Anthropocentrism and Microorganisms: Implications for Biosecurity

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ABSTRACT

The world is changing: both a conventional and a vaccine passport are now needed to travel internationally. Mask mandates, and social distancing are the new norm in a rapidly changing society. These measures were put in place to control the spread of the highly infectious and often fatal Covid-19, caused by a viral agent, a microorganism, a zoonosis, and the cause of death for over 6 million people around the world. Considering this, maintaining biosecurity is important around the world to ensure public health. Biosecurity in New Zealand supposes that people including young people understand different pests and diseases that can harm public health. This qualitative study was conducted to gauge the biosecurity knowledge of 171 young people (14–15-year-olds). Young people were tested on their knowledge about biosecurity related plants, animals, and microorganisms. This paper reports specifically on the results of knowledge of microorganisms of young people. Results show that negative anthropocentric views dominate adolescents understanding of microorganisms and anthropomorphism is widely used to explain microorganism activity. An educational programme, targeted at developing a conceptual understanding about microorganisms starting at primary education may help develop a more educated global citizen, one versed in understanding the biology of microorganisms.

Key Words: Covid-19, Microorganisms, Adolescents, Anthropomorphism, Zoonosis

INTRODUCTION

Bacteria, fungi, and viruses are collectively known as microorganisms or microbes. The importance of understanding microbes and their role in the ecosystem including their ability to adversely affect humans is invaluable in the advancement of humankind. Largely invisible to the human eye, except the fruiting bodies of fungi, microorganisms' unique capabilities have not gone unnoticed and have been discovered and made to effective use in food production. However, microorganisms' role in shaping nature as we now know has a far longer history, one dating back to the primordial soup that gave rise to earliest

forms of life (Lazcano, 2015). Nonetheless, the race to understand microorganisms and its unique capabilities steadily continues.

Increasing young people's understanding and knowledge has been purported as one way to increase understanding of microbes in the wider community (Timmis, Timmis & Jebok, 2020). Biotechnology is one subject in school that has been used to increase knowledge about microbes. Biotechnology appears in the Technology learning area of the New Zealand Curriculum, which has three strands that are embedded within five technological areas. From years 1–10, students learn in all five technological areas, and this could include learning about microorganisms. However, from years 11-13, under designing, and developing processed outcomes technological area, students learn about biotechnology, relevant to food, chemicals, and agricultural production (Ministry of Education, 2007).

Biotechnology is defined as harnessing living organisms including microorganisms in areas including medicine, and food production through improved scientific methodologies for the advancement of humankind (UNESCO, 2017). Subsequently, understanding the unique abilities of microbes is critical given the effect microorganisms can have on both living and non-living biota. In order to design relevant curricula, it would be beneficial to first understand what knowledge exists amongst young people about microbes. In this article, I report on young [13 to 14 years old] secondary school students' knowledge of microbes in New Zealand. This study focussed on gauging young people's knowledge of biosecurity including how young people understand microorganisms. For this study, microbes mean microorganisms, including bacteria, fungi, and viruses.

Education about microbes

The New Zealand Curriculum (NZC) consists of eight learning areas. The NZC facilitates learning about microbes in two learning areas. Biotechnology is part of the Technology learning area (NZC, 2007) and one of two learning areas where young people may get an opportunity to learn about microbes. Learning in the Technology learning area involves acquiring knowledge about how technology is associated with the transformation of energy, information, and materials. Biotechnology is mentioned as one area where technology is used (NZC, 2007) however, there is no mention of what biotechnology involves.

Another area where young people can acquire knowledge and understanding of microbes is in the Science learning area. Learning about science starts in primary school but becomes optional in senior secondary school. Considering this, young people could potentially be introduced to the concept of microbes during primary school education. However, during secondary school education, learning about microbes becomes an essential component.

Specifically, in level 6 [Year 11, age 15-16 years old] of the Science learning area, Living World strand, young people learn about life processes. Learning about life processes in the Living strand means "relating key structural features and functions to the life processes of plants, animals, and microorganisms and investigating environmental factors that affect these processes" (NZC, 2007, p. 59). For young people who choose to continue learning science in senior secondary school there are opportunities to gain further knowledge and

understanding of microbes and biotechnological applications of microbes within the NZC framework.

In the United Kingdom, in-depth learning about both microorganisms and biotechnology appears to occur in the biology curriculum. For example, students learn the "uses of modern biotechnology including gene technology; some of the practical and ethical considerations of modern biotechnology" (UK Department of Education, 2015 para 5). In Australia, like New Zealand, learning about microorganisms occurs in early secondary school however, there is an explanation of the type of learning students could be introduced to in biotechnology. For example, "the use of bacterial enzymes, plasmids as vectors, and techniques including gel electrophoresis, bacterial transformations and PCR" are mentioned (Australian Curriculum Assessment Reporting Authority, 2015).

Prescribed or otherwise, it appears that curricula from different countries caters for learning about microbes either through biotechnology or life sciences. Understanding how young people comprehend microbes may help teachers better engage them in teaching and learning related to microorganisms.

Understanding of microbes

Learning biotechnology and science can contribute towards increasing understanding of microbe biology amongst young people. However, microorganisms are not visible to the unaided human eye, and this may pose challenges for advancing young people's understanding. For young people, it could become difficult to comprehend how microorganisms can pose a threat or are beneficial or that microorganisms are found everywhere when they cannot be seen. Nonetheless, central to learning is that accurate information during educational encounters about microorganisms must be able to be retained long-term for young people to be make clever use (Cuevas-Parra, 2020). Information is said to be better retained long-term if it is associated with an object (Schurgin, Flombaum, 2017). Considering this perspective, young people appear to perceive unfamiliar phenomena including microorganisms using human-like forms, a concept known as anthropomorphism.

Anthropomorphism can be understood through animism theory, a concept initially introduced to developmental psychology by Piaget (1929) and familiar to those who work with children. Children tend to animate their biotic and abiotic surrounding, using human feelings and motivations to refer to not only animals but inanimate objects. Piaget attributed animism in children to irrational thinking prevalent during the preliminary stages of development. He posited that as children reach more advanced stages of development, their thinking change, and children begin to move away from animistic thinking into more rational thinking.

Unfamiliarity with microbial biology and consequently the tendency of young people to give microorganisms' human-like form appears to be the link between perception and anthropomorphism. Anthropomorphism is the act of referring to non-human and inanimate objects as if they were humans, resembling traits such as emotion and reasoning (Guthrie, 1997). For example, young children [35 pre-schoolers, age 4.5-5.5] drew germs as human-like and only saw microbes as disease causing agents (Ergazaki, Saltapida, & Zogza, 2009). Equivalent results of human-like appearance and disease-causing abilities of microbes were reported with 414 primary and secondary school [7 to 14-year-old] children (Bryne, Hanley & Grace, 2010).

Anthropomorphism, largely the use of anthropomorphised features in inanimate and non-human characters has become a widely used concept to engage children, especially with books (Li, Eisen, & Lillard, 2019) and television (Akshaya, Chellerian, 2021). In terms of classroom learning, it is claimed that anthromorphised concepts especially in science, and scientific learning, familiarize, and help young people understand unfamiliar and complex scientific concepts (Wood, 2019; Dorion, 2011). For example, (Yue et al., 2021) reported that promoting anthropomorphic ideas about animals can not only lead to a 'decrease in disease outbreaks and pandemics' but also has the potential of increasing conservation by decreasing the illegal trade in wildlife. Brossard Stoos and Haftel (2017) reported that young people better understood human disease-causing agents when they were told a fictional story with anthropomorphised human disease-causing agents.

There appears to be a growing body of research supporting the use of pedagogy and materials that are anthromorphised to increase young people's understanding of unfamiliar concepts. Some, however, argue that realistic ("with human characters" or anthropocentric), not anthropomorphised scenarios are better at engaging young people, for example in adopting pro-social behaviour (Larsen, Lee & Garnea, 2016). Anthropocentrism is a perspective whereby everything in the universe is seen from the viewpoint of human beings, the dominant species.

Nevertheless, the need to focus on developing young people's knowledge about microbes has become a salient issue (Timmis et al., 2020) given the cause of current pandemic is a microbial agent that causes Covid-19, a zoonosis, first reported in Wuhan, China. Covid-19 has and continues to cause immense distress throughout the world through human death and measures such as lockdowns to limit the spread of the airborne virus. Considering the mental and economic strain Covid-19 of related lockdowns (Sibley et al., 2020), and at the same time the need to maintain biosecurity which enables New Zealand's primary-produce-driven economy to continue, the concept of biosecurity is critical as it plays an expansive role in all aspects of New Zealand society. Biosecurity in New Zealand is defined as the protection of the economy, environment, people's health, social and cultural well-being from pests and diseases. Biosecurity is maintained by stopping pests and diseases from arriving and controlling pests and diseases already present in New Zealand (MPI, 2021a). Stringent protocols at points of entry at the border stop many harmful pests from entering. However, preventing the entry of organisms of a microscopic nature becomes difficult. Moreover, biosecurity breaches where pathogenic microbes have arrived in New Zealand undetected are increasing at an alarming rate.

Many pathogenic microbial agents are causing devastation in New Zealand. For example, a microscopic water mould, a fungi (Phytophthora agathidicida) causes Kauri dieback, a disease that kills Kauri (Agathis australis) trees. Another bacterial disease caused by Pseudomonas syringae pv. Actinidiae [Actinidia are climbing vines that belong to the family Actinidiaceae and are commonly known as kiwifruit (Henare, 2016)] which infects and kills kiwifruit vines, a major export earner for New Zealand, arrived in infected pollen from China.

Understanding viral disease cycles is important for public health around the world. Microbial agents that are zoonoses such as the Corona virus, one of

over 200 microbes (WHO, 2020) able to jump the species barrier. Although, it has become noticeably clear that Covid-19 is caused by a viral agent, a microorganism, a zoonosis that is the cause of death for over 6 million around the world. What also needs to be understood is the concept of reverse zoonosis especially with severe acute respiratory syndrome virus type 2 (SARS-CoV-2). Reverse zoonosis is the transfer of pathogens from humans to animals (Ayudhya & Kuiken, 2021). Because of the high number of infections in humans from SARS-CoV-2, humans have become a reservoir and are transferring the virus back into uninfected animal populations. There are conclusive reports of reverse zoonosis, for example, tigers in a Bronx Zoo in New York were found to have been infected with a similar strain of SARS-CoV-2 as the zookeepers (McAloose et al., 2020). Similarly, dogs were found to be infected with Covid-19 from households with confirmed human cases (Cit et al., 2020). Perhaps, the most widely reported case of reverse zoonosis, was the transfer of SARS-CoV-2 from humans to minks, first reported in the Netherlands (Oreshkova, 2020).

Minks (Neovison vison and Mustela vison) are farmed for their fur in many countries. But what made news globally was the directive from some governments to cull all farmed mink. For example, in 2020, Denmark had a mink population of approximately 17 million animals. Upon detection of SARS-CoV-2 in minks and reports of the virus mutating resulting in a mink variant of the virus, the government of Denmark gave the directive to cull all mink, citing that the control of the pandemic caused by SARS-CoV-2 would be complicated because minks act as a reservoir for the virus (Larsen, 2020).

Considering the effect of microorganisms on public health, zoonosis and reverse zoonosis, research about young people's understanding of microbes is crucial from a global perspective. Further, given that biosecurity in New Zealand supposes people, including young people, understand microorganisms, learning about microbes is essential. This research was conducted to gauge young secondary school students' knowledge of biosecurity in New Zealand. Included in the biosecurity questionnaire was a section on microorganisms. Understanding how young people perceive microbes may help teachers better design education material for targeted learning about microbes in schools.

METHODS

An interpretive mode of inquiry was used to gather personal points of views and interpret their meaning by finding relationships within data and linking them to young people's understandings (Neuman, 2003). Following ethics approval, purposive sampling was used to identify two urban multicultural schools in Auckland with rolls reflecting the multicultural nature of Auckland City— New Zealand's largest city. Young people who took part in this study were in their first year of secondary school (Year 9) and were 13 years old to 14 years old. There are various reasons young people are chosen for research. For example, Watson et al., (2023) posited that young people's views must be sought about issues that directly affect them. Other studies seek to uncover young people's views because they are the next generation who in-time will take the responsibility of governance systems (Ram, 2019; Ram, 2016; Ram, 2020).

Further in the "era of pandemics, asylum seekers, and conflict between superpowers" (Ram, 2022 para 1) it is crucial that young people understand,

adequately prepare, and support policies that allow governments to protect the citizenry from emerging zoonosis (Timmis, Timmis & Jebok, 2020). Subsequently, uncovering how young people understand microbes may help better target education towards furthering their knowledge.

Reliability and validity are important concepts to establish in social research. However, Bryman (2004) posits that instead of reliability and validity, common concepts used in quantitative research to show credibility, interpretive qualitative research use the construct of trustworthiness. One way that trustworthiness of qualitative research can be established is through the concept of transferability. Transferability in qualitative research is achieved by providing thick descriptions or rich detailed accounts of participants views because qualitative findings report on contextual uniqueness (Bryman, 2004). Transferability in this research was established by providing readers with 'rich thick descriptions' of young people's understandings of microorganisms.

A questionnaire was used to gather data. Questionnaires are a popular method employed in social science research to gather copious amounts of data in a brief period of time (Bryman, 2008; Bryman, 2004). Questionnaires also offer the added benefit of eliminating any effect the researcher could have on participants as research questionnaires can be administered by other people (Bryman, 2004). In this research, questionnaires were administered by classroom teachers. The questionnaire was divided into sections and results of only the microorganism section which included five questions are presented. The responses from these give a snapshot of young people's perceptions of microbes.

The questionnaire included Likert-scale type and open-ended questions. The five questions in the microorganism section were all open-ended questions. The questionnaire was completed by 171 young people; of whom 89 were males and 82 females. Responses only from a select group of questions from the questionnaire are presented because these responses reveal knowledge of microbes of young people. The questionnaire was designed to gather information about microbes relative to biosecurity in New Zealand. Subsequently, the intent was to uncover how aware or unaware young people were of harmful microbes. Because open questions were used, young people could describe both positive and negative aspects of microbes relative to their understanding. The five questions were: name any unwanted microorganisms that are found in New Zealand and are harmful; describe any problems caused by these unwanted microorganisms; describe how this microorganism has spread in New Zealand; how this microorganism could have got into New Zealand; what you could do to stop the spread of unwanted microorganisms in New Zealand.

Data analysis

The analysis of the open-ended questions was conducted by thematic coding into categories. The categories were derived from thematic analysis, post transcription of the data. Thematic analysis is based on identifying, analysing, and reporting on patterns or themes present in data (Braun & Clark, 2006). The themes emerged from coded data and were ideas or words captured in the transcript that indicated a response could be placed in a category. For example, responses to the question, name a harmful microorganism such as 'hepatitis' were placed in the Diseases category which included the sub-categories 'Disease human' and

'Disease plant.' The response 'hepatitis' was placed in the sub-category 'Disease human' because salmonella can infect and cause problems in people.

RESULTS

The results show that many young people who took part in the research failed to attempt to answer questions about microorganisms in the questionnaire. This could be a result of a lack of knowledge of young people about microbes or through fatigue; the questionnaire had too many questions or young people's refusal to answer questions or all the above. As a result, there were many instances of 'No response.'

Microorganisms in New Zealand

The invisibility aspect of microorganisms poses many challenges for young people's understanding. Because microbes cannot be seen, young people may only know about them through what they have heard, seen, or read. This could mean that young people may associate microbes with only good or bad aspects or may not be aware of them at all. To reveal young people's knowledge of microbes they were asked to name microbes. The following themes emerged from the data: Diseases, Fungi, Microorganisms, Unrelated, Don't know/Not sure what microorganisms mean and No response. See Table 1 for frequency of student responses and the percentages.

Name of unwanted harmful microorganism	Frequency of student responses	Percentage (%)
Diseases	20	11.7
Fungi	7	4.1
Microorganisms	15	8.7
Unrelated	3	1.8
I don't know anything about microorganism	22	12.9
No response	104	60.8
Total	171	100.0

Table 1: Unwanted harmful microorganisms in New Zealand

The Diseases theme included 20 (11.7%) responses and included the sub-categories 'Disease human' and 'Disease plant'. The 'Disease human' sub-category was created for ideas that related to diseases caused by microorganism activity. Responses like, "hepatitis," and "salmonella," both microorganisms capable of causing serious harm to humans were included in this category. Responses appear to show a perspective of microorganisms that is anthropocentric in nature; young people's association with microbes to human disease. One response was recorded for the 'Disease plant' sub-category where, "kauri disease" was given. However, the microbe causing the disease was not mentioned.

The Microorganisms theme included 15 (8.7%) responses and included sub-categories of 'Bacteria' and 'Plankton' in response to students specifically mentioning microbes. For example, "plankton" was included in the Plankton sub-category. Plankton is a term used to refer to many kinds of microscopic organisms that spend their lives drifting in the ocean. The Bacteria sub-category included 12

responses with examples such as, “bacteria”, “botulism” and “germ”. Botulism is a life-threatening condition caused by the bacterium *Clostridium botulinum* (Ministry of Health, 2020). The Fungi theme included seven (4.1%) responses and included responses such as, “fungi” and “mould.”

Overall, the responses provided for the Microorganisms and Fungi theme suggested a general understanding of microbes because the term bacteria, germs and fungi appear to be used interchangeably. Another possible explanation for using germs and bacteria could be because of the wide use of the terms when referring to sickness in humans. The Unrelated category had three responses with examples such as, “rats” and “dust mites”. This shows that these students might be referring to vectors of microorganisms.

Further analysis of the ‘No Responses’ category revealed that 22 (12.9%) of young people indicated that they did not know anything about microbes, hence the theme Don’t know/not sure what microorganisms mean was created. Responses such as “Don’t know what microorganisms are, sorry,” “Not sure” and “Don’t know, sorry” were placed in this theme. Instances where students wrote nothing for a response were placed in the No response category which had 104 (60.8%) responses. It appears that many students did not know or understand about microbes.

Problems caused by microorganisms

There are many beneficial microorganisms, for example, bacteria used in cheese production. However, many microbes are harmful and to get an idea of young people’s knowledge about these aspects they were asked an open-ended about describing problems caused by microorganisms. Student responses were categorised to reflect these different ideas. The different themes that emerged from the data were: Negative human health, Negative attribute, Negative ecosystem, and No response. See Table 2 for frequency of responses.

Problems caused by microorganisms	Frequency of student response	Percentage (%)
Negative human health	40	23.4
Negative attribute	4	2.3
Negative ecosystem	3	1.8
No response	124	72.5
Total	171	100.0

Table 2: Problems caused by unwanted microorganisms

The Negative human health theme had 40 (23.4%) responses. This category included responses that were associated with microorganisms causing sickness in humans. Many responses received were anthropocentric in nature and included the use of human qualities and/or human physical characters to explain problems caused by microorganisms. For example, “…leads to a cruel death” and “causes some severe pain…” were placed in this theme. Other responses in this theme included “sickness,” “decays teeth” and “causes cancer” can be said to be anthropocentric in nature.

The Negative ecosystem category had three (1.8%) responses. Examples such as, “spreads into roots” and “kills kauri trees” placed in this category suggested that young people are aware about microorganisms’ ability to cause

harm in plants. The Negative attribute category recorded four (2.3%) responses with examples such as, "harms all living things" and "you may accidently eat them." These may suggest a generally negative view about the capabilities of microorganisms. The difficulty in understanding microorganism activity was evident in the No response category which included 72.5% responses.

Spread of microorganisms

The microscopic nature of microbes allows undisturbed spread; spread is only detected when effects good or bad become visible like the symptoms as a result of infection from Covid-19. Knowledge of how microorganisms spread may indicate an awareness of the existence of microbes and help design educational material to further educate young people about how microbes spread and how to limit their spread. Data for this question were collected by asking students to describe how microorganisms spread and responses were categorised to reflect their ideas. The different themes that emerged from the data were Human agents, Natural spread, Economic reasons, and No response. See Table 3 for a summary of the results.

Spread of unwanted microorganism	Frequency of student response	Percentage (%)
No response	130	76.0
Human agents	23	13.5
Natural spread	15	8.8
Unrelated	2	1.2
Economic reasons	1	0.6
Total	171	100.0

Table 3: Spread of unwanted microorganisms

Twenty-three (13.5%) responses were placed in the Human agents' category. Examples such as, "germs," "spitting" and "person to person" were included in this category and appeared to relate to how human diseases are spread, pertinent to how Covid-19 spreads. The 15 (8.8%) of responses placed in the Natural spread category further reinforced the link between microorganisms and anthropocentrism in young people. For example, spread of unwanted microorganisms through, "sexual intercourse," and "uncleanliness" appeared to indicate a perception amongst young people that the spread of microorganisms is through humans after infection.

One response was placed in the Economic reasons category where it was indicated that, "plants exported from other countries" was one-way microorganisms could spread. This concept aligns with biosecurity in New Zealand, microorganism entry is controlled through placing restrictions on the entry of host materials such as seeds, and bulbs etc. This question had 76% responses in the No response category.

How microorganisms arrive in New Zealand

The microscopic nature of microbes makes it extremely hard to keep unwanted microbes out. Knowing and understanding different vectors for microbes may help better educate young people on how microbes spread, for example, zoonotic aspects. From a New Zealand biosecurity perspective, it could mean young people

not bringing into the country material that could potentially have microbes such as flowers or dairy products or wearing a mask to stop the spread of the flu virus or Covid-19. Data for this question were collected by asking students an open question about how microorganisms enter New Zealand. The many ideas represented in the responses were placed into the following themes: Human agent, Transport agent, Natural processes, Animal agent, Biosecurity mistakes and No response. See Table 4 for a summary of the responses.

Method of unwanted microorganism entry	Frequency of student response	Percentage (%)
Human agent	25	14.6
Transport agent	6	3.5
Natural processes	4	2.3
Animal agent	3	1.8
Biosecurity mistakes	1	0.6
No response	132	77.2
Total	171	100.0

Table 4: How unwanted microorganisms enter New Zealand

The Human agent category recorded 25 (14.6%) responses with examples such as, “from foreigners” and “people to people”. Young people perceive that other people spread microbes, a view that resonates with how Covid-19 is spreading among communities around the world. Other ways that microbes could enter that young people mentioned were through, “vents in planes” placed in the Transport agent (3.5% response) category; “from pigs” placed in the Animal agent (1.8% response) category; through, “wind, water, soil” placed in the Natural processes (2.3% response) category and through, “biosecurity mistakes” placed in the Biosecurity mistakes (1 response) category. The No response category included 77.2% responses.

Limiting the spread of microorganisms

Stopping the spread of microorganisms can be a difficult and at times an impossible task as the nations around the world are realising with the virus that is causing Covid-19. Knowledge about how to stop or limit the spread of microbes could reveal young people’s knowledge about microbes which could potentially better engage them, consequently, halting the spread of microbes. Young people were asked what could be done to stop the spread of microbes. The following themes emerged from the data Hygiene action, Eradication, Monitoring, Social, Fatalistic, Prevention, Tighten security at the border, Education and No response. See Table 5 for a summary of the results.

Responses such as, “self-hygiene,” “stop spitting” and “keep foods fresh” were placed in the Hygienic action 20 (11.7%) category suggested that students were thinking more about hygienic actions to stop the spread of disease-causing microorganisms in humans. Hygienic actions, including handwashing, sneezing into the crook of one’s elbow, and mask wearing are some ways advocated by health professionals to limit the spread of Covid-19. In terms of biosecurity, many plant pathogenic bacteria, viruses and fungi are transmitted by infected horticultural equipment like secateurs or through soil found in the soles of shoes.

The MPI uses hygienic methods to mitigate the risk posed by microorganisms. For example, visitors to New Zealand are asked to declare sports shoes. If soiled with mud, the MPI cleans the soles of muddy shoes with powerful antimicrobial solutions (MPI, 2021b).

Method of stopping the spread of unwanted microorganisms	Frequency of student responses	Percentage (%)
Hygienic action	20	11.7
Eradication	5	2.9
Monitoring	4	2.3
Social	3	1.8
Fatalistic	3	1.8
Prevention	3	1.8
Tighten security at borders/ increase biosecurity	2	1.2
Education	2	1.2
No response	129	75.4
Total	171	100

Table 5: How unwanted microorganisms can be stopped from spreading

Eradication (2.9%) was chosen as another means of getting rid of microorganisms by this cohort. Although a desirable option, it is difficult to achieve as New Zealand and rest of the world is discovering with the airborne delta variant of the Corona virus. In the United Kingdom, more than six million ungulates were slaughtered to control the spread of the airborne virus that caused the foot and mouth disease (Bates, 2016). Other responses received were placed in the Monitoring (2.3%) and Education (1.2%) categories. Equally small numbers of responses were included in categories such as Tighten security at borders/increase biosecurity (1.2%), suggesting a need for education about biosecurity practices relative to microbes.

DISCUSSION

This research was conducted to reveal the knowledge about biosecurity of young people (14-15-year old's) in New Zealand. Biosecurity has an expansive role and includes the protection of the economy, environment, people's health, social and cultural well-being (MPI, 2021a). Considering this, the questionnaire used to gauge biosecurity knowledge of young people had a section about microorganisms. Analysis of the data revealed that many young people [12.9% or 22] mentioned "I don't know anything about microorganisms". These results appear to be consistent with recent research that shows a lack of knowledge about microorganisms in people 14 years and older (Ruiz-Gallardo & Paños, 2019; Špernjak, Puhmeister & Šorgo, 2021).

Microorganism biology is part of learning in science and technology learning areas in secondary schools in New Zealand. However, as the data from Table 1 shows, a vast majority of young people in this study [60.8% or 104] did not respond. There is a risk to society when young people fail to understand microorganism biology. For example, in New Zealand, Covid-19 vaccination rates among young youth from some ethnicities were the lowest compared to other

demographics; a key role in this hesitancy was the influence of 'antivaxxers' (Jacobs, 2021). From a biosecurity human health perspective, it is crucial that young people understand microbes so when measures such as vaccinations, mask mandates, handwashing and social distancing are implemented to stop the spread of infectious, harmful microbial agents, young people are participating with a conceptual understanding.

Further, understanding microbes from a technological perspective would mean that young people could develop an understanding of how microbes are used in food production, medicine and in environmental protection. Considering this, biotechnology education can help young people better understand how vaccines are created and how they work and prompt them to challenge mis, and disinformation around vaccines. The teaching and learning about microorganism relative to the NZC can be revisited to see what education school leaders are implementing.

The data shows that young people's understandings of microbes were predominantly anthropomorphic and anthropocentric in nature. For example, microbes were associated with causing harm and disease to humans, an anthropocentric view, and human emotions such as 'leads to a cruel death,' an anthropomorphic perspective, were used to describe outcomes when encountering microbes. These results are like what was reported about other young people perceptions about microbes (Ergazaki et al., 2009; Bryne et al., 2010).

Arguments for, and against, can be made for having anthropocentric and/or anthropomorphic views about concepts. Anthropocentrism is a viewpoint that puts human beings at the centre of the universe. Anthropocentric thinking can be linked to destruction of the environment, the movement of animals from one geographical region to another and current problems posed by human induced and accelerated climate change as experienced in the Anthropocene epoch. Although, it can be argued that anthropocentrism is realism, for example, people are encouraged to get vaccinated so when they get Covid-19, the outcome is not fatal for them.

Nonetheless, it can also be argued that anthropocentrism is an approach that only benefits one dominant species and may fail to allow development of conceptual understanding of issues related to other species. An example of anthropocentrism from a uniquely biosecurity perspective in New Zealand was the historical relocation of the Australian brushtail possum (T*richosurus vulpecula*). The possum was geographically relocated to New Zealand to create a fur trade. Since its relocation, the number of possums exponentially increased because no natural predator species existed in New Zealand. Possums are now regarded as one of the most destructive, alien, and unwanted animals in New Zealand. Considering this, only understanding microorganisms from their ability to cause harm to humans, an anthropocentric view may not be beneficial in developing a conceptual understanding about microbes.

The data also shows that young people anthropomorphised microbes to describe their activity, for example, "it can cause severe pain." Anthropomorphism is the use of human qualities to describe non-humans and is said to be a basic attitude that exists throughout a person's lifetime (Airenti, 2018). In this study young people have used their lived experience to give meaning to microbes, an unfamiliar concept as data appears to show. It appears

that the unfamiliar and unexplained is what we struggle with. However, what we are familiar and can explain are human qualities, such as thought and order. Hence our tendency to use human form, and order to give meaning to unexplainable phenomenon because we know of no higher order (Airenti, 2018).

Anthropomorphisms, the use of attitudes and emotions appeared to have played a part in helping young people in this study make meaning of phenomenon related to microbes they encountered. However, some argue that the use of anthropomorphisms is not scientifically accurate (Wood, 2019) and can lead to emotional problems in young people (Kallery& Psillos, 2004) and even promote less prosocial (become more selfish) behaviour (Larsen et al., 2017). However, from a social constructivist's perspective, lived experience which includes attitudes, and emotions, plays a significant role in how people make meaning of phenomenon. For example, young people's use of anthropomorphic language to describe microbial activity led Simonneaux (2000) to the conclusion that a young person's lived experience including attitudes and emotions should be taken into consideration in biotechnology education.

Anthropomorphisms have been used to make meaning of microbes, data from this study shows. Considering this, other studies have shown the use of anthropomorphism to increase understanding about microbiology. For example, the use of anthropomorphism has been advocated and is seen to better engage young people in conservation (Root-Bernstein, Douglas & Verı´ssimo, 2013). McCabe and Nekaris (2018) reported that the use of anthropomorphic characters in books increased the knowledge about conservation in young people. The use of anthropomorphisms provides an additional tool to help engage young people with often unfamiliar scientific concepts (Wood, 2019).

Educational implications

Anthropomorphic and anthropocentric ideas dominate understanding of microbiology among this cohort of young people. Whereas the latter can lead to accumulation of only one idea about microbes, anthropomorphism can be used to develop a conceptual, more comprehensive understanding of microbiology.

The science learning area in the NZC runs from level 1 to 8 and could provide an ideal opportunity to introduce the concept of microbiology to young people at level 1 and subsequently build upon this understanding as young people move through their education within the system. Planning between school leaders and teachers could potentially allow progression of learning about microorganisms, building from basic to conceptual understanding. Anthropomorphisms could be used to engage young people with the goal of slowly moving towards using scientific language to explain microbiology which could help young people make meaning of their childhood understandings of microbes.

Real life situations may provide an ideal opportunity to engage young people at any level when learning about microbiology. From a New Zealand biosecurity perspective, Kauri dieback, which one student identified as a disease caused by microbes, provides an opportunity to not only learn about the pathogenic nature of microbes but expand into learning about mycology to explore both beneficial and harmful effects of fungi.

Opportunities to see microbes in action could be another avenue to promote learning. Teachers could consider taking young people on educational trips from an early age to show them beneficial uses of microbes in society such as in food production and their extensive use in sewage treatment. These

experiences may help counter information they may get from their peers, parents, and social media about microorganisms' role in only causing harm to humans, an anthropocentric view that can cement overtime.

Real life situations could also provide an opportunity to teach young people about vaccinations, why they are needed, what is in them and how they work. For example, because of high social interaction behaviour amongst young people, and the increased likelihood of contracting, and spreading viruses such as influenza and Covid-19. It is important for young people to understand the benefits of vaccination as being unvaccinated they pose the risk of transmitting viruses to older people which can lead to severe consequences (Fitzpatric, 2021).

Vaccinations have been encouraged around the world to prevent severe symptoms' from developing after infection from Covid-19. However, people around the world including many in New Zealand are refusing to take the Covid-19 vaccine. A conceptual understanding of microbes may help young people make informed decisions about vaccine uptake. The NZC provides scope within science and technology learning areas for education about vaccinations.

CONCLUSION

Data from this study shows that young people understand microbes from an anthropocentric and anthropomorphic perspective. Data also shows that many have no understanding of microbes. Learning about microorganisms in schools will create an informed New Zealand citizenry that is able to understand pathogenic microbes can create a global megashock such as that caused by the outbreak of Covid-19, a pandemic. Learning about microbes in school from a conceptual perspective can cement the view over time that it is in the interest of everybody around the world to critically understand microbiology.

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