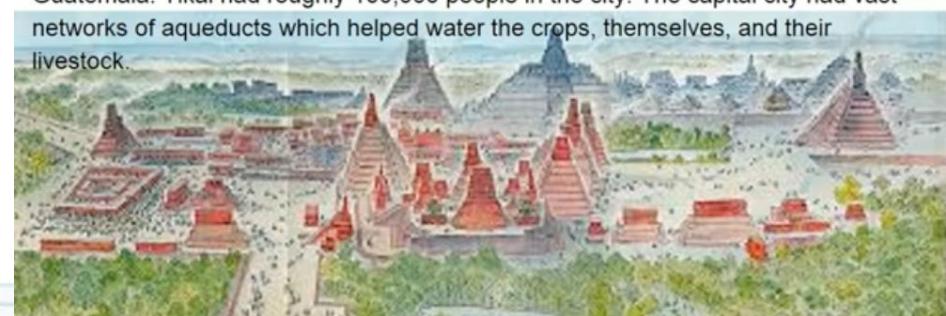
Mayan and Aztec

- Base 20 counting system = enabled mathematical operations to performed with large numbers
- Mathematical & Astronomical Knowledge:
 - The Maya and Aztecs developed complex mathematical and astronomical knowledge, crucial for their calendar systems, architectural planning, and resource management.
- Calendar Systems:
 - The Maya and Aztecs developed sophisticated calendar systems based on astronomical observations, which were used for religious rituals, agricultural planning, and timekeeping.
- Impact on Urbanization:
 - Urban Planning: Their mathematical and astronomical knowledge facilitated the precise planning and construction of their cities, including the alignment of buildings and the creation of infrastructure like aqueducts and roads.
 - Resource Management: They used their knowledge of mathematics and astronomy to manage resources, including land allocation, taxation, and trade.
 - Social Organization: Their mathematical and astronomical systems were also intertwined with their social and religious beliefs, reinforcing the power of the ruling



Mayans Capital

The Mayans capital city was called Tikal, which is located in modern day Guatemala. Tikal had roughly 100,000 people in the city. The capital city had vast networks of aqueducts which helped water the crops, themselves, and their livestock.



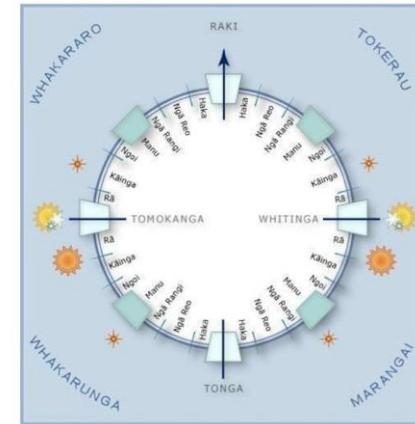
Indigenous mathematics... some examples

Māori

Much knowledge of Māori mathematics is lost, however examples include...

- The commonly used Māori term ‘Pangarau’ means ‘many relations’, reflecting an algorithmic understanding
- Aspects of mathematics were integrated into various activities, survival practices, spiritual practices, games, and art.
- Forms of quantification, measurement, utilisation of patterns, means of orientation, and the ability to form and recognise relationships and interactions between people, things, and place.
- Numbering system
- Concepts of nothingness, or zero: te kore; concepts of infinity

- Perhaps most well-known feat is navigating using stars



Indigenous Peoples and Data....

- ‘Indigenous peoples have always been data collectors and knowledge holders’

About Us

WHO WE ARE

PURPOSE

HISTORY OF
INDIGENOUS DATA
SOVEREIGNTY

HISTORY OF INDIGENOUS DATA SOVEREIGNTY

While the term Indigenous Data Sovereignty is relatively new, **Indigenous Peoples have always been data collectors and knowledge holders.** The rise of national Indigenous Data Sovereignty networks reflects a growing global concern about the need to protect against the misuse of Indigenous data and to ensure Indigenous Peoples are the primary beneficiaries of their data. GIDA connects these national communities to advocate for shared rights and interests in data.

<http://gida-global.org/history-of-indigenous-data-sovereignty>

WHAT ARE INDIGENOUS DATA?

Data, information and knowledges, in any format, that impacts Indigenous Peoples, nations, and communities at the collective and individual levels:

DATA ABOUT OUR NON-HUMAN RELATIONS

Land, water,
geology, titles, air,
soil, sacred
ecosystems,
territories, plants,
animals, etc.

DATA ABOUT US AS INDIVIDUALS

Administrative, legal,
health, social,
commercial,
corporate, services,
etc.

DATA ABOUT US AS COLLECTIVES

Traditional and
cultural information,
languages
knowledge systems,
ancestral and clan
knowledges, etc.

USINDIGENOUSDATA.ORG
@USIDSN

Informed by British Columbia First Nations Data Governance Institute - BCFNDGI.COM

GIDA-GLOBAL.ORG
@GidaGlobal

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What are traditional Māori concepts of data ?

- Data = knowledge/information...
- Cosmological mythologies:
 1. Tawhaki the demi-god (= a person of human and divine lineage) ascended to the heavens to retrieve four baskets of knowledge:
 - Ritual, prayer, and memory.
 - Knowledge of the natural world and patterns of energy.
 - Knowledge of both terrestrial and celestial forms of knowledge.
 - Incantations, literature, philosophy, and ritual practices.
 2. Tane Mahuta – a god – passed down to humans three baskets of knowledge:
 - Te Kete Aronui:
 - This basket holds the knowledge that benefits humankind, including knowledge of the natural world, and the physical, spiritual, and mental well-being of people.
 - Te Kete Tuauri:
 - This basket contains knowledge of ritual, prayer, memory, and spiritual communication, representing the realm of the spirit and the sacred.
 - Te Kete Tuatea:
 - This basket holds knowledge of evil or mākutu, which is harmful to humanity, representing the darker aspects of life.
- Knowledge is from the gods... therefore tapu (= restricted)

What are contemporary Māori concepts of data ?

- Language (te reo Māori words): data = raraunga, tātauranga
 - raraunga motukore (continuous data), raraunga motumotu (discrete data), and raraunga houanga (time series data), roopu matatini – multivariate categorical data
- Perspectives:
 - ‘Māori data. Māori data refers to information produced by or about Māori, and about the environments we have relationships with.
 - Māori view data as a living taonga (treasure) with immense strategic value. It’s an important tool in understanding our whenua and our tangata whenua. It helps us answer questions like how many people whakapapa to our iwi and where they live, how many Māori live within Aotearoa, and how many live or were born overseas’
- Ethics:
 - ‘Māori data is subject to the rights articulated in the Treaty of Waitangi and the UN’s Declaration on the Rights of Indigenous Peoples, to which Aotearoa New Zealand is a signatory.’

COMMENT & ANALYSIS
Māori data is a taonga
by Ngäpera Riley | May 28, 2023 | 8 min read

Data collected about Māori people and resources is a valuable asset – it can be a powerful mechanism for informing and driving significant change in communities.

But that will only happen if Māori are able to exercise authority over data and treat it as a taonga, as Ngäpera Riley tells us here.



Source: <https://e-tangata.co.nz/comment-and-analysis/maori-data-is-a-taonga/#:~:text=M%C4%81ori%20view%20data%20as%20a,live%20or%20were%20born%20overseas.>

Data are taonga...

- ‘He taonga he tapu... na te tapu i puta mai te tikanga’
- Māori data are treasured, i.e., of emotional value, thus are restricted and should be treated appropriately
- But what does ‘appropriate’ consist of?

HE TAONGA HE TAPU

Tissue is a taonga [precious]
Tissue, DNA and Data are taonga, separately and together
Data refers to both genomic and clinical information

He Taonga, He Tapu
- Protection of taonga
- Na te tapu i puta mō te tikanga
(Physical and Spiritual components)



STAT110 2025 – Lecture B

Data and Interpretation II: Where do the data come from? (and why this matters...)

Phillip Wilcox

(Ngāti Rakaipaaka, Ngāti Kahungunu ki Wairoa, Rongomaiwahine, Pakeha)

Ahorangi Tuarua (= Associate Professor)

Department of Mathematics and Statistics

(Also: Affiliate Faculty, Bioethics Centre)



What we covered last lecture

- Why we teach this material in STAT110
- Indigenous concepts of data, mathematics and their use including in te ao Māori
- Examples of indigenous knowledge applications that impact our lives
- Māori concepts of data – both traditional and contemporary – and why data are a taonga

What we're covering today...

Tuesday: Context and Rationale

- Why are we learning this?
- Indigenous peoples and knowledge... and some examples of how that impacts YOUR lives TODAY...
- Indigenous peoples and concepts of mathematics and data

Wednesday: Methods and tools

- Indigenous data sovereignty (IDS): key principles and tools
- Study design and conduct with Māori communities: tikanga-informed study design
- Co-design – an emerging area in conduct of research studies

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DATA ABOUT US AS COLLECTIVES

Traditional and cultural information, languages knowledge systems, ancestral and clan knowledges, etc.

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@USIDSN

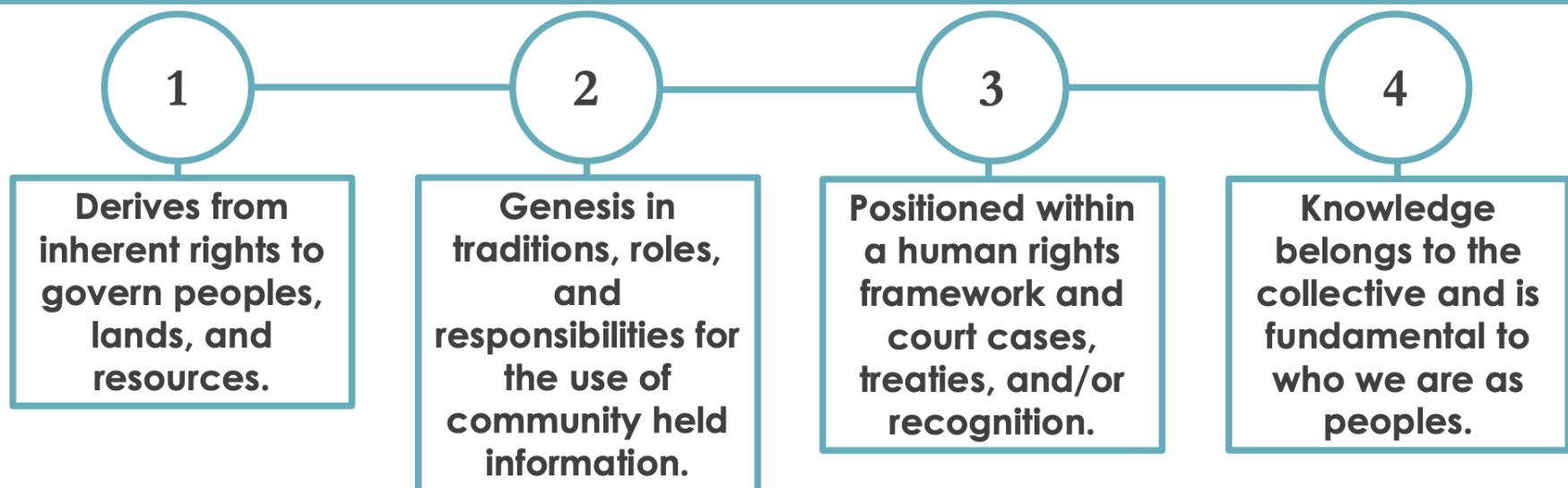
Informed by British Columbia First Nations Data Governance Institute - BCFNDGI.COM

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@GidaGlobal

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INDIGENOUS DATA SOVEREIGNTY

The *right* of Indigenous Peoples and nations to govern the collection, ownership, and application of their own data.



See Kukutai T & Taylor J. (Eds). (2016). Indigenous Data Sovereignty. Canberra: Australian National University Press.

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The CARE Principles*

C = Collective Benefit: ‘Data ecosystems shall be designed and function in ways that enable Indigenous Peoples to derive benefit from the data’

A = Authority to control: ‘Indigenous Peoples rights and interests in indigenous data must be recognised and their authority to control such data be empowered. Indigenous data governance enables indigenous peoples and governing bodies to determine how Indigenous Peoples, as well as indigenous lands, territories, resources knowledges and geographical indicators, are indicated and identified within data.’

R = Responsibility: ‘Those working with Indigenous data have a responsibility to share how those data are used to support Indigenous Peoples’ self determination and collective benefit. Accountability requires meaningful and openly available evidence of these efforts and the benefits accruing to Indigenous Peoples.’

E = Ethics: ‘Indigenous Peoples’ rights and wellbeing should be the primary concern at all stages of the data life cycle and across the data ecosystem.’



*Source: Global Indigenous Data Alliance
<https://www.gida-global.org/care>

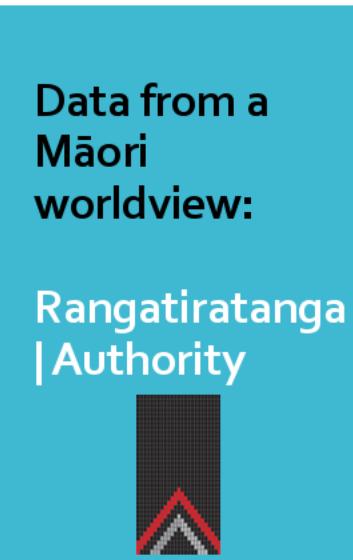
Māori Data and Data Sovereignty

- Māori data (from yesterday...) = ‘digital or digitisable information or knowledge that is about or from Māori people, our language, culture, resources or environments’
- Māori Data Sovereignty (MDS) MDS refers to the inherent rights and interests that Māori have in relation to the collection, ownership, and application of Māori data*

Principles of
Māori Data
Sovereignty

Source: https://www.otago.ac.nz/__data/assets/pdf_file/0014/321044/tmr-maori-data-sovereignty-principles-october-2018-832194.pdf

Māori Data Sovereignty in Action...



- **Control.** Māori have an inherent right to exercise control over Māori data and Māori data ecosystems. This includes but is not limited to data creation, development, stewardship, analysis, dissemination and infrastructure.
- **Jurisdiction.** Decisions about the physical and virtual storage of Māori data should enhance control for current and future generations. Whenever possible, Māori data should be stored in Aotearoa NZ
- **Self-determination.** Māori have the right to data that is relevant and empowers sustainable self-determination and effective self-governance.

Principles of
Māori Data
Sovereignty

Source: https://www.otago.ac.nz/__data/assets/pdf_file/0014/321044/tmr-maori-data-sovereignty-principles-october-2018-832194.pdf

Māori Data Sovereignty in Action...

Data from a
Māori
worldview:

Kaitiakitanga |
Guardianship

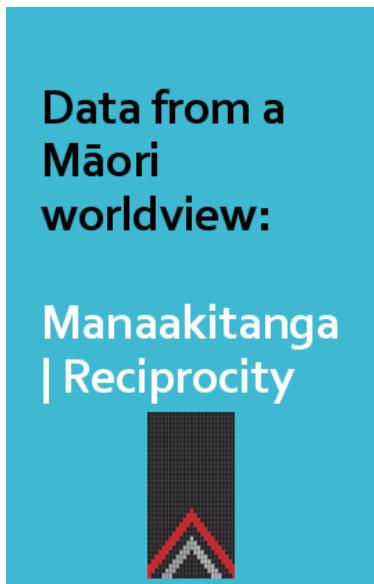


- *Stewardship.* Maori data needs to be stored and transferred in such a way that it enables and reinforces the capacity of Māori to exercise kaitiakitanga over Māori data .
- *Restrictions.* Māori should decide which Māori data sets should be controlled (tapu) or open (noa) access.
- *Ethics.* Tikanga, kawa (protocols) and mātauranga Māori (knowledge) should underpin the protection, access and use of Māori data.

Principles of
Māori Data
Sovereignty

Source: https://www.otago.ac.nz/__data/assets/pdf_file/0014/321044/tmr-maori-data-sovereignty-principles-october-2018-832194.pdf

Māori Data Sovereignty in Action...



- *Respect.* The collection, use and interpretation of data should uphold the intrinsic dignity of Māori individual, groups and communities.
- *Consent.* Free, prior and informed consent should underpin the collection and use of all data from or about Māori. Less defined types of consent must be balanced by stronger governance arrangements.

Principles of
Māori Data
Sovereignty

Source: https://www.otago.ac.nz/__data/assets/pdf_file/0014/321044/tmr-maori-data-sovereignty-principles-october-2018-832194.pdf

DIGITAL TOOLS TO PROTECT INDIGENOUS DATA SOVEREIGNTY

- ✓ **Traditional Knowledge (TK) Labels.** Digital markers that define attribution, access, and use rights for Indigenous cultural heritage
- ✓ **Biocultural (BC) Labels.** Digital markers for provenance, transparency and integrity in research engagements related to community expectations and consent for use of collections and data.
- ✓ **Dynamic Consent Portal.** An Indigenous-led data repository to house Tribally-consented genomic sequence data and manage access and attribution.
- ✓ **Blockchain.** A distributed ledger system that tracks sharing via transactions, can fine-tune user access, attribute provenance, and facilitate data governance.
- ✓ **Federated learning.** To facilitate secure and community-consented data sharing.



Native BioData
consortium

Tools for Protecting Indigenous Data

- **Biocultural (BC) labels and traditional knowledge indicators**
 - metadata tags on data sets that provide provenance and attribution
 - ‘BC Labels define community expectations about appropriate use of biocultural collections and data. The BC Labels focus on accurate provenance, transparency and integrity in research engagements with Indigenous communities.’ source: <https://localcontexts.org/>

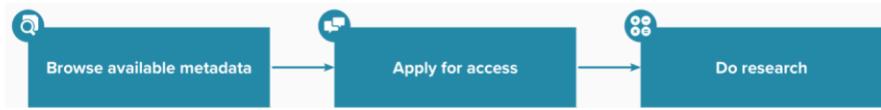


Tools for Protecting Indigenous Data

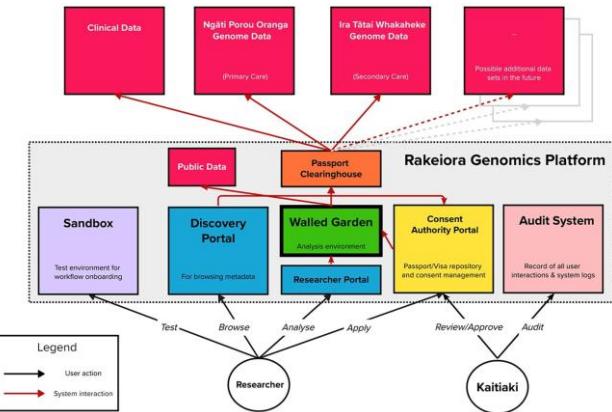
Dynamic Consent portals/Platforms

- Embed indigenous governance and oversight in access to, and analyses of, specific data sets within custom-built computational platforms/online environments

Researcher:



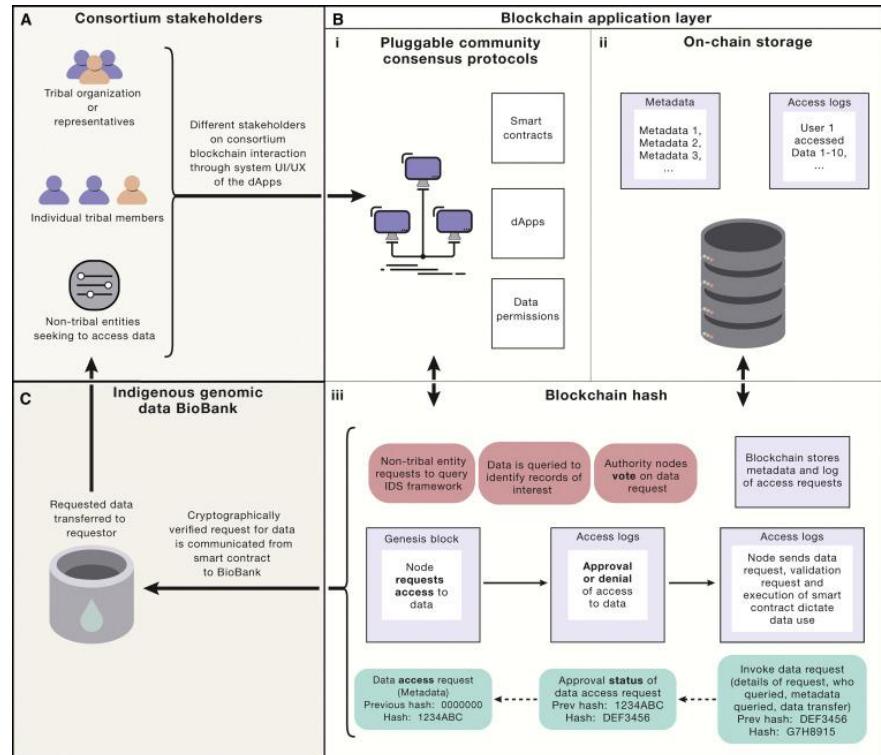
Community representatives:



Tools for Protecting Indigenous Data

Blockchain (also used for cryptocurrencies):

- ‘Distributed ledger that records transactions and is shared and agreed upon by all parties as the sole record of transactions... creating a “blockchain” of timestamped data establishing the agreement, provenance, and finality of the history of a transaction or management of data between a network of users’



Cell

Volume 185, Issue 31, 21 July 2022, Pages 2626-2632

Commentary

Establishing a blockchain-enabled Indigenous data sovereignty framework for genomic data

Tim K. Mocky^{1,2,3,4}, Alec J. Colar^{3,5}, B. S. Chennu Keshava³, Joseph Ynacheta², Krystal S. Hostie², Keolu Fox^{1,4,6,7,8}



Implications for Study Designs when working with Māori...

- Where the data come from and how they are handled is VERY important...
- Māori have their own knowledge base (typically not well known outside of te ao Māori ‘institutions’)
- Māori have their own concepts of ‘data’ both traditionally and in a contemporary sense
- Data are treasured items (= taonga)
- There are restrictions regarding data – how data are generated stored and utilized
- There are tools and frameworks that now enable this

Study Design – in a Maori Context

Things to consider when working in indigenous subject areas*...

- Ensuring Māori participation in research – including ethics (= tikanga)
- Te Tiriti o Waitangi: data are taonga, and under Article 2 of Te Tiriti, all taonga are to be under Māori control
- 1993 Human Rights Act:
 - Individual's right to freedom from discrimination
 - Right to complain if rights are breached

Things to consider when working in indigenous subject areas*...

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 - Right to complain if rights are breached

What is ‘tikanga Māori’?

Guiding behaviour and relationships

Tikanga are more than just ‘rules’. They are best described as a form of social control and can guide the way relationships are formed, provide ways for groups to interact, and even guide the way people identify themselves.

Tikanga inform frameworks that address ethical issues. They guide good behaviour and practice when engaging with Māori and the things that matter to them.

Practical applications of tikanga

In Aotearoa New Zealand, tikanga are already present in many domains and have become widely known and accepted for some time. They exist in many corners of our society, are heard on television and radio, and are seen in almost all daily interactions, from social media and classrooms to the sports fields.

References to tikanga and their definitions appear in some of our legislation, education policies, government services, court processes, and political systems. Tikanga principles reflected in areas beyond the marae context is not new, neither is it unheard of in Aotearoa New Zealand.

“Tikanga Māori accompanies Māori wherever they go and whatever they do. Tikanga Māori is adaptable, flexible, transferable, and capable of being applied to entirely new situations.”

<https://data.govt.nz/toolkit/data-ethics/nga-tikanga-paihere/data-and-tikanga>

- Tikanga is underpinned by **values** that provide the cultural logic for **study design and conduct** with Māori communities

Tikanga Māori

- ‘Cultural concepts are conceptual markers, derived from mātauranga Māori (indigenous knowledge) and tikanga Māori (Māori values), which are intrinsic to an indigenous way of viewing and living in the world. These cultural cues provide the basis for describing the cultural logic that underpins engagement in a culturally acceptable manner.’

- Hudson et al 2019

Commonly Used Māori Values in Ethical Frameworks:

- *whakapapa* (genealogy)
- *mauri* (life essence)
- *mana* (power/authority)
- *kaitiakitanga* (guardianship)
- *mātauranga* (indigenous knowledge)
- *tapu* (sacred/restricted) and *noa* (not sacred or restricted)
- *pono* (honest, transparent)
- *mātau* (expertise)
- *wairua* (emotional or spiritual sides)

Tikanga Māori can be applied at all stages of Study Design and Conduct*

- **Pre-proposal Phase**
 - best practice is engage with Māori communities/partners/entities at research conceptualisation phase (ie., before research starts)
 - Evaluate researcher's readiness to engage with Māori
 - Evaluate research project according to Māori values
- **Dialogue (with Māori) Phase**
 - Consult not inform – open-minded dialogue with willingness to change the study design (which can also lead to better designs...)
 - Discuss questions like: who defined the research problem? What are the benefits and risks and to whom do(n't) they apply? Will study participants be treated with respect? How are Māori values being applied in this study? What expertise in te ao Māori does the research team have? Etc etc
- **Data collection/Study Implementation Phase**
 - Māori governance and oversight... how is this implemented
 - Reporting back to communities on research progress
- **Translation/Implementation Phase**
 - Best practice is Indigenous/Māori control over narratives...
 - Translation into benefits for Māori primarily
 - How are contributions from Māori acknowledged?
 - Who owns IP and how are Māori data being protected?

*Examples only...

Example: Tikanga-based evaluation of a Research Proposal Aimed at Identifying Genes in a Native Tree Species (Kauri) for resistance to a new pathogen...

Value	Trigger Question(s) for Researchers to Answer
Kaitiakitanga (the duty of care, for people and the environment)	<p>How does the project take into account respect for people, the environment and organisms involved?</p> <p>How might project assist in the utilisation of wood from infected trees?</p> <p>How does the project incorporate and acknowledge the kaitiakitanga rights and responsibilities of whānau, hapū and iwi over their environment?</p> <p>How might these tools developed assist Maori communities in identifying/managing ngahere (forests) potentially infected with the disease.</p> <p>What other means of evaluation could be included in this project that would be easy to implement/use?</p> <p>How does the research contribute to resource sustainability?</p>
Mauri (lifeforce)	<p>How might the mauri of the organism(s) or the environment be affected? [affects could be beneficial or detrimental]</p> <p>What are the long term effects on the mauri of the whole forest (ie., not just the individual trees or the organisms?)</p> <p>During the site visit at Huia/Watakere we noticed healthy regeneration under thinning canopy of PTA infected trees, but not under the canopy of healthy kauri. What is this telling us?</p>
Whakapapa (interconnectivity including genealogy)	<p>What are the likely affects, if any, on whakapapa or relationships of the research and/or its implementation?</p> <p>This project will reveal some DNA sequence of a taonga species. How are the researchers accommodating sensitivities regarding such information? How will this be safeguarded?</p> <p>There are dynamic interrelationships in the past (what was), now (what is standing), and in the future (what is coming up/what is to come) among humans, ngahere, taiao. This parallels with the Maori belief of interconnectedness of whakapapa between land and people. How might this research impact those interrelationships/interconnectedness?</p>

There are many tikanga-informed study design guidelines and frameworks ...



Journal of the Royal Society of New Zealand
Volume 36, Number 3, September, 2006, pp 213–227

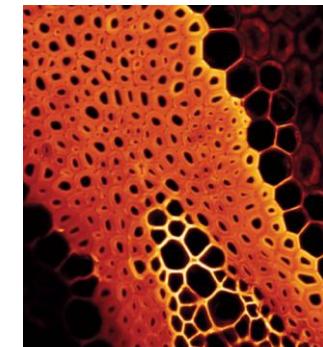
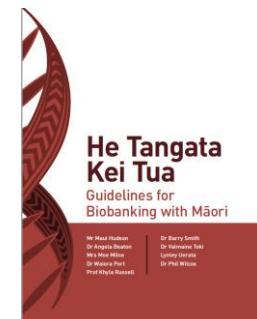
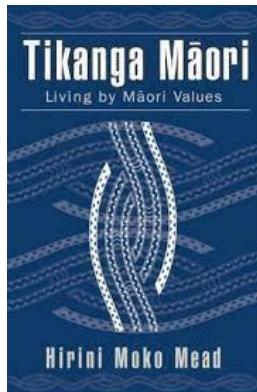
A values-based process for cross-cultural dialogue between scientists and Māori¹

P. L. Wilcox¹, J. A. Chaytor¹, M. R. Roberts^{1,2}, S. Tawharere³, B. Tipene-Matua^{1,3}, E. Kerevuna-Koroi⁴, K. Hunter⁵, H. M. Keast⁶, P. Moles-Denton^{7,8}

Abstract Cross-cultural dialogue is an essential part of the evaluation of controversial technologies and research proposals of significance to indigenous peoples. In this paper we present our experience of developing a process for ensuring that effective processes are developed and implemented to ensure enduring outcomes for their communities. We describe the development of a values-based process for cross-cultural dialogue that starts well before research applications are submitted to funding and/or regulatory agencies. The process begins with processes to 'hui' both the researchers and the Māori partners involved in the research, and continues with the process to have a constructive dialogue with each other concerning the proposal and its intended outcomes.



Ngā Tikanga Paihere draws on 10 tikanga (Te Ao Māori - Māori world concepts) to help you establish goals, boundaries, and principles that guide and inform your data practice.



Te Nohonga Kaitiaki
Guidelines for Genomic
Research on Taonga Species



RAUIKA MĀNGAI



LESSONS FROM MĀORI VOICES IN THE NEW ZEALAND SCIENCE SECTOR

JUNE 2022

Co-design – a type of Study Design

What?

- A research process by which researchers, AS WELL AS users, participants and/or communities are involved in defining the research aims, process, analysis and dissemination of research findings
- In other words, *those being studied are part of the team designing and conducting the study...*
- (*Bate & Robert, 2006*): 'True co-design... involves all stakeholders as partners through every stage of the design process—identifying a challenge, engaging people, capturing experiences, understanding experiences, planning improvements and measuring the impact of changes'

Co-design... Why?

- Improved Research Outcomes:
 - Co-design ensures that research aligns with user needs and priorities, leading to more relevant and impactful findings.
- Enhanced Idea Generation:
 - By involving users, co-design facilitates a wider range of perspectives and ideas, leading to more innovative solutions.
- Increased User Satisfaction:
 - Co-design promotes user involvement and empowers them, leading to increased satisfaction with the research process
- Greater Project Success:
 - Co-design can lead to faster implementation, reduced costs, and increased sustainability by aligning research with user needs and priorities from the outset.
- Stronger Relationships:
 - Co-design fosters collaboration and builds trust between researchers, users, and other stakeholders, strengthening partnerships and promoting long-term success.
- Improved Access to Knowledge:
 - Co-design provides researchers with access to user knowledge, expertise, and perspectives, which can be crucial for understanding complex problems and developing effective solutions.
- Increased Relevance and Uptake:
 - By involving users, co-design ensures that research findings and solutions are more relevant and practical, increasing the likelihood of successful implementation and adoption.
- More Equitable Outcomes:
 - Co-design can help address health disparities and improve outcomes for marginalized groups by involving them in the research process and ensuring that their needs are considered.
- Capacity Building:
 - Co-design can empower users and communities, building their capacity to participate in research and contribute to service development.

Adapted from: Goodwin and Boulton (2024) see <https://wairangahau.waipareira.com/wp-content/uploads/2019/11/Rita-Wakefield-What-is-Co-Design-in-a-M%C4%81ori-Space.pdf>

Co-design... how?

- How does this work?
 1. **Learn:** identify right problem, assemble team with right people, and project design = who to work with, what's issue/problem, how to work together to solve
 2. **Design:** how is the research to be conducted? What could the project look like... and what does it look like? Ethical issues are addressed before next phase...
 3. **Do:** undertake the research project... ensuring aspects such as communication are undertaken. Analyse data, communicate results and define implications. Implement.
 4. **Review...** what worked, what didn't...

Co-design... some key things

- Requires trusting relationships
- Must be cognisance of accountabilities of community members to their communities
- Requires time and flexibility
- Transparency in use of frameworks and methods
- Opportunity for reciprocal capacity and capability building
- Must involve the right people
- Appropriate resourcing for communities to undertake study
- Funding for design, implementation and evaluation

Source: https://healthierlives.co.nz/wp-content/uploads/Co-designing-health-research-in-Aotearoa-2024_lessons_digital.pdf

In summary...

- ‘where the data come from’ is not trivial
- There are societal contexts that are VERY important:
 - How data are generated
 - How data are used
 - How data are shared and stored
 - These things can impact lives of people, careers, environments etc etc
- There ways of thinking that can inform what we do to generate data and what we do with them, and tools that can assist...

Learning Outcomes...

By the end of these two lectures you should be able to describe:

- Examples of how indigenous peoples used data including use of mathematics
- What Māori and indigenous data sovereignty (IDS) are, why these exist, what are the underpinning principles, and what tools that can be used to implement IDS
- What is ethically appropriate (= tikanga informed) study design in an Māori context
- What ‘Co-design’ is (and why...)
- Why you need to know about all these things...

- Final Comment -

Ko te manu e kai ana i te miro, nōna te ngahere.

Engari, ko te manu e kai ana i te mātauranga, nōna te ao.

The bird that eats the fruit of the miro will have the forest as it's domain, but the bird that eat the tree of knowledge will inherit the earth

