Progress report

COVID-19 and National Immunisation Programme research

Submitted by
Victoria University of Wellington

Project title
PROP-053 COVID-19 Vaccine Evaluation (COVE) in Aotearoa New Zealand

Progress report period
Nine month progress report

Please submit this report to research@health.govt.nz

Section 1 : Contact information

1.1 Point of Contact for this report

a.

Item	Detail
Contact person	S 9(2)(a)
Position	
Phone number	
Mobile number	
Email address	

Section 2 : Progress update

2.1 High-level update on progress

When writing your update, you should refer to the plan you outlined in your proposal, which has been included in your contract. Updates should provide information on the status and progress towards delivering the plan in your contract.

b. Although the stated word limits are a guide, please be concise and only write more if necessary.

Item	Response
Do you consider your project to be on track to deliver on the plan described in your contract	No
Supporting information Please provide information about progress towards delivering the plan described in your contract. Please include information on key achievements and a brief overview of activities. This section will help us assess whether you are executing your plan as expected and highlight important milestones.	(100 words) The progress to date includes 1. Completed: Set-up phase including privacy impact assessments, data sharing agreements and research access approvals 2. Completed: Data wrangling phase involving identification of cohorts, post-vaccination outcomes 3. In progress: Quantitative analysis 4. Completed: Māori vaccine data phase involving access, curation and creation of a complete data set (created and curated a complete dataset of all Māori vaccination data up to 21 Feb 2023 linked to broad range of IDI variables)

Changes Tell us whether you have done or are planning on something different from what you originally expected to do to complete the project fully. Let us know why you are making the change and what the impacts may be, e.g. amendment to ethics approval, additional participant recruitment, etc.	We are having some delays to our regression analyses where we have encountered some technical challenges (an unanticipated limitation of frequentist statistical approaches using whole population data). We're actively progressing with statistical experts towards a regression analysis method that can cope with our very large dataset. The final date to be moved by three months to 30 November 2023 to allow more time to ascertain an optimal methodology. There are no impacts from these changes.
Emerging risks and mitigations Tell us whether any risks have emerged and how you propose to or have mitigated these	(100 words) Data analyses Mitigations: Prof Simpson and Dr Sheppard have worked with ESR and created a secure Trusted Research Environment (TRE) platform. All the team members who have undergone confidentiality training are able to remotely access and run the regression models on a high performance computer.

Te Whatu Ora
Health New Zealand

MANATŪ HAUORA
MINISTRY OF HEALTH

Progress report

COVID-19 and National Immunisation Programme research

Submitted by

Auckland University of Technology

Project title

PROP-020 The role of vaccine mandates in New Zealand's COVID-19 response

Progress report period

1 June 2023 progress report

Please submit this report to research@health.govt.nz

Section 1: Contact information

1.1 Point of Contact for this report

• Item	• Detail
• Contact person	S 9(2)(a)
• Position	
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• Mobile number	
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• Item	• Response
• Do you consider your project to be on track to deliver on the plan described in your contract	• Yes/~~No~~
• Supporting information • Please provide information about progress towards delivering the plan described in your contract. Please include information on key achievements and a brief overview of activities. This section will help us assess whether you are executing your plan as expected and highlight important milestones.	Quantitative component: • Draft report has been included as part of this progress update. Qualitative component: • Interviews are underway with more confirmed over the next 4 weeks. • Initial recruitment was slow, however the opportunity to participate appears to be spreading by word of mouth, with a number of potential participants are now expressing interest. This may enable focus groups to be held and this is being discussed with potential participants currently.
• Changes • Tell us whether you have done or are planning on something different from what you originally expected to do to complete the project fully. • Let us know why you are making the change and what the impacts may be, e.g. amendment to ethics approval, additional participant recruitment, etc.	• No changes planned

• Emerging risks and mitigations • Tell us whether any risks have emerged and how you propose to or have mitigated these	• To date, no emerging risks identified.

Te Whatu Ora
Health New Zealand

MANATŪ HAUORA
MINISTRY OF HEALTH

Progress report

COVID-19 and National Immunisation Programme research

Submitted by
Auckland UniServices Ltd

Project title
PROP-047 Examining vaccine effectiveness of two and three doses of Comirnaty mRNA vaccine during the 2022 Omicron wave in Aotearoa

Progress report period
1 June 2023 progress report

Please submit this report to research@health.govt.nz

Section 1: Contact information

1.1 Point of Contact for this report

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Section 2: Progress update

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Item	Response
Do you consider your project to be on track to deliver on the plan described in your contract?	We have had some significant challenges with data access but believe that almost all the required data sets have now been secured pending final negotiations with MoH
Supporting information Please provide information about progress towards delivering the plan described in your contract. Please include information on key achievements and a brief overview of activities. This section will help us assess whether you are executing your plan as expected and highlight important milestones.	We have all required ethical and IDI approval in place with our Maori and Pasifika reference groups set up and meetings oragnised for feedback in July and our final review in October. We have our key exposure and outcome data for our vaccine effectiveness defined which follows our independently peer-reviewed statistical analysis plan and are awaiting final data from MoH to complete our data analysis.
Changes Tell us whether you have done or are planning on something different from what you originally expected to do to complete the project fully. Let us know why you are making the change and what the impacts may be, e.g. amendment to ethics approval, additional participant recruitment, etc.	No changes to report other than Dr Anna Howe has left the project due to a change of roles and has been replaced by Dr Janine Paynter who has relevant expertise in this area so it does not affect the project delivery.

Emerging risks and mitigations Tell us whether any risks have emerged and how you propose to or have mitigated these	Our major risk here is a lack of clarity around the definition of some fields in the data as delivered to us i.e. how each variable is derived. As mentioned above, our timelines being impacted by delays in receiving data has also been a constraint but has now to a large extent rectified. At this stage, we had envisaged that initial data analysis would be complete and a progress report available. However, we have had to delay this as there was a significant delay in obtaining any data. Currently, we have some very preliminary results and are awaiting further advice from MoH. Nevertheless, I am happy as PI with our overall progress and am confident we will still achieve all the goals we set out to achieve.

Te Whatu Ora
Health New Zealand

MANATŪ HAUORA
MINISTRY OF HEALTH

Progress report

COVID-19 and National Immunisation Programme research

Submitted by
University of Otago

Project title
PROP-071 Does the increased attention to COVID-19 vaccine-related side effects change reporting behaviour for a comparable adult vaccine?

Progress report period
1 June 2023 progress report

Please submit this report to research@health.govt.nz

Section 1: Contact information

1.1 Point of Contact for this report

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Section 2: Progress update

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Item	Response
Do you consider your project to be on track to deliver on the plan described in your contract	Yes
Supporting information Please provide information about progress towards delivering the plan described in your contract. Please include information on key achievements and a brief overview of activities. This section will help us assess whether you are executing your plan as expected and highlight important milestones.	Ethical approval for both the quantitative and qualitative projects were in place early 2023. Data requested from the NIR arrived 27th March 2023 Data for the quantatative aspect has been collated, curated and is currently being analysed Data for the qualitative aspect has been collated, and will be prepared for analysis in May
Changes Tell us whether you have done or are planning on something different from what you originally expected to do to complete the project fully. Let us know why you are making the change and what the impacts may be, e.g. amendment to ethics approval, additional participant recruitment, etc.	There have been no changes or deviations from the original project
Emerging risks and mitigations Tell us whether any risks have emerged and how you propose to or have mitigated these	There have been no identified risks

Title: Impact of the COVID-19 Delta-Omicron outbreak on the health and psychosocial wellbeing of New Zealanders living in aged residential care

Lay summary: COVID-19 related restrictions could lead to poorer health outcomes in older adults. This project will investigate the health and wellbeing impacts of the Delta-Omicron outbreak in aged residential care.

Researchers: S 9(2)(a)

[1] Department of Psychological Medicine, School of Medicine, The University of Auckland
[2] Centre for Medical and Health Science Education, School of Medicine, The University of Auckland
[3] Department of General Practice, School of Population Health, The University of Auckland
[4] School of Medicine, University of Otago
[5] Department of Statistics, School of Science, The University of Auckland
[6] School of Pharmacy, The University of Auckland
[7] interRAI New Zealand

Draft report 2nd June 2023

Background and objectives

Our research team has previously investigated the impact of the first wave of COVID-19 (March to June 2020) on Māori, Pacific Peoples and New Zealand Europeans living in aged residential care (ARC) across Aotearoa (Cheung et al., 2021; doi:10.1111/ajag.13025). In the study, interpreting data from the national standardised interRAI assessment, we did not find any immediate negative impact of the first wave of COVID-19 on the health and psychosocial wellbeing amongst Māori (n=536) and Pacific Peoples (n=276) living in ARC. On the contrary, we found lower rates of loneliness and hospitalisation amongst Māori residents. European ARC residents (n=11,322) also had a lower rate of hospitalization during the first wave of COVID-19, but they reported more severe depressive symptoms. What we do not know from these findings is whether certain individual characteristics increase or decrease the risk of experiencing negative health and psychosocial wellbeing effects from the first wave of COVID-19. The present study builds on our previous study. Our objectives are to

1. investigate the impact of the COVID-19 Delta-Omicron outbreak (17/8/2021 to 16/8/2022) on the health and psychosocial wellbeing amongst the main ethnic groups of Aotearoa (Māori, Pacific Peoples, Asian and NZ European) living in ARC; and
2. identify individual factors that increase or decrease the risk of experiencing negative health outcomes.

This study is needed because a report from the International Science Council (2022) suggests the COVID-19 pandemic (or epidemic) is likely to stay. This means the impacts of COVID-19 and any related public health measures to manage COVID-19 could be ongoing for our ARC population. In addition, some ARC facilities are considering implementing this type of public health measures over the winter months independent of the pandemic. Therefore, it is important to understand the balance between infection control and physical/psychosocial health

outcomes. This study will also include Asians, the third largest ethnic group living in ARC in Aotearoa but who were not included in our earlier study.

ARC facilities tend to have a "one size fits all" approach when applying COVID-19 prevention policy on their residents. This study will identify individual factors that increase or decrease the risk of experiencing negative health outcomes. ARC policy makers and clinicians can use this information to identify at risk individuals at the beginning of a future COVID-19 outbreak (or other pandemics) and implement measures to ameliorate their poor outcomes. The findings will also inform whether there are factors that are protective against negative health outcomes, which can be implemented or modified to prevent future negative impacts of COVID-19 outbreaks.

This study will contribute to Māori health outcomes by providing data that is specific for Māori living in ARC. In the year 2020-21 there were a total of 3582 interRAI assessments with Māori ARC residents and these assessments will be included in this research. Fear of disconnect from whānau, community, and culture was identified as issues faced by Māori living in ARC. Therefore, it is important to understand whether longer term COVID-19 related isolation impacts on these fears and mental health change further.

This research will contribute to equity of health outcomes for the following populations living in ARC: Māori, Pacific Peoples, older adults with mental distress, disabled people, and older migrants. This contribution will be made through including all interRAI assessments (n≈75,000) completed in ARC across Aotearoa during the Delta-Omicron outbreak. The ARC sector is one often excluded from research. Aotearoa's exceptional public health response means we have not experienced the overwhelming mortality in ARC that has been seen globally. This study has the chance to shine further light on how effective public health

measures can lead to equitable health outcomes for the most vulnerable, in an internationally novel context.

Methodology

The key research questions for this study are:

1) How did the Delta-Omicron outbreak impact on the health outcomes of older adults living in ARC?
2) Are there any differences in these health outcomes amongst ethnic groups in ARC?
3) What are the individual factors that increase or decrease the risk of negative health outcomes?

We used routinely collected national health data and quantitative research methods to answer the above research questions. interRAI Long-Term Care Facility (LTCF) assessment is a globally validated geriatric assessment which provides information on 280 demographic, clinical and psychosocial factors. interRAI is a collaborative network of researchers and practitioners in over 35 countries. This research used nationwide interRAI LTCF data to examine the impacts of the Delta-Omicron outbreak on ARC residents. The study period of interest is the first year of the Delta-Omicron outbreak in Aotearoa (17/8/2021 to 16/8/2022). We compared interRAI LTCF data from the Delta-Omicron period with data from a pre-COVID-19 era (17/8/2018 to 16/8/2019).

Ethics approval was obtained from Auckland Health Research Ethics Committee (Ref. AH3334).

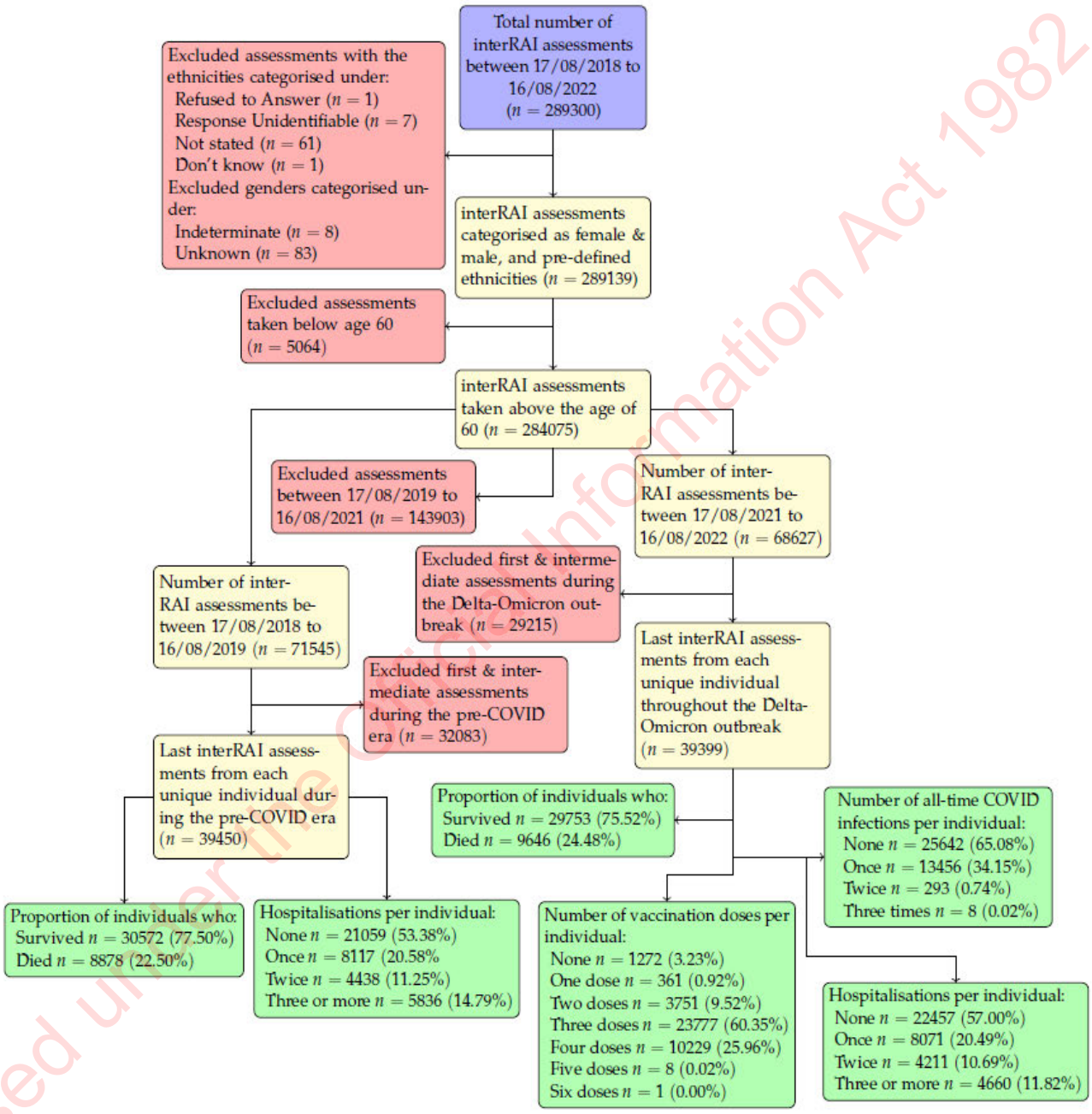
interRAI data collection and data access:

Aotearoa has a nationwide mandated interRAI programme in ARC. interRAI LTCF is routinely used to assess ARC residents every six months. ARC facilities in Aotearoa continue to use interRAI LTCF throughout the COVID-19 pandemic. We requested interRAI data from Technical Advisory Services.

Participants selection and flow (Figure 1)

In preparing the data for the impact of the Delta-Omicron outbreak against conditions during the pre-COVID-19 era amongst ARC residents, we restricted the data to include assessments taken between ages of 60 and 105 living within ARC. As one of our research questions is to evaluate the differences in health outcomes amongst ethnic groups within ARC, we made a prudent decision to discard assessments with ethnicity responses that were imprecisely defined. We defined the pre-COVID-19 era to be between the dates of 17/08/2018 to 16/08/2019 and the Delta-Omicron outbreak to be between 17/08/2021 to 16/08/2022, thus only keeping the assessments within these two periods. This 12-monthly adjusted date choice is also advantageous to capture repeating seasonality modifiers that may occur in the data throughout every twelve months. Since interRAI LTCF is routinely administered every six months in ARC, some participants had more than one interRAI assessment during a 12-months period. Only the last interRAI assessment record of each person during each of the two 12-months periods was used for analysis. Throughout the pre-COVID-19 era, there were a total of 71527 interRAI assessments. By reducing this total down to each unique individual's last assessment within the 12-months period, we gathered the 39444 interRAI assessments of each person. During the Delta-Omicron outbreak, there were 68597 total assessments which were reduced to 39382 individualised last assessments. Consequently, this separation produced a set of two records that we analysed apart from one each other. Individuals who had an interRAI assessment during both the pre-COVID-19 era and the Delta-Omicron outbreak could appear in both sets of the data.

Figure 1: Participants flow and selection in the pre-COVID-19 era and Delta-Omicron outbreak



Data Linkage

Our strategy in gathering additional information onto the interRAI data was to assimilate the other external data sources through deterministic data linkage. To accomplish this linkage, we

made use of a unique identifier (encrypted National Health Index) present within the interRAI data amongst the four other external data sources provided by the Ministry of Health:

1) Mortality status & date of death
2) Hospitalisations
3) COVID-19 immunisation
4) COVID-19 case statuses

This unique identifier allowed us to summarise the information coming from these four external sources and consolidate needed relevant information belonging to each interRAI assessed individual.

The *mortality data* contain many details pertaining to an individual's cause of death. However, the only useful detail we required from these data is an individual's date of death – which we integrated with the interRAI data. Note that we split the mortality data into two parts covering deaths exclusive to the 39450 individuals assessed during the pre-COVID-19 era and the 39399 people assessed during the Delta-Omicron outbreak. Individuals who did not have a recorded date of death exhibit censoring where their lifetimes are only partially known. This split implies that individuals who had an assessment during both study periods and died during the Delta-Omicron outbreak will exhibit censoring throughout the pre-COVID-19 era.

The *hospitalisation data* are longitudinal which may contain repeated measurements on the same observation and the reasoning for each hospitalisation along with the admission and discharge dates. From these repeated measurements, we collapsed the number of observations per individual to record their hospitalisation frequency exclusively observed throughout the two periods that we collect into the interRAI data. Whilst the reasons for hospital admissions can be useful in examining the shift in hospitalisation resources over time, this information is currently not necessary as part of our study objectives.

The *COVID-19 immunisation* and *COVID-19 case statuses* are also longitudinal data, covering an individual's dosage history and recorded number of COVID-19 cases. These data only provide relevant information towards the 39382 people assessed during the Delta-Omicron outbreak. When summarising the immunisation data, we counted the total number of vaccination doses that each person received from the first immunisation entry, on 28/02/2021, towards the end of the Delta-Omicron outbreak study period – 16/08/2022. This counting scheme produced the number of all-time vaccination doses. Similarly, the summarising the count of COVID-19 case status data provided the number of accumulated COVID-19 cases per person from 20/03/2020 to 16/08/2022 as all-time COVID-19 cases. We additionally summarised the individual case counts by limiting the dates to the Delta-Omicron outbreak as specifically Delta-Omicron cases. Note that the quantities from the workflow showed only a minor increase in overall recorded COVID-19 cases. This marginal increase is due to the majority of the COVID-19 case status recordings being concentrated around late-2021 and onwards. As such, there were only a handful of recorded COVID-19 cases in the data and even fewer records of COVID-19 cases amongst ARC residents.

Outcome measures

In addition to mortality and hospitalisation outcomes, selected interRAI items/scales were chosen to provide key information on physical and psychosocial heath. We used similar interRAI measures in our previous study to assess the impact of the first wave of COVID-19:

1) Changes in Health, End-stage disease, Signs, and Symptoms (CHESS) Scale measures the health stability and medical complexity. Scores of CHESS Scale range from 0 (stable) to 5 (highly unstable). A three-level categorical variable was created for CHESS Scale with stable (0-1), unstable (2-3), and highly unstable (4-5).
2) Self-rated health was reported as "Excellent", "Good", "Fair" or "Poor"

3) Falls in the last 30 days were measured as “No fall” or “One or more falls”.
4) Depression Rating Scale has scores ranging from 0 to 14 and categorised as 0-2 (no to minimal depressive symptoms), 3-5 (moderate depressive symptoms) and 6+ (severe depressive symptoms).
5) Loneliness was measured as “Yes” or “No” to the interRAI item “Says or indicates that he /she feels lonely”.
6) The Aggressive Behaviour Scale is a measure of aggressive behaviour based on the occurrence of verbal abuse, physical abuse, socially disruptive behaviour and resistance of care. It has scores ranging from 0 to 12 and categorised as 1-4 (mild aggressive behaviour) and 5+ (moderate to severe aggressive behaviour).

Statistical Analysis

R statistical software (version 3.6.0) was used for data linking and analysis. All seven health outcomes are categorical variables. Firstly, chi-square tests were used to compare health outcomes between the pre-COVID-19 era and Delta-Omicron outbreak in each of the four age groups (60-69, 70-79, 80-89, 90+), males and females, and residents who were in a relationship (married/civil union/de facto) and those were not in a relationship. Secondly, chi-square tests were used to compare whether there were statistically significant in health outcomes between the pre-Covid-19 era and Delta-Omicron outbreak amongst the main ethnic groups: Māori, Pacific, Asian and New Zealand European. A significance level of 1% was set for statistical significance to reduce the risk of Type 1 error. For significant results, adjusted residuals were calculated to identify specific responses that made the greatest impact (applying the ± 2 criteria) on statistical significance.

We then performed statistical modelling to determine the risk and protective factors of the following significant health outcomes: mortality, hospitalisation, falls, depression and aggression. Additional interRAI variables were used as independent/explanatory variables in the models, along with the six interRAI outcome measures mentioned above.

Health Domains	interRAI Outcome Measures	Additional interRAI Variables used in modelling
Physical health	▪ Changes in Health, End-stage disease, Signs, and Symptoms (CHESS) Scale ▪ Self-rated health ▪ Falls in the last 30 days	▪ Activity of Daily Living Hierarchy ▪ Hours exercise ▪ Body mass index ▪ Pain Scale ▪ Smoking
Cognition		▪ Cognitive Performance Scale
Psychosocial health	▪ Depression Rating Scale ▪ Loneliness ▪ Aggressive Behaviour Scale	▪ Finding meanings in day- to-day life ▪ Consistent positive outlook
Social relationships		▪ Participation in social activities ▪ Visit with a long-standing social relation or family member ▪ Strong and supportive relationship with family ▪ Days went out

Mortality: We used the Cox proportional hazards model for mortality because of its robustness and the capacity of evaluating the impact of multiple explanatory variables on the hazard rate. Then we performed assumption checking on the model and if the proportional hazard assumption was violated in more than one explanatory variable, we used the time-dependent covariates approach. The mechanism of the time-dependent covariates is based on the underlying mechanism of the Cox model: at each event time the program compares the current covariate values of the subject who had the event to the current values of all others who were at risk at that time (Therneau et al., 2023). This method involves multiple observations per

subject, with each observation corresponding to an interval (start, stop); intervals are assumed to be open on the left and closed on the right. The start represents the beginning time of the interval, while the stop indicates the end time. There is an event in each observation that represents whether a specific event (such as death) occurred at the end of that interval, normally 0=alive, 1=dead. Such data is in the so-called counting process style: the response variable is in the counting process form (T. M. Therneau Grambsch, 2000).

The statistical modelling of the other four outcomes (hospitalisation, falls, depression and aggression) is presented in a separate report.

Results

Pre-COVID-19 and Delta-Omicron ARC cohorts

There are a total of 39450 ARC residents (female: 64.9%) in the pre-COVID-19 cohort. Their mean age was 84.5 years (SD=8.4). 24.0% of the residents were in a relationship. Majority of the residents were New Zealand European (90.4%), followed by Māori (4.1%), Asian (3.2%) and Pacific peoples (2.0%). **(Table 1)**

There are a total of 39399 ARC residents (female: 64.0%) in the Delta-Omicron cohort. Their mean age was 84.5 (SD=8.5). 27.7% of the residents were in a relationship. Majority of the residents were New Zealand European (89.1%), followed by Māori (4.7%), Asian (3.7%) and Pacific peoples (2.2%). **(Table 1)**

The mortality rate in the Delta-Omicron period (17/8/2021 to 16/8/2022) was higher than the pre-COVID-19 period (17/8/2018 to 16/8/2019): 24.5% versus 22.5%. (Figure 1). Hospitalisation rate was lower in the Delta-Omicron period than the pre-COVID-19 period; 57.0% of the Delta-Omicron cohort had no hospital admission during the Delta-Omicron period, compared to 53.4% of the pre-COVID-19 cohort.

60.4% of the Delta-Omicron cohort had three doses of COVID-19 vaccine (i.e. 2 doses plus a booster) and 26.0% had four doses (i.e. 2 doses plus 2 boosters). Of the 13757 residents who had at least one COVID-19 infection, 80.5% of COVID-19 infection was confirmed on a rapid antigen test (RAT), 14.5% was confirmed on polymerase chain reaction (PCR), while 5.0% was confirmed on both RAT and PCR.

Table 1: Ethnicity distribution in Pre-COVID cohort and Delta-Omicron cohort

	Pre-COVID period N=39450		Delta-Omicron period N=39399	
Māori	1626	4.1%	1841	4.7%
Pacific Peoples	770	2.0%	847	2.2%
Asian	1273	3.2%	1467	3.7%
NZ European	35658	90.4%	35118	89.1%
Others	123	0.3%	188	0.5%

Age groups: 60-69, 70-79, 80-89, 90+

The distribution of age groups remained relatively stable over the pre-COVID-19 era and the Delta-Omicron outbreak, with the highest proportion of residents in the 80-90 age group, followed by the 90+, 70-79 and 60-69 age groups. **(Table 2)** During the Delta-Omicron outbreak, there was a significant increase in mortality rates for individuals aged 80-90 (pre-COVID=22.1%, Delta-Omicron=23.8%, p=0.000) and 90+ (pre-COVID=27.7%, Delta-Omicron=31.2%, p=0.000), while the number of ≥3 hospital admissions decreased across all age groups (Age 60-69: pre-COVID=19.2%, Delta-Omicron=15.5%, p=0.002; Age 70-79: pre-COVID=16.2%, Delta-Omicron=13.6%, p=0.000; Age 80-89: pre-COVID=15.4%, Delta-Omicron=12.5%, p=0.000; Age 90+: pre-COVID=12.2%, Delta-Omicron=9.0%, p=0.000). The rate of falls increased in the Delta-Omicron period for residents aged 70-79, 80-89, and 90+ (≥1 fall: Age 70-79: pre-COVID=18.2%, Delta-Omicron=20.7%, p=0.000; Age 80-89: pre-COVID=21%, Delta-Omicron=23.1%, p=0.000; Age 90+: pre-COVID=22.1%, Delta-Omicron=24.4%, p=0.000). Residents aged 70-79 reported a lower level of poor self-reported health in the Delta-Omicron period (pre-COVID=7.4%, Delta-Omicron=6.1%, p=0.002). Residents aged 80-89 and 90+ experienced higher rates of moderate depression symptoms with the Depression Rating Scale in the Delta-Omicron period (Age 80-89: pre-COVID=16.3%,

Delta- Omicron=17.8%, p=0.001; Age 90+: pre-COVID=14.1%, Delta- Omicron=16.1%, p=0.000). The rates of mild aggressive behaviour were higher for residents aged 80-89 in the Delta-Omicron period (Age 80-89: pre-COVID=27.2%; Delta-Omicron=28.5%, p=0.008).

Table 2: Outcomes by age groups

	Age 60-69			Age 70-79			Age 80-89			Age 90+		
	Pre-COVID	*Delta-Omicron*		*Pre-COVID*	*Delta-Omicron*		*Pre-COVID*	*Delta-Omicron*		*Pre-COVID*	*Delta-Omicron*	
	n = 2355	*n = 2330*		*n = 7855*	*n = 7863*		*n = 17082*	*n = 16912*		*n = 12158*	*n = 12294*	
	n (%)	n (%)	pValue	n (%)	n (%)	pValue	n (%)	n (%)	pValue	n (%)	n (%)	pValue
Mortality												
No	2029 (86.2)	2026 (87.0)	0.450	6455 (82.2)	6380 (81.1)	0.097	13303 (77.9)	12894 (76.2)	**0.000**	8785 (72.3)	8453 (68.8)	**0.000**
Yes	326 (13.8)	304 (13.0)		1400 (17.8)	1483 (18.9)		3779 (22.1)	4018 (23.8)		3373 (27.7)	3841 (31.2)	
Hospitalisation												
0	1222 (51.9)	1317 (56.5)	**0.002**	4202 (53.5)*	4519 (57.5)*	**0.000**	8888 (52.0)*	9289 (54.9)*	**0.000**	6747 (55.5)*	7332 (59.6)*	**0.000**
1	432 (18.3)	407 (17.5)		1523 (19.4)	1472 (18.7)		3563 (20.9)	3643 (21.5)		2599 (21.4)	2549 (20.7)	
2	248 (10.5)	245 (10.5)		855 (10.9)	803 (10.2)		2003 (11.7)	1862 (11.0)		1332 (11.0)	1301 (10.6)	
≥3	453 (19.2)*	361 (15.5)*		1275 (16.2)*	1069 (13.6)*		2628 (15.4)*	2118 (12.5)*		1480 (12.2)*	1112 (9.0)*	
CHESS												
0-1 (Stable)	1732 (73.5)	1763 (75.7)	0.053	5470 (69.6)	5459 (69.4)	0.925	11074 (64.8)	10839 (64.1)	0.016	7442 (61.2)	7393 (60.1)	0.194
2-3 (Unstable)	502 (21.3)	479 (20.6)		2004 (25.5)	2013 (25.6)		4859 (28.4)	5018 (29.7)		3733 (30.7)	3902 (31.7)	
4-5 (Highly unstable)	121 (5.1)	88 (3.8)		381 (4.9)	391 (5.0)		1149 (6.7)	1055 (6.2)		983 (8.1)	999 (8.1)	
Falls												
No fall	1993 (84.6)	1986 (85.2)	0.589	6426 (81.8)	6239 (79.3)	**0.000**	13491 (79.0)	13010 (76.9)	**0.000**	9467 (77.9)	9296 (75.6)	**0.000**
≥1 fall	362 (15.4)	344 (14.8)		1429 (18.2)	1624 (20.7)		3591 (21.0)	3902 (23.1)		2691 (22.1)	2998 (24.4)	
Self-reported health												
Excellent	63 (2.7)	55 (2.4)	0.092	188 (2.4)	149 (1.9)	**0.002**	338 (2.0)	319 (1.9)	0.010	226 (1.9)	232 (1.9)	0.013
Good	968 (41.1)	1004 (43.1)		3394 (43.2)	3385 (43.0)		7522 (44.0)	7575 (44.8)		5551 (45.7)	5612 (45.6)	
Fair	516 (21.9)	530 (22.7)		1713 (21.8)	1829 (23.3)		4153 (24.3)	4037 (23.9)		3115 (25.6)	3264 (26.5)	
Poor	218 (9.3)	168 (7.2)		578 (7.4)*	483 (6.1)*		1170 (6.8)	1014 (6.0)		825 (6.8)	706 (5.7)	
Could not (would not) respond	590 (25.1)	573 (24.6)		1982 (25.2)	2017 (25.7)		3899 (22.8)	3967 (23.5)		2441 (20.1)	2480 (20.2)	

Depression Rating Scale												
0–2 (No-to-minimal)	1706 (72.4)	1640 (70.4)	0.087	5854 (74.5)	5757 (73.2)	0.103	13238 (77.5)	12881 (76.2)	**0.001**	9794 (80.6)	9657 (78.6)	**0.000**
3–5 (Moderate)	440 (18.7)	495 (21.2)		1439 (18.3)	1484 (18.9)		2785 (16.3)*	3006 (17.8)*		1714 (14.1)*	1976 (16.1)*	
6+ (Severe)	209 (8.9)	195 (8.4)		562 (7.2)	622 (7.9)		1059 (6.2)	1025 (6.1)		650 (5.3)	661 (5.4)	
Says or indicates that he / she feels lonely												
No	2164 (91.9)	2131 (91.5)	0.631	7325 (93.3)	7267 (92.4)	0.043	15901 (93.1)	15790 (93.4)	0.325	11420 (93.9)	11554 (94.0)	0.949
Yes	191 (8.1)	199 (8.5)		529 (6.7)	596 (7.6)		1177 (6.9)	1119 (6.6)		734 (6.0)	739 (6.0)	
Aggressive Behaviour Scale												
0 (Nil)	1258 (53.4)	1258 (54.0)	0.670	4586 (58.4)	4477 (56.9)	0.145	11121 (65.1)	10735 (63.5)	**0.008**	8703 (71.6)	8666 (70.5)	0.013
1–4 (Mildly aggressive behaviour)	859 (36.5)	824 (35.4)		2497 (31.8)	2611 (33.2)		4645 (27.2)^	4818 (28.5)^		2736 (22.5)	2950 (24.0)	
5+ (Moderate to severely aggressive behaviour)	238 (10.1)	248 (10.6)		772 (9.8)	775 (9.9)		1316 (7.7)	1356 (8.0)		719 (5.9)	677 (5.5)	

* |adjusted residuals| ≥2
^ |adjusted residuals| 1.5-1.9

Gender

The distribution of gender remained unchanged between the pre-COVID-19 era and the Delta-Omicron outbreak. **(Table 3)** During the Delta-Omicron outbreak, there was a significant increase in mortality rates for both females and males (female: pre-COVID=20.9%, Delta-Omicron=23%, p=0.000; male: pre-COVID=25.5%, Delta-Omicron=27.1%, p=0.002). The number of ≥3 hospital admissions decreased for both females and males (female: pre-COVID=12.7%, Delta-Omicron=10.1%, p=0.000; male: pre-COVID=18.7%, Delta-Omicron=15%, p=0.000). The rates of falls increased in the Delta-Omicron period for both females and males (≥1 fall: female: pre-COVID=18.5%, Delta-Omicron=20.3%, p=0.000; male: pre-COVID=24.1%, Delta-Omicron=26.5%, p=0.000). Both females and males reported a lower level of poor self-reported health (female: pre-COVID=6.7%, Delta-Omicron=5.9%, p=0.004; male: pre-COVID=7.8%, Delta-Omicron=6.2%, p=0.000). Female residents experienced a higher rate of moderate depression symptoms with the Depression Rating Scale in the Delta-Omicron period (pre-COVID=17.0%, Delta- Omicron=18.9%, p = 0.000). The rate of mild aggressive behaviour was higher for females in the Delta-Omicron period (pre-COVID=24.8%; Delta- Omicron=26.1%, p = 0.003).

Table 3: Outcomes by gender

	Female			Male		
	Pre-COVID	*Delta-Omicron*		*Pre-COVID*	*Delta-Omicron*	
	n = 25618	*n = 25210*		*n = 13832*	*n = 14189*	
	n (%)	n (%)	pValue	n (%)	n (%)	pValue
Mortality						
No	20263 (79.1)	19412 (77.0)	**0.000**	10309 (74.5)	10341 (72.9)	**0.002**
Yes	5355 (20.9)	5798 (23.0)		3523 (25.5)	3848 (27.1)	
Hospitalisation						
0	14451 (56.4)*	15121 (60.0)*	**0.000**	6608 (47.8)*	7336 (51.7)*	**0.000**
1	5193 (20.3)	5044 (20.0)		2924 (21.1)	3027 (21.3)	
2	2726 (10.6)	2509 (10.0)		1712 (12.4)	1702 (12.0)	
≥3	3248 (12.7)*	2536 (10.1)*		2588 (18.7)*	2124 (15.0)*	
CHESS						
0-1 (Stable)	16813 (65.6)	16293 (64.6)	0.017	8905 (64.4)	9161 (64.6)	0.315
2-3 (Unstable)	7158 (27.9)	7332 (29.1)		3940 (28.5)	4080 (28.8)	
4-5 (Highly unstable)	1647 (6.4)	1585 (6.3)		987 (7.1)	948 (6.7)	
Falls						
No fall	20880 (81.5)	20097 (79.7)	**0.000**	10497 (75.9)	10434 (73.5)	**0.000**
≥1 fall	4738 (18.5)	5113 (20.3)		3335 (24.1)	3755 (26.5)	
Self-reported health						
Excellent	555 (2.2)	496 (2.0)	**0.004**	260 (1.9)	259 (1.8)	**0.000**
Good	11367 (44.4)	11286 (44.8)		6068 (43.9)	6290 (44.3)	
Fair	6188 (24.2)	6160 (24.4)		3309 (23.9)	3500 (24.7)	
Poor	1717 (6.7)*	1498 (5.9)*		1074 (7.8)*	873 (6.2)*	
Could not (would not) respond	5791 (22.6)	5770 (22.9)		3121 (22.6)	3267 (23.0)	
Depression Rating Scale						
0–2 (No-to-minimal)	19368 (75.6)*	18482 (73.3)*	**0.000**	11224 (81.1)	11453 (80.7)	0.026
3–5 (Moderate)	4364 (17.0)*	4770 (18.9)*		2014 (14.6)	2191 (15.4)	
6+ (Severe)	1886 (7.4)	1958 (7.8)		594 (4.3)	545 (3.8)	
Says or indicates that he / she feels lonely						
No	23832 (93)	23418 (92.9)	0.538	12978 (93.8)	13324 (93.9)	0.861
Yes	1780 (6.9)	1788 (7.1)		851 (6.2)	865 (6.1)	
Aggressive Behaviour Scale						
0 (Nil)	17402 (67.9)	16797 (66.6)	**0.003**	8266 (59.8)	8339 (58.8)	0.229
1–4 (Mildly aggressive behaviour)	6359 (24.8)*	6587 (26.1)*		4378 (31.7)	4616 (32.5)	
5+ (Moderate to severely aggressive behaviour)	1857 (7.2)	1822 (7.2)		1188 (8.6)	1234 (8.7)	

* |adjusted residuals| ≥2

Relationship

There was a higher proportion of residents who were in a relationship in the Delta-Omicron period. **(Table 4)** During the Delta-Omicron period, mortality rate increased for residents who were not in a relationship (Not in a relationship: pre-COVID=21.4%, Delta-Omicron=23.7%, p=0.000). The number of ≥3 hospital admissions decreased for both relationship statuses (In a relationship: pre-COVID=18.5%, Delta-Omicron=13.2%, p=0.000; Not in a relationship: pre-COVID=13.6%, Delta-Omicron=11.3%, p=0.000). The rate of "highly unstable health" (CHESS 4-5) reduced amongst residents who were in a relationship in the Delta-Omicron period. The rate of falls increased in the Delta-Omicron period for residents who were not in a relationship (≥1 fall: pre-COVID=19.2%, Delta-Omicron=21.1%, p=0.000). A lower level of poor self-reported health was found in residents who were not in a relationship (pre-COVID=7.1%, Delta-Omicron=6.1%, p=0.000). Residents who were not in a relationship experienced a higher rate of moderate depression symptoms with the Depression Rating Scale in the Delta-Omicron period (pre-COVID=15.9%, Delta- Omicron=17.6%, p=0.000). The rate of mildly aggressive behaviour was also higher in the residents not in a relationship in the Delta-Omicron period (pre-COVID=26.3%; Delta- Omicron=27.5%, p=0.003).

Table 4: Outcomes by relationship

	In a relationship			Not in a relationship		
	Pre-COVID	*Delta-Omicron*		*Pre-COVID*	*Delta-Omicron*	
	n = 9468	*n = 10929*		*n = 29982*	*n = 28470*	
	n (%)	n (%)	pValue	n (%)	n (%)	pValue
Mortality						
No	6996 (73.9)	8027 (73.4)	0.482	23576 (78.6)	21726 (76.3)	**0.000**
Yes	2472 (26.1)	2902 (26.6)		6406 (21.4)	6744 (23.7)	
Hospitalisation						
0	4670 (49.3)*	6042 (55.3)*	**0.000**	16389 (54.7)*	16415 (57.7)*	**0.000**
1	1913 (20.2)	2271 (20.8)		6204 (20.7)	5800 (20.4)	
2	1135 (12.0)	1174 (10.7)		3303 (11)	3037 (10.7)	
≥3	1750 (18.5)*	1442 (13.2)*		4086 (13.6)*	3218 (11.3)*	
CHESS						
0-1 (Stable)	6012 (63.5)	7021 (64.2)	**0.004**	19706 (65.7)	18433 (64.7)	0.036
2-3 (Unstable)	2747 (29.0)	3218 (29.4)		8351 (27.9)	8194 (28.8)	
4-5 (Highly unstable)	709 (7.5)^	690 (6.3)^		1925 (6.4)	1843 (6.5)	
Falls						
No fall	7149 (75.5)	8079 (73.9)	0.010	24228 (80.8)	22452 (78.9)	**0.000**
≥1 fall	2319 (24.5)	2850 (26.1)		5754 (19.2)	6018 (21.1)	
Self-reported health						
Excellent	122 (1.3)	155 (1.4)	0.013	693 (2.3)	600 (2.1)	**0.000**
Good	3535 (37.3)	4211 (38.5)		13900 (46.4)	13365 (46.9)	
Fair	2033 (21.5)	2386 (21.8)		7464 (24.9)	7274 (25.5)	
Poor	673 (7.1)	657 (6.0)		2118 (7.1)*	1714 (6.0)*	
Could not (would not) respond	3105 (32.8)	3520 (32.2)		5807 (19.4)	5517 (19.4)	
Depression Rating Scale						
0–2 (No-to-minimal)	7195 (76)	8291 (75.9)	0.086	23397 (78.0)	21644 (76.0)	**0.000**
3–5 (Moderate)	1618 (17.1)	1952 (17.9)		4760 (15.9)*	5009 (17.6)*	
6+ (Severe)	655 (6.9)	686 (6.3)		1825 (6.1)	1817 (6.4)	
Says or indicates that he / she feels lonely						
No	8834 (93.3)	10231 (93.6)	0.423	27976 (93.3)	26511 (93.1)	0.346
Yes	630 (6.7)	696 (6.4)		2001 (6.7)	1957 (6.9)	
Aggressive Behaviour Scale						
0 (Nil)	5648 (59.7)	6505 (59.5)	0.380	20020 (66.8)	18631 (65.4)	**0.002**
1–4 (Mildly aggressive behaviour)	2870 (30.3)	3380 (30.9)		7867 (26.2)*	7823 (27.5)*	
5+ (Moderate to severely aggressive behaviour)	950 (10.0)	1042 (9.5)		2095 (7.0)	2014 (7.1)	

* |adjusted residuals| ≥2
^ |adjusted residuals| 1.5-1.9

Summary of demographic findings

1. Mortality	Rates increased in the Delta-Omicron period o Age 80-89 and Age 90+ groups o Both genders o Residents who were not in a relationship
2. Hospitalisation	Rates reduced in the Delta-Omicron period o All age groups o Both genders o Both relationship statuses
3. CHESS	The rate of "highly unstable health" reduced in the Delta-Omicron period o Residents who were not in a relationship
4. Falls	Rates increased in the Delta-Omicron period o Age 70-79, Age 80-89, Age 90+ o Both genders o Residents who were not in a relationship
5. Self-report health Omicron	The rate of poor self-rated health reduced in the Delta-period o Age 70-79 o Both genders o Residents who were not in a relationship
6. Depression	The rate of moderate depression increased in Delta-Omicron period o Age 80-89, Age 90+ o Females o Residents who were not in a relationship
7. Aggressive behaviour	The rate of mildly aggressive behaviour increased in the Delta Omicron period o Age 80-89 o Females o Residents who were not in a relationship

Ethnicity: Māori, Pacific peoples, Asian, New Zealand European

Table 5-8 show the eight health outcomes between the two study periods amongst Māori, Pacific, Asian and New Zealand European residents.

New Zealand European residents (Table 8) had a higher mortality rate during the Delta-Omicron outbreak (pre-COVID=22.9%, Delta-Omicron period=25.1%, p=0.000). Māori (Table 5) and New Zealand European residents had lower rates of ≥3 hospitalisation in the Delta-Omicron period (Māori: pre-COVID=19.7%, Delta-Omicron=13.0%, p=0.000; NZ European: pre-COVID=14.6%, Delta-Omicron=11.8%, p=0.000). Māori residents in the Delta-Omicron period had a higher rate of unstable health (CHESS=2-3: pre-COVID=23.8%, Delta-Omicron=27.7%, p=0.004) but a lower rate of highly unstable health (CHESS=4-5: pre-COVID=6.9%, Delta-Omicron=5.10%, p=0.004). Asian (Table 7) and New Zealand European residents had increased rates of falls in the Delta-Omicron period (≥1 fall - Asian: pre-COVID=15.2%, Delta-Omicron=19.2%, p=0.008; NZ European: pre-COVID=21.0%, Delta-Omicron=23.2%, p=0.000).

In terms of self-reported health, New Zealand European residents reported a lower rate of being "poor" in the Delta-Omicron period (pre-COVID=7.2%, Delta-Omicron=6.2%; p=0.000). New Zealand European residents also had a higher rate of moderate depression symptoms with the Depression Rating Scale in the Delta-Omicron period (pre-COVID=16.4%, Delta-Omicron=18.0%, p = 0.000) and a higher rate of mildly aggressive behaviour in the Delta-Omicron period (pre-COVID=26.6%; Delta-Omicron=27.8%, p = 0.001).

These results suggest the Delta-Omicron outbreak had varying impacts on different ethnic groups in terms of health outcomes. However, since about 90% of ARC residents identified themselves as New Zealand European, (Table 4) the New Zealand European ethnicity findings

mirror those of the main demographic findings reported above. Given the sample sizes for Māori, Pacific Peoples and Asian are much smaller, the lack of significant findings in these ethnic groups may be due to Type 2 error.

Table 5: Outcomes in Māori

	Pre-COVID	Delta-Omicron	
	n = 1626	*n = 1841*	
	n (%)	n (%)	pValue
Mortality			
No	1299 (79.9)	1463 (79.5)	0.791
Yes	327 (20.1)	378 (20.5)	
Hospitalisation			
0	823 (50.6)*	1077 (58.5)*	0.000
1	317 (19.5)	348 (18.9)	
2	165 (10.1)	176 (9.6)	
≥3	321 (19.7)*	240 (13.0)*	
CHESS			
0-1 (Stable)	1126 (69.2)	1238 (67.2)	0.004
2-3 (Unstable)	387 (23.8)^	510 (27.7)^	
4-5 (Highly unstable)	113 (6.9)^	93 (5.1)^	
Falls			
No fall	1377 (84.7)	1551 (84.2)	0.758
≥1 fall	249 (15.3)	290 (15.8)	
Self-reported health			
Excellent	49 (3.0)	55 (3.0)	0.19
Good	777 (47.8)	851 (46.2)	
Fair	280 (17.2)	363 (19.7)	
Poor	85 (5.2)	74 (4.0)	
Could not (would not) respond	435 (26.8)	498 (27.1)	
Depression Rating Scale			
0–2 (No-to-minimal)	1310 (80.6)	1458 (79.2)	0.521
3–5 (Moderate)	240 (14.8)	284 (15.4)	
6+ (Severe)	76 (4.7)	99 (5.4)	
Says or indicates that he / she feels lonely			
No	1530 (94.1)	1747 (94.9)	0.339
Yes	96 (5.9)	94 (5.1)	
Aggressive Behaviour Scale			
0 (Nil)	864 (53.1)	934 (50.7)	0.348
1–4 (Mildly aggressive behaviour)	590 (36.3)	696 (37.8)	
5+ (Moderate to severely aggressive behaviour)	172 (10.6)	211 (11.5)	

* |adjusted residuals| ≥2

^ |adjusted residuals| 1.5-1.9

Table 6: Outcomes in Pacific peoples

	Pre-COVID	Delta-Omicron	
	n = 770	*n = 847*	
	n (%)	n (%)	pValue
Mortality			
No	644 (83.6)	679 (80.2)	0.081
Yes	126 (16.4)	168 (19.8)	
Hospitalisation			
0	453 (58.8)	483 (57)	0.016
1	135 (17.5)	195 (23)	
2	75 (9.7)	81 (9.6)	
≥3	107 (13.9)	88 (10.4)	
CHESS			
0-1 (Stable)	585 (76.0)	656 (77.4)	0.782
2-3 (Unstable)	156 (20.3)	161 (19)	
4-5 (Highly unstable)	29 (3.8)	30 (3.5)	
Falls			
No fall	642 (83.4)	718 (84.8)	0.486
≥1 fall	128 (16.6)	129 (15.2)	
Self-reported health			
Excellent	16 (2.1)	12 (1.4)	0.528
Good	358 (46.5)	400 (47.2)	
Fair	123 (16)	122 (14.4)	
Poor	30 (3.9)	26 (3.1)	
Could not (would not) respond	243 (31.6)	287 (33.9)	
Depression Rating Scale			
0–2 (No-to-minimal)	660 (85.7)	710 (83.8)	0.285
3–5 (Moderate)	84 (10.9)	113 (13.3)	
6+ (Severe)	26 (3.4)	24 (2.8)	
Says or indicates that he / she feels lonely			
No	731 (94.9)	810 (95.6)	0.587
Yes	39 (5.1)	37 (4.4)	
Aggressive Behaviour Scale			
0 (Nil)	404 (52.5)	447 (52.8)	0.904
1–4 (Mildly aggressive behaviour)	283 (36.8)	304 (35.9)	
5+ (Moderate to severely aggressive behaviour)	83 (10.8)	96 (11.3)	

Table 7: Outcomes in Asian

	Pre-COVID	Delta-Omicron	
	n = 1273	*n = 1467*	
	n (%)	n (%)	pValue
Mortality			
No	1060 (83.3)	1217 (83.0)	0.869
Yes	213 (16.7)	250 (17.0)	
Hospitalisation			
0	685 (53.8)	845 (57.6)	0.195
1	257 (20.2)	274 (18.7)	
2	150 (11.8)	169 (11.5)	
≥3	181 (14.2)	179 (12.2)	
CHESS			
0-1 (Stable)	959 (75.3)	1119 (76.3)	0.502
2-3 (Unstable)	274 (21.5)	294 (20.0)	
4-5 (Highly unstable)	40 (3.1)	54 (3.7)	
Falls			
No fall	1079 (84.8)	1186 (80.8)	0.008
≥1 fall	194 (15.2)	281 (19.2)	
Self-reported health			
Excellent	12 (0.9)	15 (1.0)	0.457
Good	446 (35.0)	552 (37.6)	
Fair	357 (28.0)	400 (27.3)	
Poor	86 (6.8)	79 (5.4)	
Could not (would not) respond	372 (29.2)	421 (28.7)	
Depression Rating Scale			
0–2 (No-to-minimal)	1052 (82.6)	1185 (80.8)	0.289
3–5 (Moderate)	171 (13.4)	228 (15.5)	
6+ (Severe)	50 (3.9)	54 (3.7)	
Says or indicates that he / she feels lonely			
No	1181 (92.8)	1353 (92.2)	0.59
Yes	91 (7.2)	114 (7.8)	
Aggressive Behaviour Scale			
0 (Nil)	854 (67.1)	984 (67.1)	0.987
1–4 (Mildly aggressive behaviour)	333 (26.2)	386 (26.3)	
5+ (Moderate to severely aggressive behaviour)	86 (6.8)	97 (6.6)	

Table 8: Outcomes in New Zealand European

	Pre-COVID	Delta-Omicron	
	n = 35658	*n = 35118*	
	n (%)	n (%)	pValue
Mortality			
No	27477 (77.1)	26297 (74.9)	0.000
Yes	8181 (22.9)	8821 (25.1)	
Hospitalisation			
0	19033 (53.4)*	19982 (56.9)*	0.000
1	7377 (20.7)	7223 (20.6)	
2	4029 (11.3)	3776 (10.8)	
≥3	5219 (14.6)*	4137 (11.8)*	
CHESS			
0-1 (Stable)	22965 (64.4)	22362 (63.7)	0.029
2-3 (Unstable)	10246 (28.7)	10405 (29.6)	
4-5 (Highly unstable)	2447 (6.9)	2351 (6.7)	
Falls			
No fall	28176 (79.0)	26981 (76.8)	0.000
≥1 fall	7482 (21.0)	8137 (23.2)	
Self-reported health			
Excellent	736 (2.1)	672 (1.9)	0.000
Good	15823 (44.4)	15739 (44.8)	
Fair	8708 (24.4)	8741 (24.9)	
Poor	2585 (7.2)*	2184 (6.2)*	
Could not (would not) respond	7806 (21.9)	7782 (22.2)	
Depression Rating Scale			
0–2 (No-to-minimal)	27483 (77.1)	26501 (75.5)	0.000
3–5 (Moderate)	5861 (16.4)*	6305 (18.0)*	
6+ (Severe)	2314 (6.5)	2312 (6.6)	
Says or indicates that he / she feels lonely			
No	33251 (93.3)	32718 (93.2)	0.629
Yes	2399 (6.7)	2396 (6.8)	
Aggressive Behaviour Scale			
0 (Nil)	23484 (65.9)	22711 (64.7)	0.001
1–4 (Mildly aggressive behaviour)	9483 (26.6)*	9767 (27.8)*	
5+ (Moderate to severely aggressive behaviour)	2691 (7.5)	2636 (7.5)	

* |adjusted residuals| ≥2

Cox Model: Mortality

Table 9 presents the hazard ratios and p-values for various demographic and health factors. The hazard ratio represents the likelihood of death happening in one group compared to a reference group.

Table 9: Harzard ratios of mortality

	Hazard Ratio						Interaction with time period (p-value)
	Pre-COVID	95% CI	P-value	Delta-Omicron	95% CI	P-value	
Gender (REF = Female)							<0.001
Male	1.49	[1.42;1.57]	<0.001	1.32	[1.27;1.38]	<0.001	<0.001
Ethnicity (REF = European)							<0.001
Maori	1.13	[1.00;1.28]	0.05048	1.09	[0.98;1.20]	0.09804	<0.001
Pacific	0.77	[0.63;0.93]	0.00617	0.99	[0.85;1.15]	0.90211	<0.001
Asian	0.64	[0.55;0.74]	<0.001	0.72	[0.63;0.81]	<0.001	<0.001
Marital Group (REF = Married/Civil union/Defacto)							<0.001
Other	0.93	[0.88;0.98]	0.00754	0.99	[0.95;1.04]	0.80819	<0.001
Self Rated Health (REF = Excellent/Good)							<0.001
Fair	1.25	[1.18;1.33]	<0.001	1.16	[1.10;1.22]	<0.001	<0.001
Good	1.58	[1.44;1.72]	<0.001	1.47	[1.37;1.59]	<0.001	<0.001
Could not (would not) respond	1.43	[1.33;1.53]	<0.001	1.37	[1.29;1.45]	<0.001	<0.001
ADL Hierarchy (REF = 0 (independent))							<0.001
1–2 (mild to moderate dependent)	1.34	[1.22;1.46]	<0.001	1.33	[1.23;1.44]	<0.001	<0.001
3+ (severe dependent)	2.15	[1.96;2.35]	<0.001	1.87	[1.73;2.03]	<0.001	<0.001
Fall (REF = No Fall)							<0.001
≥ 1 Fall	1.12	[1.06;1.19]	<0.001	1.18	[1.13;1.23]	<0.001	<0.001
Cognitive Performance Scale (REF = 0 (intact))							<0.001
1-2 (Borderline or mild cognitive impairment)	0.87	[0.80;0.95]	0.00141	0.87	[0.81;0.94]	<0.001	<0.001

	Hazard Ratio						Interaction with time period (p-value)
	Pre-COVID	95% CI	P-value	Delta-Omicron	95% CI	P-value	
3+ (Moderate to severe cognitive impairment)	0.95	[0.87;1.04]	0.29110	0.94	[0.87;1.02]	0.13147	<0.001
Depression Rating scale (REF = 0–2 (No-to-minimal))							<0.001
3–5 (Moderate)	0.94	[0.88;1.00]	0.06291	0.99	[0.94;1.04]	0.62315	<0.001
6+ (Severe)	0.89	[0.81;0.98]	0.01873	1.01	[0.93;1.09]	0.79105	<0.001
Aggressive Behaviour (REF: 0 (Nil))							<0.001
1–4 (Mildly aggressive behaviour)	0.93	[0.88;0.98]	0.01288	0.98	[0.93;1.02]	0.28191	<0.001
5+ (Moderate to severely aggressive behaviour)	1.04	[0.95;1.14]	0.37646	0.93	[0.86;1.00]	0.04296	<0.001
Pain (REF: No pain)							<0.001
1-2 (Slight daily pain)	1.12	[1.07;1.18]	<0.001	1.12	[1.07;1.17]	<0.001	<0.001
3-4 (Excruciating daily pain)	1.33	[1.17;1.50]	<0.001	1.34	[1.21;1.49]	<0.001	<0.001
CHESS (REF: 0-1 (Stable))							<0.001
2-3 (Unstable)	1.88	[1.78;1.98]	<0.001	1.48	[1.42;1.55]	<0.001	<0.001
4-5 (Highly unstable)	3.68	[3.42;3.96]	<0.001	2.25	[2.12;2.39]	<0.001	<0.001
Participation in social activities (REF: Never)							<0.001
30 days ago	0.91	[0.86;0.96]	<0.001	0.91	[0.87;0.96]	<0.001	<0.001
≥ 30 days ago	0.97	[0.90;1.05]	0.50730	1.01	[0.95;1.07]	0.81291	<0.001
Unable to determine	1.06	[0.98;1.14]	0.14848	0.96	[0.91;1.03]	0.24964	<0.001
Visit with a long-standing social relation or family member (REF: Never)							<0.001
30 days ago	1.42	[1.12;1.79]	0.00332	0.82	[0.71;0.95]	0.00657	<0.001
≥ 30 days ago	1.46	[1.13;1.87]	0.00326	0.80	[0.69;0.92]	0.00271	<0.001
Unable to determine	1.44	[1.11;1.87]	0.00620	0.71	[0.60;0.83]	<0.001	<0.001
Says or indicates that he / she feels lonely (REF: No)							<0.001
Yes	0.91	[0.83;1.00]	0.04904	0.93	[0.86;1.00]	0.05699	<0.001

	Hazard Ratio						Interaction with time period (p-value)
	Pre-COVID	95% CI	P-value	Delta-Omicron	95% CI	P-value	
Strong and supportive relationship with family(REF: No)							<0.001
Yes	1.14	[1.03;1.26]	0.00917	1.13	[1.04;1.24]	0.00547	<0.001
Consistent positive outlook (REF: No)							<0.001
Yes	0.97	[0.90;1.04]	0.39667	0.96	[0.90;1.02]	0.18285	<0.001
Finds meaning in day-to-day life (REF: No)							<0.001
Yes	0.93	[0.86;1.00]	0.05123	0.94	[0.89;1.01]	0.08496	<0.001
Hours exercise (REF: None)							<0.001
Less than 1 hour	0.83	[0.79;0.88]	<0.001	0.85	[0.81;0.89]	<0.001	<0.001
1-2 hours	0.61	[0.57;0.66]	<0.001	0.76	[0.71;0.81]	<0.001	<0.001
3-4 hours	0.60	[0.54;0.67]	<0.001	0.59	[0.53;0.67]	<0.001	<0.001
More than 4 hours	0.43	[0.37;0.51]	<0.001	0.58	[0.48;0.69]	<0.001	<0.001
Days went out (REF: No days out)							<0.001
Did not go out in last 3 days but usually goes out over a 3-day period	0.90	[0.83;0.97]	0.00539	0.94	[0.88;0.99]	0.03192	<0.001
	0.86	[0.81;0.92]	<0.001	0.88	[0.83;0.93]	<0.001	<0.001
Smoking (REF: No)							<0.001
Yes	1.20	[1.06;1.37]	0.00515	1.06	[0.93;1.21]	0.36201	<0.001
BMI (REF: Healthy)							<0.001
Overweight	0.76	[0.72;0.81]	<0.001	0.85	[0.81;0.89]	<0.001	<0.001
Obese	0.54	[0.49;0.58]	<0.001	0.76	[0.72;0.81]	<0.001	<0.001
Underweight	1.24	[1.17;1.32]	<0.001	1.19	[1.13;1.25]	<0.001	<0.001
Hospitalisation (REF: 0)							<0.001
1-2	1.23	[1.15;1.32]	<0.001	1.07	[1.01;1.14]	0.02966	<0.001
3+	1.23	[1.16;1.31]	<0.001	1.06	[0.99;1.12]	0.08107	<0.001

interRAI COVID-19 Study

Perspectives on the impact of Delta-Omicron wave using statistical inference

Tony Wu
Preliminary draft
1 June, 2023

Overview

This deliverable report details on the progress of investigating the impacts of the COVID-19 Delta-Omicron wave on New Zealanders living in Aged Residential Care (ARC). In particular, this report addresses the preliminary results from building statistical models on joint International Resident Assessment Instrument (interRAI) and Ministry of Health data, including the potential for further work.

Keywords: Bayesian inference, robust statistics, dependence correction

Initialisms and Abbreviations

ADL Hierarchy Activities of Daily Living Hierarchy 1, 8, 10, 14, 16
ARC Aged Residential Care 1, 2, 4, 5, 14

BMI Body Mass Index 1, 8, 10, 12, 13, 16–18

CHESS Changes in Health, End-Stage Disease, Signs, and Symptoms 1, 5–8, 10, 12, 14–18
CPS Cognitive Performance Scale 1, 7, 11, 14, 16

DRS Depression Rating Scale 1, 6, 8, 10, 11, 13, 17, 18

interRAI International Resident Assessment Instrument 1–3, 5, 7, 14, 15

MCMC Markov Chain Monte Carlo 1, 11, 13

Nomenclature and List of Symbols

$\mathrm{E}(\cdot)$	The expectation operator for a random variable/distribution

λ	The expected rate of event occurrences for a count response
$\text{Var}(\cdot)$	The variance operator for a random variable/distribution
Y	A response/outcome designated as a random variable

Data Processing

As the interRAI data holds over 300 items pertaining to an individual's assessed health outcomes, the initial decision to dilute these items to around 20 factors of interest was mostly due to the understandings about the constituents that impacted the older adults living in ARC in a previous study [6]. In this subsequent study, we seek to emulate the similar goals from this previous research for the purposes of comparing the nation-wide lockdown during the peak reportings of subvariants Delta and Omicron within the community (defined as a 12-month period beginning from 17 August 2021 to 16 August 2022) and the pre-COVID era (17 August 2018 to 16 August 2019).

Participant selection for this study centers around people living within the ARC and we accepted that we would involve those who had interRAI assessments over the age of 60 into the study. Since interRAI long-term care facilities tend to routinely assess individuals every six months in ARC, many participants would have more than one interRAI assessment during a 12-month period. As a summary of their outcome throughout the pre-COVID era and during the Delta-Omicron wave, we include only their last assessment throughout each of the two period into the data. Note that some individuals may have had an assessment during both periods due to this seasonal pattern of assessments. Figure 1 displays the criteria for participant selection that aligns with the objectives of this research. One such objective is to discern, if possible, any differences in health outcomes between the main ethnic groups of Aotearoa. Consequently, it was necessary to discard participants who do not identify with a particular ethnic group in their assessments. Although interRAI recognises that participants may self-identify as multiple gender identities, for ease of statistical model interpretations we intend to keep only the assesements where participants identify as female or male as their gender.

The main strategy in gathering additional information onto the interRAI data was to assimilate the other external data sources through deterministic data linkage. To accomplish this linkage, we made use of a unique identifier (the encrypted National Health Index) present within the interRAI data amongst the four external data sources that the Ministry of Health has provided:

1. Mortality status & date of death;
2. Hospitalisation admissions & discharges;
3. COVID-19 immunisations;
4. COVID-19 case statuses.

Using this unique identifier, we summarise the information coming from these four external sources and consolidate the relevant information belonging to each interRAI assessed individual. Where an individual has had a recorded event from the four data sources listed above, we decide to consolidate these events, for each individual, only if the event occured within the alloted time frame for the pre-COVID and Delta-Omicron wave periods.

Mortality status & date of death

The mortality data detail an individual's cause of death in addition to their date of death, with only the latter being of importance in this study. Recall that we defined the pre-COVID era

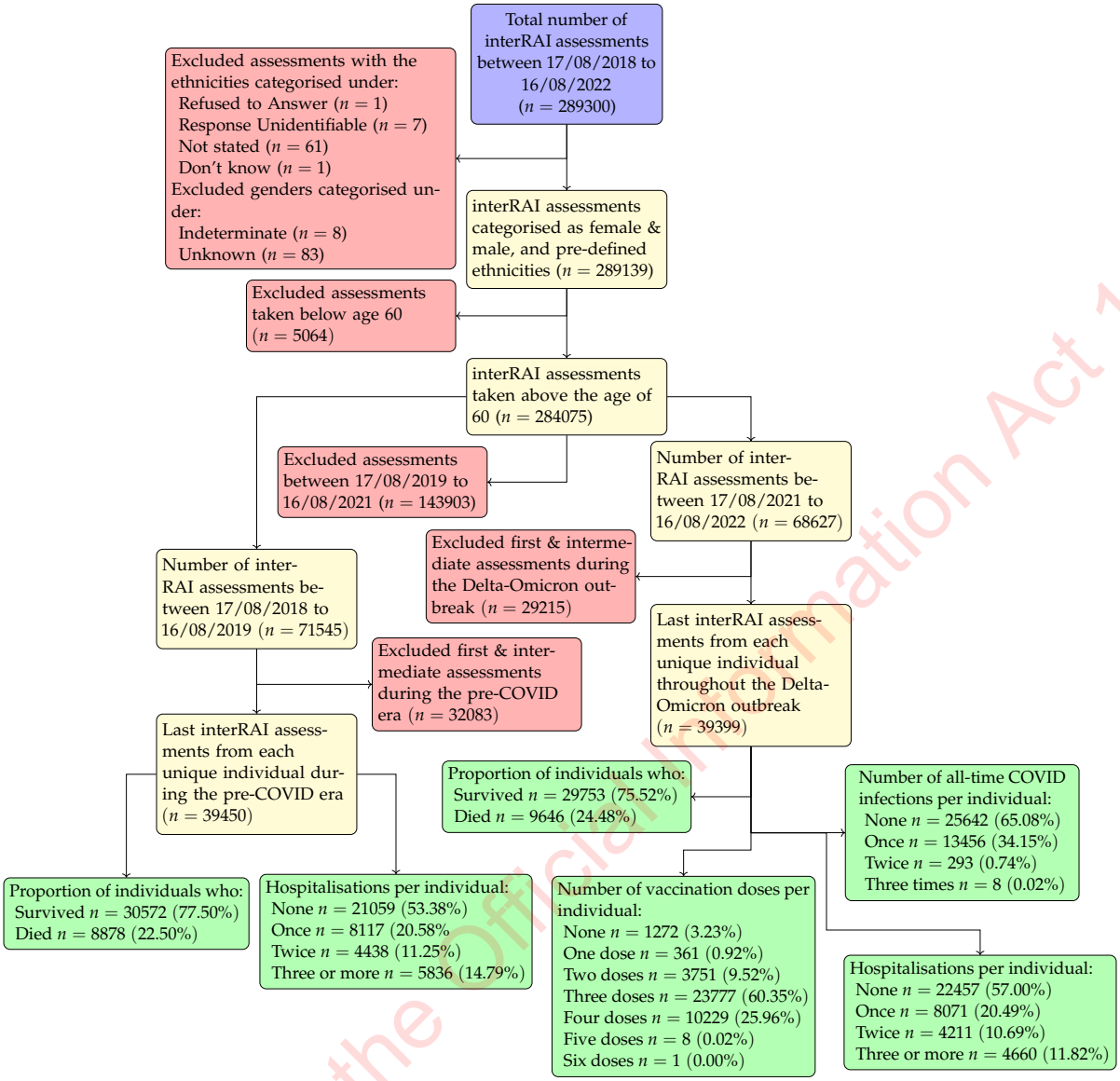


Figure 1: The initial selection of assessments (in blue) along with a workflow of the decisions (in yellow) leading to participant selection and the discarded assessments (in red). Summaries of the linked data from the Ministry of Health are also provided (in green).

and the Delta-Omicron wave periods with distinct date ranges, and thus we only decided to exclusively record their mortality status within these distinctive time frames. Individuals who did not have a recorded date of death will exhibit *censoring* where their lifetimes are only partially known. As a result of paritioning the assessments into two time periods separate from each other, if a participant had interRAI assessments throughout both periods, we may observe the outcome of their mortality status by the Delta-Omicron wave, as displayed Figure 2. Upon comparing the life expectancy, we find that as Figure 3 displays, the average age at of the cohort is similar throughout both periods and remains close to the national average life expectancy.

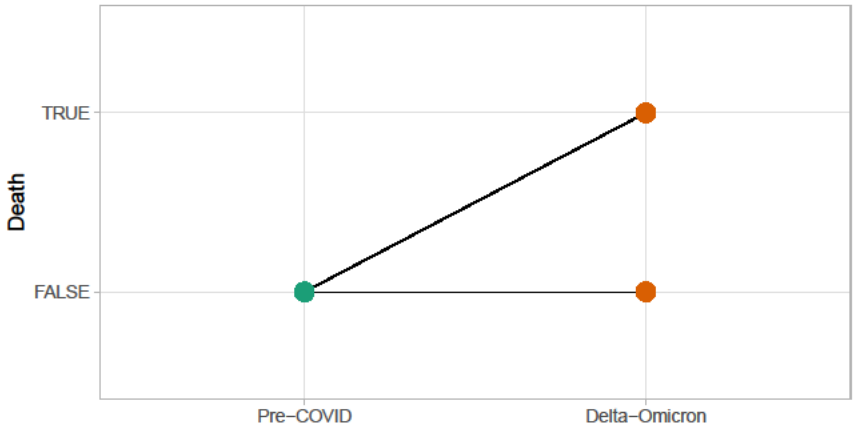


Figure 2: Possible outcomes of mortality from observing participants who have had an assessment in both periods.

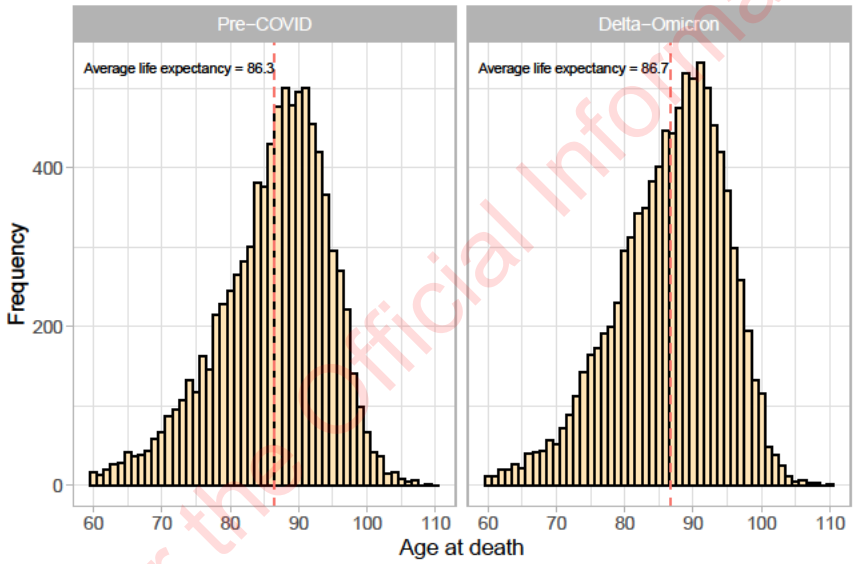


Figure 3: The distribution of life expectancy the cohorts assessed during both periods in the ARC.

Hospitalisation admissions & discharges

The hospitalisation data are longitudinal which may contain repeated measurements on the same observation and the reasoning for each hospitalisation along with the admission and discharge dates. From these repeated measurements, we summarised the number of observations per individual to record their hospitalisation frequency exclusive to the two separate time frames as previously described. Figure 4 shows the distribution of all-time hospitalisations by the selected participants (as featured in Figure 1) throughout the two periods. Overall, the hospitalisation distribution is right-skewed with Figure 5 displaying that participants are generally opting for fewer hospitalisation admissions during the Delta-Omicron wave, compared to their frequency of admissions in the pre-COVID era.

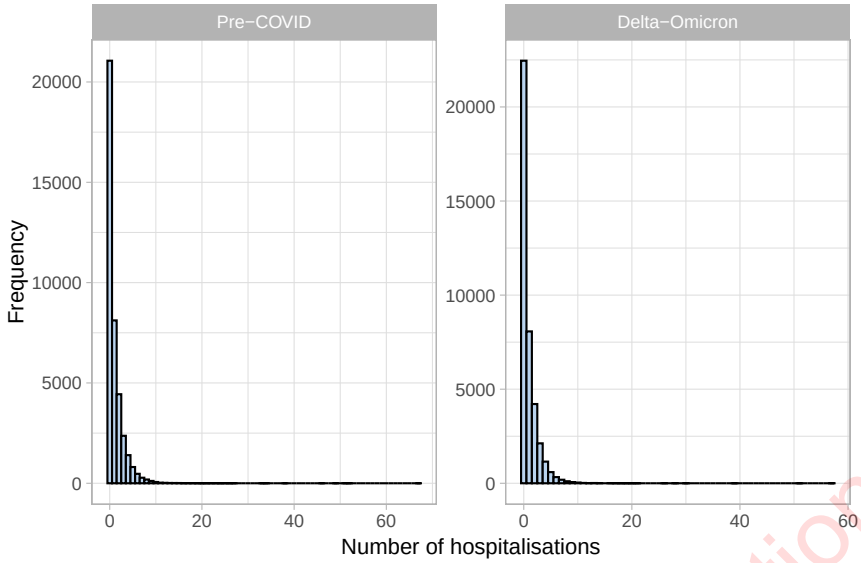


Figure 4: The distribution of hospitalisations between the pre-COVID era and the Delta-Omicron wave.

COVID-19 immunisations and case statuses

Within the immunisation data, we encountered and discarded doses that were given on the same date in addition to records categorized with no dose given, which were recurring impurities in the dataset. This encounter meant that we only decided to count towards an individual's follow-up vaccination dose if there was atleast a three week gap between the two subsequent doses. Similar to the hospitalisation data, we summarised the COVID-19 immunisation and case status data by counting the total amount of doses received and the number of times each individual in the ARC was infected. These data linkages are only relevant to the number of participants that had interRAI assessments throughout the Delta-Omicron wave.

From the summarised findings (Figure 1), the number of vaccinations are reasonable as three total doses contributes to the majority of vaccination doses in the ARC; a recommendation for giving extra protection from COVID-19. Providing for the immunocompromised is service that the ARC upholds thus it is not uncommon to observe people with 4 or more total doses.

Data exploration & analyses

As one of our research objectives are to question if Delta-Omicron impacted the health outcomes of older adults living in the ARC through statistical analysis, we favour generalised linear models that include interactions between independent variables. This inclusion is within our interest to learn whether a change in one level of a categorical independent variable may affect the level of another one. In particular, we intend to ask if the interRAI assessments taken during the Delta-Omicron period may lead to significant differences in various health measurements.

Of all the multitudes of items that interRAI assessments capture, perhaps one of the broadest assessment item within the interRAI repository, among many, would be the Changes in Health, End-Stage Disease, Signs, and Symptoms (CHESS) scale. Developed as an algorithm to predict mortality based on other adverse outcomes associated with frailty [1], the CHESS is a fusion of many other related assessment items within interRAI data. In our analysis, we may be particularly interested in how the CHESS scale interacts with other related interRAI assessment items, seeing as this scale typically associates with poor self-rated health, pain, etc. These associations are evident when viewing Figure 6 which showcases correlations with the Pain

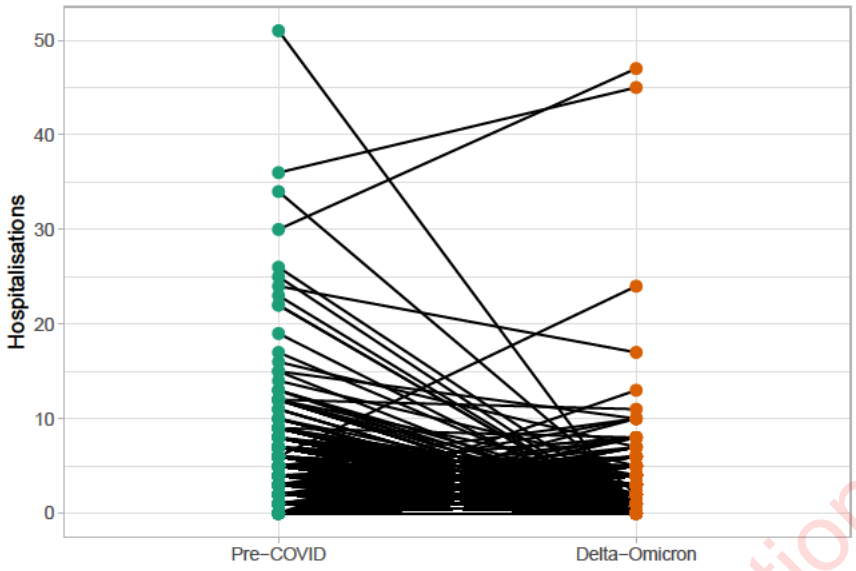
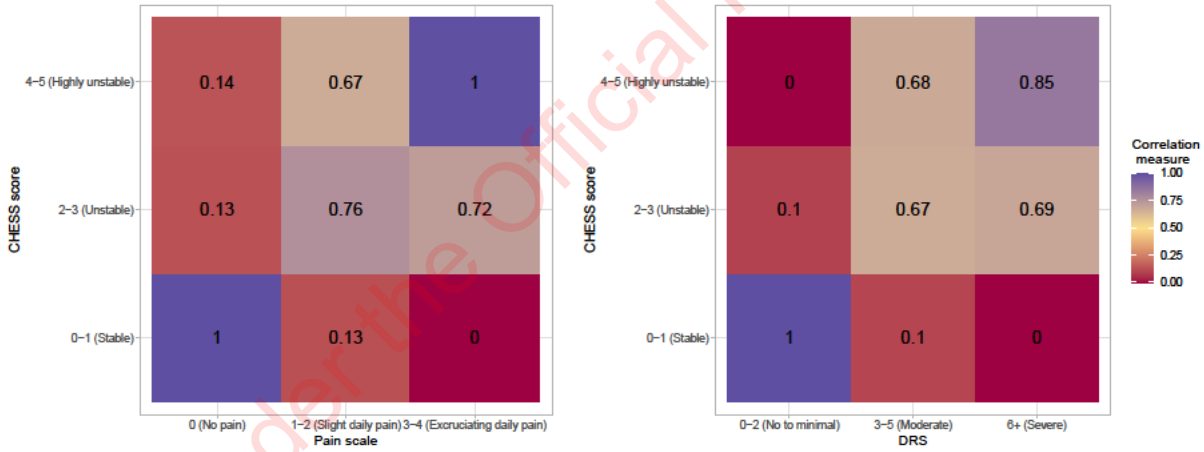


Figure 5: The difference between hospitalisation admissions for paired observations.

Scale and the Depression Rating Scale (DRS) as examples. These diagrams exemplify how an increase to the CHESS scale is easily correlated with an increase to both the pain scale and DRS.



(a) CHESS & Pain scale, on a daily basis

(b) CHESS & DRS

Figure 6: Examples of correlations taken from Chi-square residuals, normalised to $[0, 1]$. On the y-axes are the categories for the CHESS score and the x-axes indicate (a) daily pain scale and (b) DRS. Note that these values are taken from a Chi-square test without adjustments to paired observations, and thus may not be an accurate representation of correlation.

Hospitalisations as an outcome

With hospitalisation as an outcome, this event expresses the number of events occurring during a time interval. An initial method to model this response is with a Poisson distribution which assumes the following properties:

$$\lambda = \mathrm{E}(Y) \approx \mathrm{Var}(Y). \tag{1}$$

However, we find a case of overdispersion which occurs when there is greater variability in our

observed data than we expect it to be. In any given poisson distributed random variable, we typically assume that the mean and variance are similar, which is approximately equal to the rate of hospitalisations as shown in Equ. (1). Upon examining the hospitalisation distribution outcome, we find a gross violation where $\text{Var}(Y) \gg E(Y)$ which means that the observed data exhibits this overdispersion property. Instead, we model the rate of hospitalisation as a negative binomial distribution which is an explicit overdispersed Poisson process [3].

Excess zeros within the response variable is also an issue when observing the hospitalisation counts. With an excess of zeros, a negative binomial model would underpredict the outcome displayed in Figure 4. As such, a further adjustment would be to utilise a zero-inflated model. This type of adjustment is useful due to the number of zeros that arise in the count variable that cannot be explained due to chance alone [5]. Two components comprises this type of model distribution being that of a negative binomial distribution and a logistic distribution which, together, form a mixture distribution to model the response. Consequently, this model no longer belongs to the class of generalised linear models.

As this interRAI data contains individual assessments throughout both periods, a final adjustment is to correct for dependecy across samples through the two time periods. We make this correction by including a random intercept for each unique participant in the study for our model. Ultimately, we utilise a zero-inflated negative binomial mixed model to capture the response of hospitalisations. Table 1 presents the preliminary results of utilising this model, capturing some of the significant interactions between period and CHESS. The model coefficient estimates for a zero-inflated negative binomial mixed model are given as rate ratios. In the case of interRAI data, we are mainly concerned with categorical variables whereby we compare the estimated effect of one category with the baseline. To highlight this comparison, within table 1 we observe that avid participation in social activities, compared to never, seems to lead to more hospitalisations. Throughout the Delta-Omicron wave, participation becomes protective in lowering hospitalisations.

Table 1: Estimated rate ratios from a zero-inflated negative binomial mixed model with hospitalisation count as the response. This table only shows some of the significant variable-by-period interactions.

Predictor variable	Pre-COVID		Delta-Omicron	
	Rate ratio (95% CI)	p-value	Rate ratio multiplier (95% CI)	p-value
Participation in social activities: Never	Reference	-	Reference	-
$\leq$ 30 days ago	1.21 (1.15, 1.27)	0.0000***	0.90 (0.84, 0.96)	0.0021**
$>$ 30 days ago	1.73 (1.60, 1.86)	0.0000***	0.88 (0.81, 0.96)	0.0047**
Unable to determine	1.52 (1.40, 1.64)	0.0000***	0.99 (0.90, 1.08)	0.7948
Hours of excerise in the last 3 days: None	Reference	-	Reference	-
$<$ 1 hour	1.11 (1.05, 1.18)	0.0005**	0.95 (0.89, 1.02)	0.1807
1-2 hours	1.00 (0.94, 1.07)	0.9657	0.89 (0.83, 0.96)	0.0018**
3-4 hours	0.79 (0.73, 0.86)	0.0000***	1.04 (0.94, 1.16)	0.4417
$>$ 4 hours	0.69 (0.62, 0.77)	0.0000***	1.00 (0.85, 1.17)	0.9942
Martial status: Married/civil union/defacto	Reference	-	Reference	-
Other	0.79 (0.76, 0.83)	0.0000***	1.12 (1.06, 1.19)	0.0001***
Period: Pre-COVID	Reference	-		
Delta-Omicron	0.84 (0.78, 0.91)	0.0000***		
Cognitive Performance Scale (CPS): 0 (Intact)	Reference	-		
1-2 (Mild to moderately dependent)	0.85 (0.80, 0.89)	0.0000***		

3-6 (Moderate to severe cognitive impairment)	0.64 (0.61, 0.69)	0.0000***
Falls in the last 30 days: No fall	Reference	
≥ 1 fall	1.76 (1.68, 1.83)	0.0000***
Activities of Daily Living Hierarchy (ADL Hierarchy): 0 (Independent)	Reference	
1-2 (Mild to modeately dependent)	1.19 (1.14, 1.25)	0.0000***
3+ (Severely dependent)	0.98 (0.93, 1.04)	0.5537
Self-rated health: Excellent/good	Reference	
Fair	1.33 (1.28, 1.39)	0.0000***
Poor	1.58 (1.45, 1.72)	0.0000***
Could (would) not respond	0.80 (0.76, 0.85)	0.0000***
Ethnic group: European	Reference	-
Māori	1.10 (1.02, 1.20)	0.0200*
Pacific Peoples	0.93 (0.83, 1.04)	0.2166
Asian	0.89 (0.82, 0.98)	0.0124*
Gender: Female	Reference	-
Male	1.30 (1.26, 1.34)	0.0000***
Age: per 1 unit increase	0.98 (0.98, 0.98)	0.0000***
Body Mass Index (BMI) Healthy	Reference	-
Overweight	0.87 (0.84, 0.92)	0.0000***
Obese	0.77 (0.74, 0.81)	0.0000***
Underweight	0.95 (0.90, 1.01)	0.0905
CHESS: 0-1 (Stable)	Reference	-
2-3 (Unstable)	2.84 (2.01, 4.00)	0.0000***
4-5 (Highly unstable)	5.30 (2.76, 10.16)	0.0000***
Smokes tobacco daily: No	Reference	-
Yes	0.95 (0.89, 1.02)	0.1708
Days went out: No days out	Reference	-
1 or more days	0.96 (0.93, 0.99)	0.0319*
Did not go out, but usually goes out over a 3 day period	0.89 (0.85, 0.93)	0.0000***
Finds meaning in day-to-day life No	Reference	-
Yes	0.97 (0.93, 1.02)	0.2864
Consistent positive outlook: No	Reference	
Yes	1.03 (0.98, 1.07)	0.2432
Says or indicate that he/she feels lonely: No	Reference	-
Yes	1.23 (1.17, 1.30)	0.0000***
Visit with a long-standing social relation or family member: Never	Reference	-
≤ 30 days ago	1.13 (1.01, 1.27)	0.0264*
> 30 days ago	0.64 (0.56, 0.72)	0.0000***
Unable to determine	0.78 (0.69, 0.89)	0.0002**
Pain Scale: 0 (No pain)	Reference	-
1-2 (Slight daily pain)	1.07 (1.04, 1.10)	0.0000***
3-4 (Excruciating daily pain)	1.43 (1.32, 1.54)	0.0000***
Aggressive Behaviour Scale: 0 (Nil)	Reference	-
1-4 (Mildly aggressive behaviour)	0.81 (0.78, 0.84)	0.0000***
5+ (Moderate to severely aggressive behaviour)	0.88 (0.83, 0.93)	0.0000***
DRS: 0-2 (No to minimal)	Reference	-
3-5 (Moderate)	0.99 (0.95, 1.03)	0.6190
6+ (Severe)	0.96 (0.90, 1.01)	0.1364

$^{*}p < 0.05$; $^{**}p < 0.01$; ***; $p < 0.0001$

Falls as an outcome

The outcome for falls is binary, taking a response of either:

$$Y = \begin{cases} 0 & \text{if no fall in the last 30 days;} \\ 1 & \geq 1 \text{ fall in the last 30 days.} \end{cases} \tag{2}$$

Experiencing a fall is not a one time event, as Figure 7 indicates. With this outcome, the initial principle of modelling a binary response is to utilise the well-known logistic regression to obtain odds ratios from each predictor. However, logistic regression is notable for overestimating the odds ratios [4]. If the incidence of this outcome is typically frequent ($> 10\%$), then this overestimation can be especially apparent. An alternative to logistic regression is to use a Poisson model with a robust sandwich variance estimator to provide valid confidence intervals [2]. This adjustment is necessary as the variance of a poisson distributed random variable differs from the variance of a binomial distributed random variable. Finally, the relative risk offers a more superior interpretation over the odds ratio.

Table 2 shows the sole categorical variable that, we have currently found, to interact significantly with the period. Whilst seemingly counterintuitive, exercising can lead to a higher rate of falls. Throughout the Delta-Omicron period, we find that any form of exercise can decrease the risk of falls even with the same amount of exercise compared to the pre-COVID era.

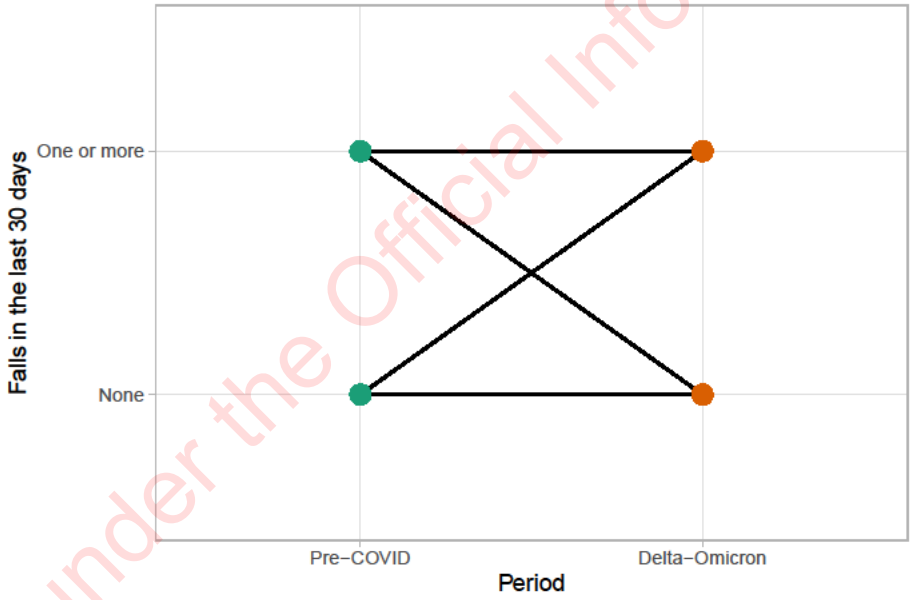


Figure 7: A pairplot of the possible combination of outcomes for falls through the two periods.

Table 2: Estimated relative risks from a Poisson regression model with corrected confidence intervals and p-values. This table shows the only categorical variable which included significant interaction with the period.

Predictor variable(s)	Pre-COVID		Delta-Omicron	
	Relative risk (Robust 95% CI)	p-value	Relative risk multiplier (Robust 95% CI)	p-value
Hours of excerise in the last 3 days: None	Reference	-	Reference	-
$<$ 1 hour	1.45 (1.35, 1.54)	0.0000***	0.87 (0.82, 0.93)	0.0000***

1-2 hours	1.33 (1.25, 1.43)	0.0000***	0.87 (0.81, 0.94)	0.0002**
3-4 hours	1.27 (1.15, 1.39)	0.0000***	0.83 (0.74, 0.93)	0.0018**
> 4 hours	1.29 (1.14, 1.46)	0.0000***	0.82 (0.70, 0.97)	0.0206*
Period: Pre-COVID	Reference	-		
Delta-Omicron	1.23 (1.18, 1.29)	0.0000		
DRS: 0-2 (No to minimal)	Reference	-		
3-5 (Moderate)	1.18 (1.11, 1.24)	0.0000***		
6+ (Severe)	1.24 (1.14, 1.35)	0.0000***		
Ethnic group: European	Reference	-		
Māori	0.67 (0.59, 0.76)	0.0000***		
Pacific Peoples	0.73 (0.62, 0.85)	0.0001***		
Asian	0.78 (0.69, 0.87)	0.0000***		
Middle Eastern/Latin American/African/Others	0.71 (0.47, 1.07)	0.1014		
BMI: Healthy	Reference	-		
Overweight	0.84 (0.80, 0.88)	0.0000***		
Obese	0.72 (0.67, 0.76)	0.0000***		
Underweight	0.95 (0.89, 1.02)	0.1445		
CHESS: 0-1 (Stable)	Reference	-		
2-3 (Unstable)	1.84 (1.73, 1.96)	0.0000***		
4-5 (Highly unstable)	2.29 (2.11, 2.47)	0.0000***		
Participation in social activities: Never	Reference	-		
≤ 30 days ago	1.05 (1.02, 1.09)	0.0020**		
>30 days ago	1.13 (1.08, 1.18)	0.0000***		
Unable to determine	1.14 (1.09, 1.19)	0.0000***		
Visit with a long-standing social relation or family member: Never	Reference	-		
≤ 30 days ago	1.21 (1.07, 1.37)	0.0027**		
> 30 days ago	0.97 (0.85, 1.10)	0.6010		
Unable to determine	1.11 (0.96, 1.27)	0.1567		
Says or indicates that he/she feels lonely: No	Reference	-		
Yes	1.11 (1.06, 1.17)	0.0000***		
Strong and supportive relationship with family: No	Reference	-		
Yes	1.05 (0.99, 1.11)	0.1274		
Consistent positive outlook: No	Reference	-		
Yes	0.97 (0.93, 1.01)	0.1754		
Finds meaning in day-to-day life: No	Reference	-		
Yes	0.96 (0.92, 1.00)	0.0700		
Days went out: No days out	Reference	-		
1 or more days	0.95 (0.92, 0.98)	0.0051**		
Did not go out in the last 3 days but usually goes out over a 3-day period	1.01 (0.97, 1.05)	0.6775		
Smokes tobacco daily: No	Reference	-		
Yes	0.92 (0.84, 0.99)	0.0323*		
Gender: Female	Reference	-		
Male	1.30 (1.26, 1.33)	0.0000***		
Aggressive Behaviour Scale: 0 (Nil)	Reference	-		
1-4 (Mildly aggressive behaviour)	1.09 (1.06, 1.13)	0.0000***		
5+ (Moderate to severely aggressive behaviour)	1.23 (1.18, 1.29)	0.0000***		
Marital status: Married/civil union/defacto	Reference	-		
Other	0.93 (0.90, 0.96)	0.0000***		
ADL Hierarchy: 0 (Independent)	Reference	-		
1-2 (Mild to moderately dependent)	1.63 (1.55, 1.72)	0.0000***		

3-6 (Severely dependent)	1.68 (1.59, 1.77)	0.0000***

*$p < 0.05$; **$p < 0.01$; ***; $p < 0.0001$

The Aggressive Behaviour Scale as an outcome

This outcome is a scale and can take up to three categories of increasingly aggressive behavioural rating, expressed as:

$$Y = \begin{cases} 0 \text{ if } 0 \text{ (Nil)}; \\ 1 \text{ if } 1\text{-}4 \text{ (Mildly aggressive behaviour)}; \\ 2 \text{ if } 5+ \text{ (Moderate to severely aggressive behaviour)}. \end{cases} \quad (3)$$

We make use of ordinal logistic regression which is an extention of the logistic regression model for more than two ordered responses. Considering that we have three outcomes ordered by increasing dependence then the ordinal logistic regression model will estimate odds ratios that a participant belonging to a category, compared to the categorical baseline, is associated with further aggressive behaviour. Table 3 highlights this notion along with the significant variable-by-period interactions. For this ordinal logistic regression model, we make use of Markov Chain Monte Carlo (MCMC) algorithms whereby the odds ratios are determined using Bayesian inference.

Table 3: Odds ratios obtained from constructed probability distributions using the MCMC algorithm with the Aggressive Behaviour Scale as the outcome.

Predictor variable(s)	Pre-COVID		Delta-Omicron	
	Odds ratio posterior mean (95% Credible Interval)	p-value	Odds ratio multiplier (95% Credible Interval)	p-value
Hours of exercise in the last 3 days: None	Reference	-	Reference	-
< 1 hour	1.14 (1.08, 1.21)	0.001**	0.96 (0.89, 1.03)	0.268
1-2 hours	1.14 (1.07, 1.21)	0.001**	0.91 (0.84, 0.98)	0.012
3-4 hours	1.46 (1.35, 1.59)	0.001**	0.81 (0.72, 0.90)	0.001**
>4 hours	1.55 (1.41, 1.73)	0.001**	0.97 (0.84, 1.13)	0.702
Days went out: No days out	Reference	-	Reference	-
Did not go, but usually goes out over a 3-day period	0.98 (0.92, 1.04)	0.424	1.04 (0.94, 1.12)	0.418
1 or more days	0.88 (0.84, 0.93)	0.001**	1.09 (1.01, 1.17)	0.016*
Period: Pre-COVID	Reference	-		
Delta-Omicron	1.06 (1.00, 1.14)	0.046*		
Marital status: Married/civil union/defacto	Reference	-		
Other	1.04 (1.00, 1.09)	0.0800		
DRS: 0-2 (No to minimal)	Reference	-		
3-5 (Moderate)	2.80 (2.66, 2.93)	0.001**		
6+ (Severe)	4.33 (4.02, 4.73)	0.001**		
CPS: 0 (Intact)	Reference	-		
1-2 (Borderline or mild cognitive impairment)	2.14 (1.98, 2.31)	0.001**		
3-6 (Moderate to severe cognitive impairment)	5.31 (4.88, 5.76)	0.001**		
Falls in the last 30 days: No fall	Reference	-		
≥ 1 fall	1.15 (1.10, 1.21)	0.001**		

Finds meaning in day to day life: No	Reference	-
Yes	0.88 (0.84, 0.93)	0.001**
CHESS: 0-1 (Stable)	Reference	-
2-3 (Unstable)	1.10 (0.93, 1.3)	0.26
4-5 (Highly unstable)	0.9 (0.62, 1.3)	0.59
Strong and supportive relationship with family: No	Reference	-
Yes	0.81 (0.77, 0.86)	0.001**
Self-rated health: Excellent/good	Reference -	
Fair	0.78 (0.75, 0.81)	0.001**
Poor	0.67 (0.63, 0.72)	0.001**
Could (would) not respond	1.38 (1.33, 1.43)	0.001**
Consistent positive outlook: No	Reference	-
Yes	0.68 (0.65, 0.72)	0.001**
BMI: Healthy	Reference	-
Overweight	0.98 (0.95, 1.01)	0.236
Obese	1.03 (0.99, 1.07)	0.202
Underweight	1.00 (0.96, 1.04)	0.886
Smokes tobacco daily: No	Reference	-
Yes	1.39 (1.29, 1.49)	0.001**
Participation in social activities: Never	Reference	-
$\leq$ 30 days ago	0.82 (0.75, 0.92)	0.001**
$>$ 30 days ago	0.83 (0.79, 0.87)	0.001**
Unable to determine	0.88 (0.84, 0.93)	0.001**
Says or indicates that he/she feels lonely: No	Reference	-
Yes	0.96 (0.91, 1.01)	0.13
Visit with a long-standing social relation or family member: Never	Reference	-
$\leq$ 30 days ago	0.83 (0.75, 0.92)	0.001**
$>$ 30 days ago	0.83 (0.79, 0.87)	0.001**
Unable to determine	0.88 (0.84, 0.93)	0.001**
Ethnic group: European	Reference	-
Māori	1.42 (1.33, 1.53)	0.001**
Pacific Peoples	1.39 (1.26, 1.53)	0.001**
Asian	0.96 (0.88, 1.03)	0.278
Middle Eastern/Latin American/African/Others	1.30 (1.00, 1.65)	0.034*

The results show that exercising throughout the Delta-Omicron wave can lead to an ease of aggressive behaviour, and this easing of aggression is especially true for those who exercise 3-4 hours. For those who typically spend their time outside, especially during 1 or more days, the odds of developing increasingly aggressive behaviour is increased by a factor of 1.09. Despite this increase, the overall odds ratio for developing a more severe form of aggressive behaviour is $0.88 \times 1.09 = 0.96$ which is still a protective factor as this ratio is below 1.

DRS as an outcome

Similar to the previous outcome, the DRS is based on three categories that increase in intensity denoted by:

$$Y = \begin{cases} 0 \text{ if 0-2 (No to minimal);} \\ 1 \text{ if 3-5 (Moderate);} \\ 2 \text{ if 5+ (Severe).} \end{cases} \tag{4}$$

Making use of the ordinal logistic regression model, using MCMC, we obtain the mean of the probability distributions for each variable shown in 4. In this table, we gather that excruciating daily pain can influence higher odds of greater DRS. Throughout the Delta-Omicron wave, this pain can marginally alleviate worsening depression although the odds ratio is still high (at $3.15 \times 0.84 = 2.65$). Compared to being those who are married, in a civil union or in a de-facto relationship, those categorised under a marital status of "other" is protective against worsening depression. In the Delta-Omicron period, this category may lead to increasing DRS.

Table 4: Odds ratios taken from the mean of the constructed probability distributions using the MCMC algorithm with the DRS as the outcome.

Predictor variable(s)	Pre-COVID		Delta-Omicron	
	Odds ratio posterior mean (95% Credible Interval)	p-value	Odds ratio multiplier (95% Credible Interval)	p-value
Pain Scale: 0 (No pain)	Reference	-	Reference	-
1-2 (Slight daily pain)	1.49 (1.43, 1.56)	0.001**	0.99 (0.95, 1.04)	0.816
3-4 (Excruciating daily pain)	3.15 (2.69, 3.66)	0.001**	0.84 (0.73, 0.99)	0.028*
Martial status: Married/civil union/defacto	Reference	-	Reference	-
Other	0.90 (0.87, 0.95)	0.001**	1.08 (1.02, 1.15)	0.016*
Period: Pre-COVID	Reference	-		
Delta-Omicron	1.10 (1.02, 1.15)	0.001		
Participation in social activities: Never	Reference	-		
$\leq$ 30 days ago	1.08 (1.03, 1.14)	0.001**		
$>$ 30 days ago	1.10 (1.03, 1.18)	0.022*		
Unable to determine	1.03 (0.95, 1.10)	0.458		
Falls in the last 30 days: No fall	Reference	-		
$>$ 1 fall	1.12 (1.07, 1.17)	0.001*		
Self-rated health: Excellent/good	Reference	-		
Fair	1.37 (1.31, 1.44)	0.001**		
Poor	2.42 (2.22, 2.63)	0.001**		
Could (would) not respond	0.79 (0.75, 0.84)	0.001**		
BMI: Healthy	Reference	-		
Overweight	1.01 (0.97, 1.06)	0.570		
Obese	0.99 (0.94, 1.04)	0.612		
Underweight	0.97 (0.91, 1.03)	0.386		
Finds meaning in day to day life: No	Reference	-		
Yes	1.18 (1.12, 1.24)	0.001**		
Ethnic group: European	Reference	-		
Māori	0.69 (0.63, 0.76)	0.001**		
Pacific Peoples	0.57 (0.49, 0.66)	0.001**		
Asian	0.78 (0.7, 0.87)	0.0014**		
Middle Eastern/Latin American/African/Others	1.22 (0.90, 1.70)	0.228		

CHESS: 0 (Stable)	Reference	-
2-3 (Unstable)	1.29 (1.17, 1.43)	0.001**
4-5 (Highly unstable)	1.56 (1.26, 1.91)	0.001**
Consistent positive outlook: No	Reference	-
Yes	0.4 (0.38, 0.42)	0.001**
Age per 1 unit increase	0.98 (0.98, 0.99)	0.001**
Gender: Female	Reference	-
Male	0.58 (0.56, 0.6)	0.001**
Days went out: No days out	Reference	-
Did not go, but usually goes out over a 3-day period	1.07 (1.03, 1.13)	0.014*
1 or more days	1.11 (1.07, 1.15)	0.001**
Smokes tobacco daily: No	Reference	-
Yes	0.89 (0.83, 0.96)	0.001**
Aggressive Behaviour Scale: 0 (Nil)	Reference	-
1-4 (Mildly aggressive behaviour)	2.26 (2.18, 2.34)	0.001**
5+ Moderate to severely aggressive behaviour	5.12 (4.84, 5.48)	0.001**
CPS: 0 (Intact)	Reference	-
1-2 (Borderline or mild cognitive impairment)	1.39 (1.31, 1.47)	0.001**
3-6 (Moderate to severe cognitive impairment)	1.44 (1.34, 1.53)	0.001**
Visit with a long-standing social relation or family member: Never	Reference	-
$\leq$ 30 days ago	1.09 (0.97, 1.22)	0.172
$>$ 30 days ago	1.05 (0.92, 1.21)	0.464
Unable to determine	0.95 (0.83, 1.08)	0.478
Says or indicates that he/she feels lonely: No	Reference	-
Yes	3.05 (2.89, 3.24)	0.001**
Strong and supportive relationship with family: No	Reference	-
Yes	0.93 (0.88, 0.98)	0.008**
Hours of exercise in the last 3 days: None	Reference	-
$<$ 1 hour	1.08 (1.04, 1.12)	0.001**
1-2 hours	1.06 (1.01, 1.11)	0.001**
3-4 hours	1.10 (1.04, 1.16)	0.001**
$>$ 4 hours	1.18 (1.10, 1.29)	0.001**
ADL Hierarchy: 0 (Independent)	Reference	-
1-2 (Mild to moderately dependent)	1.10 (1.05, 1.15)	0.001**
3-6 (Severely dependent)	0.98 (0.94, 1.03)	0.476

*$p < 0.05$; **$p < 0.01$; ***; $p < 0.0001$

Concluding remarks

Note that the these are crude results from all four models and may not be accurate to provide decisive decisions on which factors contribute to the health impacts of the Delta-Omicron wave on New Zealanders living in the ARC. This inaccuracy is mainly due to having oversaturated statistical models that have included nearly all the variables that we initially considered. Consequently, this inclusion is not at all ideal as there can be multicollinearity, confounders and mediators between the variables that the interRAI assessments can produce. To remedy these issues, we intend to fine-tune the models with regularisation techniques and/or causal inference to simplify these models and allow us to interpret the total, direct or indirect effects that act upon each of the four outcomes.

References

[1] J. P. Hirdes, D. H. Frijters, and G. F. Teare. "The MDS-CHESS Scale: A New Measure to Predict Mortality in Institutionalized Older People". In: *Journal of the American Geriatrics Society* **51** 1 (2003), pp. 96–100. DOI: https://doi.org/10.1034/j.1601-5215.2002.51017.x (cit. on p. 5).

[2] G. Zou. "A Modified Poisson Regression Approach to Prospective Studies with Binary Data". In: *American Journal of Epidemiology* **159** 7 (Apr. 2004), pp. 702–706. DOI: 10.1093/aje/kwh090 (cit. on p. 9).

[3] A. Lindén and S. Mäntyniemi. "Using the negative binomial distribution to model overdispersion in ecological count data". In: *Ecology* **92** 7 (2011), pp. 1414–1421. DOI: doi.org/10.1890/10-1831.1 (cit. on p. 7).

[4] W. Chen, L. Qian, J. Shi, and M. Franklin. "Comparing performance between log-binomial and robust Poisson regression models for estimating risk ratios under model misspecification". In: *BMC Medical Research Methodology* **18** (June 2018), p. 63. DOI: 10.1186/s12874-018-0519-5 (cit. on p. 9).

[5] O. Korosteleva. *Advanced Regression Models with SAS and R*. 1st ed. Chapman and Hall/CRC, 2018. DOI: doi.org/10.1201/9781315169828 (cit. on p. 7).

[6] G. Cheung, S. Bala, M. Lyndon, E. Ma'u, C. Rivera Rodriguez, D. L. Waters, H. Jamieson, S. Nada-Raja, A. H. Y. Chan, K. Beyene, B. Meehan, and X. Walker. "Impact of the first wave of COVID-19 on the health and psychosocial well-being of Māori, Pacific Peoples and New Zealand Europeans living in aged residential care". In: *Australasian Journal on Ageing* **41** 2 (2022), pp. 293–300. DOI: https://doi.org/10.1111/ajag.13025 (cit. on p. 2).

Appendix

We held an interest in whether an increase in the CHESS scale could influence an increase in another interRAI-related assessment item when modelled on the four different outcomes. Below are the tables that present some of the significant variable-by-CHESS interactions.

Note that the reference group is always the factor baseline regardless of the baseline interaction with increasing CHESS scale.

Predictor variable	Main effect	CHESS interaction multiplier	
	Baseline CHESS: (0-1) Stable	(2-3) Unstable	(4-5) Highly unstable
Participation in social activities: Never	Reference	-	-
≤ 30 days ago	1.21 (1.15, 1.27)**	0.97 (0.90, 1.04)	0.84 (0.74, 0.95)*
> 30 days ago	1.73 (1.61, 1.86)***	0.90 (0.81, 0.99)*	0.80 (0.69, 0.92)**
Unable to determine	1.52 (1.40, 1.64)***	0.99 (0.90, 1.10)	0.78 (0.66, 0.92)
CPS: 0 (Intact)	Reference	-	-
1-2 (Borderline or mild cognitive impairment)	0.84 (0.80, 0.89)***	1.01 (0.92, 1.11)	1.38 (1.09, 1.75)***
3+ (Moderate to severe cognitive impairment)	0.64 (0.61, 0.69)***	0.86 (0.78, 0.96)**	1.29 (1.01, 1.65)*
Falls in the last 30 days: No fall	Reference	-	-
≥ 1 fall	1.76 (1.68, 1.83)***	0.86 (0.81, 0.92)***	0.71 (0.64, 0.79)***
ADL Hierarchy: 0 (Independent)	Reference	-	-
1-2 (Mild to moderately dependent)	1.19 (1.14, 1.25)***	0.87 (0.79, 0.95)**	0.91 (0.68, 1.22)
3-6 (Severely dependent)	0.98 (0.93, 1.04)	1.01 (0.91, 1.11)	0.92 (0.72, 1.27)
Self-rated health: Excellent/good	Reference	-	-
Fair	1.33 (1.28, 1.39)***	0.90 (0.84, 0.97)**	0.77 (0.66, 0.90)**
Poor	1.58 (1.45, 1.72)***	0.79 (0.70, 0.89)***	0.64 (0.54, 0.77)***
Could (would) not respond	0.80 (0.76, 0.85)***	1.11 (1.01, 1.21)*	1.12 (0.96, 1.32)
Hours of exercise in the last 3 days: None	Reference	-	-
< 1 hour	1.11 (1.05, 1.18)**	0.93 (0.86, 1.00)	0.86 (0.76, 0.97)*
1-2 hours	1.00 (0.94, 1.07)	0.95 (0.87, 1.03)	0.94 (0.78, 1.14)
3-4 hours	0.79 (0.73, 0.86)	0.77 (0.68, 0.88)**	0.99 (0.67, 1.49)
> 4 hours	0.69 (0.62, 0.77)	0.85 (0.70, 1.03)	1.68 (0.90, 3.13)
Ethnic group: European	Reference	-	-
Māori	1.10 (1.02, 1.20)*	1.18 (1.02, 1.36)*	0.97 (0.76, 1.24)
Pacific Peoples	0.93 (0.83, 1.04)	1.19 (0.95, 1.49)	1.10 (0.69, 1.75)
Asian	0.89 (0.82, 0.98)*	1.28 (1.08, 1.51)**	1.53 (1.09, 2.14)*
Middle Eastern/Latin American/African	0.84 (0.61, 1.17)	1.05 (0.63, 1.76)	0.60 (0.16, 2.23)
Age per 1 unit increase	0.98 (0.98, 0.98)***	0.99 (0.99, 1.00)**	0.99 (0.98, 1.00)**
BMI: Healthy	Reference	-	-
Overweight	0.88 (0.84, 0.92)***	1.02 (0.95, 1.11)	1.15 (1.01, 1.31)
Obese	0.77 (0.74, 0.82)***	1.02 (0.94, 1.11)	1.16 (0.98, 1.36)
Underweight	0.95 (0.90, 1.01)	0.99 (0.91, 1.08)	0.93 (0.82, 1.06)

*$p < 0.05$; **$p < 0.01$; ***; $p < 0.0001$

Table 5: Estimated rate ratios from a zero-inflated negative binomial mixed model. This table shows the categorical variables with significant variable-by-CHESS interactions from the same model.

Predictor variable	Main effect	CHESS interaction multiplier	
	Baseline CHESS: (0-1) Stable	(2-3) Unstable	(4-5) Highly unstable
DRS: 0-2 (No-to-minimal)	Reference	-	-
3-5 (Moderate)	1.18 (1.11, 1.24)***	0.90 (0.84, 0.97)**	0.93 (0.85, 1.02)
6+ (Severe)	1.24 (1.14, 1.35)***	0.89 (0.80, 0.99)*	0.82 (0.73, 0.93)**
Hours of exercise in the last 3 days: None	Reference	-	-
$<$ 1 hour	1.45 (1.35, 1.54)***	0.84 (0.78, 0.90)***	0.84 (0.77, 0.92)**
1-2 hours	1.33 (1.25, 1.43)***	0.84 (0.78, 0.91)***	0.73 (0.63, 0.85)***
3-4 hours	1.27 (1.15, 1.39)***	0.76 (0.67, 0.86)***	0.68 (0.48, 0.96)*
$>$ 4 hours	1.29 (1.14, 1.46)***	0.82 (0.69, 0.97)*	1.07 (0.73, 1.59)
Ethnic group: European	Reference	-	-
Māori	0.67 (0.59, 0.76)***	1.28 (1.08, 1.53)*	1.41 (1.14, 1.76)**
Pacific Peoples	0.73 (0.62, 0.85)***	1.26 (0.99, 1.60)	1.09 (0.72, 1.65)
Asian	0.78 (0.69, 0.87)***	1.20 (1.01, 1.42)*	1.18 (0.89, 1.57)
Middle Eastern/Latin American/African	0.71 (0.47, 1.07)	1.54 (0.92, 2.59)	1.74 (0.86, 3.51)
BMI: Healthy	Reference	-	-
Overweight	0.84 (0.80, 0.88)***	1.12 (1.04, 1.20)**	1.22 (1.10, 1.34)***
Obese	0.72 (0.67, 0.76)***	1.08 (0.99, 1.18)	1.42 (1.26, 1.61)***
Underweight	0.95 (0.89, 1.02)	1.00 (0.92, 1.09)	1.01 (0.91, 1.12)

$^{*}p < 0.05$; $^{**}p < 0.01$; ***; $p < 0.0001$

Table 6: Estimated relative risks from a Poisson regression model with correct confidence intervals for correlated observations. This table shows the categorical variables with significant variable-by-CHESS interactions from the same model.

Predictor variable	Main effect	CHESS interaction multiplier	
	Baseline CHESS: (0-1) Stable	(2-3) Unstable	(4-5) Highly unstable
DRS: 0-2 (No-to-minimal)	Reference	-	-
3-5 (Moderate)	2.80 (2.66, 2.93)**	0.87 (0.81, 0.93)**	1.08 (0.96, 1.20)
6+ (Severe)	4.33 (4.02, 4.73)**	0.89 (0.80, 0.99)*	0.98 (0.82, 1.15)
Falls in the last 30 days: No fall	Reference	-	-
$\geq$ 1 fall	1.15 (1.10, 1.21)**	0.97 (0.90, 1.03)	0.97 (0.86, 1.08)
Finds meaning in day to day life: No	Reference	-	-
Yes	0.84 (0.80, 0.88)***	0.90 (0.84, 0.96)**	1.02 (0.91, 1.13)
Hours of exercise in the last 3 days: None	Reference	-	-
$<$ 1 hours	1.14 (1.08, 1.21)**	0.99 (0.92, 1.06)	1.03 (0.91, 1.18)
1-2 hours	1.14 (1.07, 1.21)**	1.08 (1.00, 1.18)*	1.15 (0.96, 1.42)
3-4 hours	1.46 (1.35, 1.59)**	1.25 (1.11, 1.41)**	1.22 (0.84, 1.83)
$>$ 4 hours	1.55 (1.41, 1.73)**	1.25 (1.11, 1.41)**	2.56 (1.34, 4.67)**

$^{*}p < 0.05$; $^{**}p < 0.01$; ***; $p < 0.0001$

Table 7: Significant odds ratios of variable-by-CHESS interactions from the ordinal logistic regression model with the Aggressive Behaviour Scale as the outcome.

Predictor variable	Main effect	CHESS interaction multiplier	
	Baseline CHESS: (0-1) Stable	(2-3) Unstable	(4-5) Highly unstable
Falls in the last 30 days: No fall	Reference	-	-
$\geq$ 1 fall	1.12 (1.07, 1.17)**	0.92 (0.86, 0.99)*	0.96 (0.86, 1.07)
Self-rated health: Excellent/good	Reference	-	-
Fair	1.37 (1.31, 1.44)**	0.94 (0.86, 1.02)	0.83 (0.69, 1.02)
Poor	2.42 (2.22, 2.63)**	0.86 (0.77, 0.98)*	0.82 (0.68, 0.99)*
Could (would) not respond	0.79 (0.75, 0.84)**	1.15 (1.06, 1.27)**	1.12 (0.95, 1.33)
BMI: Healthy	Reference	-	-
Overweight	1.01 (0.97, 1.06)	0.99 (0.91, 1.07)	1.02 (0.88, 1.17)
Obese	0.99 (0.94, 1.04)	0.94 (0.87, 1.03)	1.27 (1.04, 1.51)*
Underweight	0.97 (0.91, 1.03)	1.06 (0.95, 1.15)	0.90 (0.77, 1.03)
Finds meaning in day to day life: No	Reference	-	-
Yes	1.18 (1.12, 1.24)**	0.97 (0.89, 1.04)	0.87 (0.77, 0.98)*
Ethnic group: European	Reference	-	-
Māori	0.69 (0.63, 0.76)**	1.25 (1.06, 1.43)**	1.03 (0.81, 1.32)
Pacific Peoples	0.57 (0.49, 0.66)**	0.97 (0.72, 1.27)	1.87 (1.07, 3.05)*
Asian	0.78 (0.70, 0.87)**	0.86 (0.71, 1.06)	1.09 (0.71, 1.60)
Middle Eastern/Latin American/African/Others	1.22 (0.90, 1.70)	0.88 (0.48, 1.53)	1.88 (0.64, 5.64)
Pain Scale: 0 (No pain)	Reference	-	-
1-2 (Slight daily pain)	1.49 (1.43, 1.56)**	0.97 (0.91, 1.03)	1.10 (0.96, 1.26)
3-4 (Excruciating daily pain)	3.15 (2.69, 3.66)**	0.81 (0.67, 0.99)*	0.98 (0.78, 1.24)

*$p < 0.05$; **$p < 0.01$; ***; $p < 0.0001$

Table 8: Significant odds ratios of variable-by-CHESS interactions from the ordinal logistic regression model with the DRS as the outcome.

Te Whatu Ora
Health New Zealand

MANATŪ HAUORA
MINISTRY OF HEALTH

Progress report

COVID-19 and National Immunisation Programme research

Submitted by
Auckland University of Technology

Project title
PROP-017 Impact of COVID-19 on childhood vaccine uptake and ways forward for equitable immunisation services

Progress report period
1 June 2023 progress report

Te Whatu Ora
Health New Zealand

MANATŪ HAUORA
MINISTRY OF HEALTH

Please submit this report to research@health.govt.nz

Section 1: Contact information

1.1 Point of Contact for this report

Item	Detail
Contact person	S 9(2)(a)
Position	
Phone number	
Mobile number	
Email address	

Section 2: Progress update

2.1 High-level update on progress

When writing your update, you should refer to the plan you outlined in your proposal, which has been included in your contract. Updates should provide information on the status and progress towards delivering the plan in your contract.

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Item	Response
Do you consider your project to be on track to deliver on the plan described in your contract	Yes

Supporting information Please provide information about progress towards delivering the plan described in your contract. Please include information on key achievements and a brief overview of activities. This section will help us assess whether you are executing your plan as expected and highlight important milestones.	(100 words) The quantitative phase of the project uses the Integrated Data Infrastructure (IDI) managed by Stats NZ. In our last progress report, we had completed the analysis using the IDI and produced the empirical results. These include a range of figures and tables that provide a detailed overview of how the pandemic affected immunisation patterns. Some high-level key findings include: Descriptively: - Declines in vaccine uptake for the 6-week, 3, 5, and 15 month, and 4 year vaccines post pandemic (albeit with some pre-COVID decline for the earlier milestones). - Steady downward trend post pandemic is larger, with greater volatility, for the 15 month and 4 year vaccines. Using regression analysis to model the COVID impact and catchup patterns: - We compare vaccine uptake of affected children with a cohort of unaffected children born a year earlier - We control for child and household socio-demographic characteristics - Largest effects on timely vaccination at the 4 year event. - Substantive ethnic differences – For the 4 year event, European and Asian children had a 12 and 18 percentage point reduction in the share of fully immunised children 1 month after they became eligible, respectively. This difference converges to the vaccine behaviour of the earlier cohort within 8 months; i.e. they largely catchup in the 8 months after the due date of that vaccine. However, both Māori and Pacific children had approximately a 12-13 percentage point reduction in the share of fully immunised children 1 month after they became eligible; and this gap remains the same size after the following 8 months, i.e. close to no catch-up for both ethnic groups. - We have also undertaken additional heterogeneity analysis based on gender, birth order, socio-economic status, earnings, region, etc. For the qualitative phase of the project, we have conducted a series of whānau-centered interviews, wānanga, and Talanoa with Māori and Pacific whānau (n=24) and health care providers (n=13) to understand how the COVID-19 pandemic has influenced their access and acceptance of routine childhood immunisations. We have transcribed the data collected and have constructed themes following the six phases of reflexive thematic analysis. We are currently writing up the findings and drafting recommendations to improve immunisation service delivery based on these findings.

Changes Tell us whether you have done or are planning on something different from what you originally expected to do to complete the project fully. Let us know why you are making the change and what the impacts may be, e.g. amendment to ethics approval, additional participant recruitment, etc.	(100 words) Not applicable
Emerging risks and mitigations Tell us whether any risks have emerged and how you propose to or have mitigated these	(100 words) Not applicable

Te Whatu Ora
Health New Zealand

MANATŪ HAUORA
MINISTRY OF HEALTH

Progress report

COVID-19 and National Immunisation Programme research

Submitted by
University of Otago

Project title
PROP-060 The role of digital contact tracing to support improved pandemic responses

Progress report period
Three month progress report

Please submit this report to research@health.govt.nz

Section 1: Contact information

1.1 Point of Contact for this report

Item	Detail
Contact person	S 9(2)(a)
Position	
Phone number	
Mobile number	
Email address	

Section 2: Progress update

2.1 High-level update on progress

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Item	Response
Do you consider your project to be on track to deliver on the plan described in your contract	**Yes**/No
Supporting information Please provide information about progress towards delivering the plan described in your contract. Please include information on key achievements and a brief overview of activities. This section will help us assess whether you are executing your plan as expected and highlight important milestones.	**Quantitative component:** We have received ethics approval for the quantitative component, received all the data from the MoH, and begun the data cleaning and preliminary analysis. We have held multiple meetings with staff at MoH to help interpret the data [which changed substantially throughout the pandemic]. We are currently designing our analytic framework given limitations in some of the datasets aquired. **Qualitative component:** We have recruited and hired Dr Phoebe Elers, a great qualitative researcher, to lead this component We have also recruited Professor Sarah Derret and Dr Tepora Emery to help supervise the development of the qualitaitve component and assist with data collecction and analyses. Phobe has developed the interview schedules, information and consent forms, stakeholder mapping and recruitment processes for the focus groups which have all been approved by the University of Otago Ethics Committee (Health) – see attached. Recruitment has started. Focus groups will then take place in Feb 2023 as planned (see project plan submitted as part of Deliverable 1).

Changes Tell us whether you have done or are planning on something different from what you originally expected to do to complete the project fully. Let us know why you are making the change and what the impacts may be, e.g. amendment to ethics approval, additional participant recruitment, etc.	The only potential change to our quantitative component is we may not be able to generate a consistent metric for digital contact tracing data utilitsation as the standard operating procedures changed substanitally over the study period. Instead we are going to generate this metric for each of the distinct phases – currently catergorised as second wave; Delta Wave; Omicron Wave
Emerging risks and mitigations Tell us whether any risks have emerged and how you propose to or have mitigated these	One risk is that some staff within the National Investigation and Tracing Centre are due to finish their contracts in December 2022– meaning they may be difficult to recruit in 2023. I have requested a list of people from our contact at NITC that would be interested and we have discussed the potential of conducting individual key stakeholder interviews, using a similar or slightly adapated interview schedule, with individuals.

Te Whatu Ora
Health New Zealand

MANATŪ HAUORA
MINISTRY OF HEALTH

Progress report

COVID-19 and National Immunisation Programme research

Submitted by
University of Otago

Project title
PROP-060 The role of digital contact tracing to support improved pandemic responses

Progress report period
Three month progress report

Please submit this report to research@health.govt.nz

Section 1: Contact information

1.1 Point of Contact for this report

Item	Detail
Contact person	S 9(2)(a)
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Section 2: Progress update

2.1 High-level update on progress

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Item	Response
Do you consider your project to be on track to deliver on the plan described in your contract	**Yes**/No
Supporting information Please provide information about progress towards delivering the plan described in your contract. Please include information on key achievements and a brief overview of activities. This section will help us assess whether you are executing your plan as expected and highlight important milestones.	**Quantitative component:** We developed our analysis plan at a full-day workshop in Wellington. A draft results section is expected at our meeting on June 9th 2023. Compared to the project plan, we are slightly behind schedule on the analysis which was due for completion in May. We expect to have final results by the end of June, in time for the final report (due in August). **Qualitative component:** Focus group recruitment and implementation has gone well. We have one more focus group to conduct with pacific stakeholders. Focus groups and key stakeholder interviews are completed and transcribed for MoH, PHU, Māori, Disabled persons and Pacific groups (that have been conducted thus far). Against the project plan we are slightly behind (by two weeks).
Changes Tell us whether you have done or are planning on something different from what you originally expected to do to complete the project fully. Let us know why you are making the change and what the impacts may be, e.g. amendment to ethics approval, additional participant recruitment, etc.	No additional changes .

Emerging risks and mitigations Tell us whether any risks have emerged and how you propose to or have mitigated these	No emerging risks.

Burden of Long COVID in Aotearoa New Zealand: Establishing a Long COVID Registry

Progress report till May 31st 2023

- Appointed an RA Andrew McCullough on the project (parttime November 2022, fulltime from March 2023)
- Established Te Rōpū Kaitiaki in March 2023. Members include:
  - Witi Ashby (Ngāti Hine, Ngāti Kawa)
  - Iris Pahau (Te Aupouri, Te Rarawa, Ngāti Kuri, Ngāti Awa)
  - Ngapera Riley (Te Arawa, Ngāti Uenukukopako, Ngāti Rorooterangi, Ngāti Whakaue, Tūhourangi)
  - Mona Jeffreys
  - Marianna Churchward (Samoan)
  - Jenene Crossan (Ngāi Tahu)
  - Andrew McCullough
  - Paula Lorgelly
- Te Rōpū Kaitiaki operates under Te Tiriti Relationship Framework
- Additional funding secured from the EuroQol Foundation for more regular EQ-5D-5L responses from participants and to explore health inequalities using IMD18 data
- Additional funding secured from School of Population Health to help with Māori responsiveness
- Registry will collect data within Qualtrics, an online survey software
- Registry will be accessed via an auckland.ac.nz webpage that will host the participant information sheet
- Registry will be promoted on the Long Covid Support Aotearoa (LCSA) website
- https://longcovidsupport.co.nz/ launched 19th May 2023, website written by patients for patients
- In the first week 300 individuals signed up to receive notification of the registry
- Registry project sponsors the LCSA website
- Ethics submitted 19th May 2023
- Ethics provisionally approved 29th May 2023 (subject to minor amendments)
- On invitation of Chief Economist, project presented at MoH on 29th May 2023
- Forthcoming presentation at International Health Economics Association, panel on the burden of long COVID
- Planned go live date week of 11th June 2023

Te Whatu Ora
Health New Zealand

MANATŪ HAUORA
MINISTRY OF HEALTH

Progress report

COVID-19 and National Immunisation Programme research

Submitted by
Victoria University of Wellington

Project title
PROP-051 Child vaccine hesitancy: Predictors of parents' COVID-19 vaccine uptake for their children, impact on vaccine uptake of the national immunisation schedule, and translational findings for equitable immunisation outcomes among children in Aotearoa N

Progress report period
1 June 2023 progress report

Te Whatu Ora
Health New Zealand

MANATŪ HAUORA
MINISTRY OF HEALTH

Please submit this report to research@health.govt.nz

Section 1: Contact information

1.1 Point of Contact for this report

Item	Detail
Contact person	S 9(2)(a)
Position	
Phone number	
Mobile number	
Email address	

Section 2: Progress update

2.1 High-level update on progress

When writing your update, you should refer to the plan you outlined in your proposal, which has been included in your contract. Updates should provide information on the status and progress towards delivering the plan in your contract.

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Item	Response
Do you consider your project to be on track to deliver on the plan described in your contract	Yes/No

Supporting information Please provide information about progress towards delivering the plan described in your contract. Please include information on key achievements and a brief overview of activities. This section will help us assess whether you are executing your plan as expected and highlight important milestones.	We note that since the original contract was signed, that we have requested an extension from MoH to key milestone deadlines, which was approved. These were for the following reasons: • An initial delay in the expected notification and signing of the original contract. This pushed the start date back by one month, which pushed potential data collection and ethics reviews into the Christmas/holiday period, which was not optimal in terms of the data collection period and deadlines for ethics review; • Multiple sickness events among the team, with two members having longer-term recovery from COVID-19; • Ethics review process and delay at VUW (VUW does not have rapid ethics review processes such as those at other institutions); • Delays in feasability report from the survey firm being contracted to deliver the online survey and use their existing sampling frame; • Unanticipated international emmigration of the PI to Spain. Despite these challenges, we have developed our wave 1 survey, and the survey has been given ethics approval from the VUW ethics review committee (after revision and resubmission to address revisions the committee requested). Based on suggestions from team members who are practicing physicians, we expanded the scope of the survey to include more questions (validated tools) about trust in and quality of parent-GP/health care provider relationships, with that information intended to be not only of use and interest for the outcome we're examining (i.e., vaccine hesitancy) but also informative beyond the scope of the association between GP trust and relationship quality and vaccine hesitancy in terms of families having their health care needs met. We have worked with the survey firm contracted to field the survey to have the survey in the field by June 14th. The survey is currrently in the field, and set to finish data collection within two weeks. While data is being collected, the data structure and dummy data have been provided to the research team so that programme code can be written to clean the data and create analytical variables. This means preliminary analyses can be conducted and completed shortly after the final dataset is provided. We hope to have preliminary findings by mid-July, as well as the second survey draft to the ethics review board (which we do not want to submit until we check that the first round of data were collected in the way intended, in case we need to make corrections to variables on wave 2).

Changes Tell us whether you have done or are planning on something different from what you originally expected to do to complete the project fully. Let us know why you are making the change and what the impacts may be, e.g. amendment to ethics approval, additional participant recruitment, etc.	There is a concern by the survey firm contracted to deliver the survey that we may not hit our target number of respondents within each of the child ages (e.g., oversampling parents of 0- and 3-year olds). Despite this concern, the cell size numbers are still expected to be over 300 within each group, with over 3,000 parents in the total sample, which is a reasonable and statistically acceptable cell size range for examination of key age groups. As noted above, we also expanded the scope within some of the areas we will be examining. These changes were included as part of our ethics submission and approved.
Emerging risks and mitigations Tell us whether any risks have emerged and how you propose to or have mitigated these	Emerging risks include the potential of limited cell size ranges within key age groups (as noted above). We note that the survey firm stated they were conservative in their estimates, and would still try to achieve our original child age breakdown, but have flagged this as a potential issue. This will be monitored closely as data are coming in, and we have a secondary goal to boost numbers in other key groups to increase the total sample size, even if certain age groups are not exactly at the cell size we had hoped for. Another risk is retention for wave 2. In the past we have generally achieved good reponse rates (over 80% for our longitudinal lockdown survey through the same firm). But to mitigate this, we will discuss with the firm about using multiple behavioural prompts (as we have in the past) to solicit higher response rates. We have also 'front-loaded' survey 1, so that more information about sociodemographic characteristics and sociopsychological measures (e.g., indicators of institutional trust, conspiratorial thinking, ease of accessing health care, etc.) is collected in this wave so that the cross-sectional analyses from wave 1 will be robust, regardless of retention rate at wave 2.

Te Whatu Ora
Health New Zealand

MANATŪ HAUORA
MINISTRY OF HEALTH

Progress report

COVID-19 and National Immunisation Programme research

Submitted by
ESR

Project title
PROP-028 The impact of COVID-19 vaccination on disease burden and transmission and its vaccine effectiveness among participants of SHIVERS/WellKiwis community and household cohorts

Progress report period (April-June 2023)
Three month progress report

Te Whatu Ora
Health New Zealand

MANATŪ HAUORA
MINISTRY OF HEALTH

Please submit this report to research@health.govt.nz

Section 1: Contact information

1.1 Point of Contact for this report

Item	Detail
Contact person	S 9(2)(a)
Position	
Phone number	
Mobile number	
Email address	

Section 2: Progress update

2.1 High-level update on progress

When writing your update, you should refer to the plan you outlined in your proposal, which has been included in your contract. Updates should provide information on the status and progress towards delivering the plan in your contract.

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Item	Response
Do you consider your project to be on track to deliver on the plan described in your contract	Yes, overall we are on track to deliver on the plan described in our contract. However, some changes meant that we would not be able to deliver in the proposed timeline.
Supporting information Please provide information about progress towards delivering the plan described in your contract. Please include information on key achievements and a brief overview of activities. This section will help us assess whether you are executing your plan as expected and highlight important milestones.	The third milestone for SHIVERS/WellKiwis cohort study is to conduct final data analysis for publications for the four papers: 1) COVID-19 incidence; 2) COVID-19 vaccination effectiveness; 3) COVID-19 household transmission dynamics. 4) Validation of the national notifiable disease data using SHIVERS/WellKiwis cohort data as a gold standard The SHIVERS/WellKiwis team has completed and generated the statistical analysis plan for each paper. In addition, the team has done some exploratory analysis and presented the data for each paper at the SHIVERS symposium on 1-Feb 2023. The SHIVERS data team requested the whole year data (2022) from Te Whatu Ora on National Minimum Dataset and vaccination. We have received the final dataset from Te Whatu Ora on 17-May 2023. As the result of this delay of receiving the final dataset, we are not able to generate the final analytical dataset for final data analysis. Whole genome sequencing (WGS) testing for COVID-19 positive samples completed on 31-Jan 2023. Data analysis is still ongoing during April-June 2023.

Changes Tell us whether you have done or are planning on something different from what you originally expected to do to complete the project fully. Let us know why you are making the change and what the impacts may be, e.g. amendment to ethics approval, additional participant recruitment, etc.	We encountered a few changes: We thank Te Whatu Ora for getting the whole year data (2022) on National Minimum Dataset and vaccination for SHIVERS/WellKiwis study. Unfortunately, we only received the whole year data (2022) on 17-May 2023. The delay in receiving the data meant that we are unable to generate the final analytical dataset and conduct the final analysis by the original milestone date of June 2023. Whole genome sequence (WGS) data analysis for COVID-19 positive samples is still ongoing. This is a consequence of the delayed WGS testing reported in the previous reporting period. We hope to receive the final WGS results soon.
Emerging risks and mitigations Tell us whether any risks have emerged and how you propose to or have mitigated these	With delayed MoH data/WGS results, we are behind our proposed third milestone. To deliver our contract, we request a non-cost extension to deliver all promised milestones by Dec 2023.

Te Whatu Ora
Health New Zealand

MANATŪ HAUORA
MINISTRY OF HEALTH

Progress report

COVID-19 and National Immunisation Programme research

Submitted by
ESR

Project title
PROP-028 The impact of COVID-19 vaccination on disease burden and transmission and its vaccine effectiveness among participants of SHIVERS/WellKiwis community and household cohorts

Progress report period (October - December 2023)
Three month progress report

Te Whatu Ora
Health New Zealand

MANATŪ HAUORA
MINISTRY OF HEALTH

Please submit this report to research@health.govt.nz

Section 1: Contact information

1.1 Point of Contact for this report

Item	Detail
Contact person	S 9(2)(a)
Position	
Phone number	
Mobile number	
Email address	

Section 2: Progress update

2.1 High-level update on progress

When writing your update, you should refer to the plan you outlined in your proposal, which has been included in your contract. Updates should provide information on the status and progress towards delivering the plan in your contract.

Although the stated word limits are a guide, please be concise and only write more if necessary.

Item	Response
Do you consider your project to be on track to deliver on the plan described in your contract	Yes, overall we are on track to deliver on the plan described in our contract. However, some changes meant that we would not be able to deliver in the proposed timeline.
Supporting information Please provide information about progress towards delivering the plan described in your contract. Please include information on key achievements and a brief overview of activities. This section will help us assess whether you are executing your plan as expected and highlight important milestones.	The SHIVERS scientific/clinical advisory group met on 19-Oct-2022 and agreed 3 pulications to deliver for NIP funded research: 1)COVID-19 incidence; 2) COVID-19 vaccination effectiveness; 3) COVID-19 household transmission dynamics. The first authors have been identified to lead 3 publications and have conducted initial literature review and drafted concept proposals. The SHIVERS data team requested and obtained mainly the first half year data from Te Whatu Ora on National minimum dataset and vaccination. A clean, merged initial analytical dataset for exploratory analysis has been generated. Whole genome sequencing (WGS) testing for COVID-19 positive samples has not been completed during the first three months (Oct-Dec 2022).

Changes Tell us whether you have done or are planning on something different from what you originally expected to do to complete the project fully. Let us know why you are making the change and what the impacts may be, e.g. amendment to ethics approval, additional participant recruitment, etc.	We encountered a few changes: • Whole genome sequencing testing for COVID-19 positive samples were delayed (Note: the testing has just finished on 31-Jan-2023 and sequencing analysis is ongoing). • The initial data request from MoH were mainly data covering Jan-June 2022. The SHIVERS study activities did not finish till October 2022. Thus we need another data request to cover the second half of the year • We are unclear about data release permission pathway as we want to use SHIVERS data as a gold standard to validate national notifiable COVID-19 data. We had permission for access éclair data for SHIVERS but no permission for data on national notifiable COVID-19 data. This issue is currently being worked through.
Emerging risks and mitigations Tell us whether any risks have emerged and how you propose to or have mitigated these	With delayed WGS results/MoH data request, our risk is that we may be behind our proposed milestone. We would like to signal and discuss possibility to have a non-cost extension (possibly around the end of 2023 - we will advise a firm date in the next progress report), so we can deliver our contract.

Te Whatu Ora
Health New Zealand

MANATŪ HAUORA
MINISTRY OF HEALTH

Progress report

COVID-19 and National Immunisation Programme research

Submitted by
Auckland University of Technology

Project title
PROP-020 The role of vaccine mandates in New Zealand's COVID-19 response

Progress report period
Six month progress report

Please submit this report to research@health.govt.nz

Section 1: Contact information

1.1 Point of Contact for this report

• Item	• Detail
• Contact person	S 9(2)(a)
• Position	
• Phone number	
• Mobile number	
• Email address	

Section 2: Progress update

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• Item	• Response
• Do you consider your project to be on track to deliver on the plan described in your contract	• Yes/~~No~~
• Supporting information • Please provide information about progress towards delivering the plan described in your contract. Please include information on key achievements and a brief overview of activities. This section will help us assess whether you are executing your plan as expected and highlight important milestones.	Quantitative component: • Data analysis is almost complete for Research Question 1 (To what extent did the mandates increase vaccination uptake among workers who were subject to these mandates) and on-track for Research Question 2 (What were the consequences of mandates for the health workforce?). • Draft report writing is progressing well. • We plan to submit this research to conferences for consideration soon. Qualitative component: • Ethics committee amendment granted to interview individual health workers as well as health worker focus groups. • Individual interviews in progress and focus groups planned. • Some challenges encountered given the degree of pressure faced by health workers currently

• Changes • Tell us whether you have done or are planning on something different from what you originally expected to do to complete the project fully. • Let us know why you are making the change and what the impacts may be, e.g. amendment to ethics approval, additional participant recruitment, etc.	• No changes planned, however, we anticipate there may be some delays to qualitative research in the context of a under-pressure health workforce and weather-related disruptions
• Emerging risks and mitigations • Tell us whether any risks have emerged and how you propose to or have mitigated these	• To date, no emerging risks identified. However, we will keep you informed about possible delays to qualitative work if/as these arise.

Progress report

COVID-19 and National Immunisation Programme research

Submitted by
Victoria University of Wellington

Project title
PROP-053 COVID-19 Vaccine Evaluation (COVE) in Aotearoa New Zealand

Progress report period
Three month progress report

Please submit this report to research@health.govt.nz

Section 1 : Contact information

1.1 Point of Contact for this report

a.

Item	Detail
Contact person	S 9(2)(a)
Position	
Phone number	
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Section 2 : Progress update

2.1 High-level update on progress

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b. Although the stated word limits are a guide, please be concise and only write more if necessary.

Item	Response
Do you consider your project to be on track to deliver on the plan described in your contract	Yes
Supporting information Please provide information about progress towards delivering the plan described in your contract. Please include information on key achievements and a brief overview of activities. This section will help us assess whether you are executing your plan as expected and highlight important milestones.	(100 words) The progress to date includes 1. Descriptive analysis - Has been conducted to describe and summarise the baseline characteristics of the study participants. 2. Regression analysis - Data pre-processing has been carried out to prepare the data for regression models.
Changes Tell us whether you have done or are planning on something different from what you originally expected to do to complete the project fully. Let us know why you are making the change and what the impacts may be, e.g. amendment to ethics approval, additional participant recruitment, etc.	No changes have been planned so far

Emerging risks and mitigations Tell us whether any risks have emerged and how you propose to or have mitigated these	(100 words) Data analyses Mitigations: Prof Simpson and Dr Sheppard are working with ESR to create a secured platform where all the team members who have undergone confidentiality training can access and run the regression models

Progress report

COVID-19 and National Immunisation Programme research

Submitted by
Victoria University of Wellington

Project title
PROP-053 COVID-19 Vaccine Evaluation (COVE) in Aotearoa New Zealand

Progress report period
Three month progress report

Please submit this report to research@health.govt.nz

Section 1 : Contact information

1.1 Point of Contact for this report

a.

Item	Detail
Contact person	S 9(2)(a)
Position	
Phone number	
Mobile number	
Email address	

Section 2 : Progress update

2.1 High-level update on progress

When writing your update, you should refer to the plan you outlined in your proposal, which has been included in your contract. Updates should provide information on the status and progress towards delivering the plan in your contract.

b. Although the stated word limits are a guide, please be concise and only write more if necessary.

Item	Response
Do you consider your project to be on track to deliver on the plan described in your contract	Yes
Supporting information Please provide information about progress towards delivering the plan described in your contract. Please include information on key achievements and a brief overview of activities. This section will help us assess whether you are executing your plan as expected and highlight important milestones.	(100 words) The progress to date includes 2. An out of scope letter has been obtained from the Health and Disability Ethics Committee of the Ministry of Health. 3. Data wrangling - The first draft of the analysis dataset has been created by Precision data Ltd.
Changes Tell us whether you have done or are planning on something different from what you originally expected to do to complete the project fully. Let us know why you are making the change and what the impacts may be, e.g. amendment to ethics approval, additional participant recruitment, etc.	No changes have been planned so far

Emerging risks and mitigations Tell us whether any risks have emerged and how you propose to or have mitigated these	(100 words) Analysis dataset access within the Ministry of Health is required by the research team. Mitigations: Dr Ankit Patel is investigating approaches to access the data. Prof Simpson is working with other programme research teams to solve data access challenges.