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Association of Clinical Indicators of Acute Deterioration and Morbidity and Mortality in the Residential Aged Care Population: A Retrospective Cohort Study of Routinely Collected Health Data

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ABSTRACT

Introduction: The timely identification of acute deterioration in people living in residential aged care is critical to reducing rates of resident morbidity and mortality. However, residents often present with atypical or nonspecific presentations that make this difficult. This study aimed to quantify the strength of the relationship between the indicators acute deterioration reported in the literature and morbidity and mortality.

Method: A retrospective cohort study using routinely collected health data. A single dependant acute deterioration variable (emergency department presentation or hospital admission or death within 7 days of the last completed international resident assessment instrument long-term care facility (interRAI-LTCF) assessment) was correlated with indicators of acute deterioration reported in the literature and available in interRAI-LTCF. Univariate and multivariate logistic regression analysis evaluated this association.

Results: Nine variables were independently associated with acute deterioration. These were being 'largely asleep or unresponsive' odds ratio (OR): 7.95, 95% CI: 4.72–13.39, $p < 0.001$, 'easily distracted' (OR: 1.78, 95% CI: 1.28–2.49, $p < 0.001$), eating 'one or fewer meals a day' (OR: 2.13, 95% CI: 1.67–2.73, $p < 0.001$), reduced activities of daily living (OR: 2.06, 95% CI: 1.11–3.82, $p = 0.02$) inability to complete toilet transfer (OR: 1.95, 95% CI: 1.24–3.03, $p = 0.004$), 'dyspnoea; at rest' (OR: 1.81, 95% CI: 1.32–2.49, $p < 0.001$), 'two or more falls in 30 days' (OR: 1.53, 95% CI: 1.15–2.03, $p = 0.003$), peripheral oedema (OR: 1.37, 95 CI: 1.07–1.77, $p = 0.014$) and daily pain (OR: 1.37, 95% CI: 1.05–1.77, $p = 0.019$).

Conclusion: Presenting with one of nine variables made residents between 1.4 and 8 times more likely to be experiencing acute deterioration than others living in the facility. The monitoring the resident for these variables by healthcare assistants could support the timely identification of acute deterioration.

Trial Registration: Not applicable.

1 | What Does This Study Add to Existing Knowledge in Gerontology?

- This study quantifies the likelihood of acute deterioration occurring in residents presenting with one of the nine observable clinical variables.
- This study reinforces the emerging discussion in the literature of the important of assessing nonspecific clinical indicators in the event of acute deterioration in this population.

2 | What Are the Implications of This New Knowledge for Older People Living in Care?

- Monitoring older people living in long-term care for evidence of the nine clinical indicators could support the timely identification of acute deterioration.
- The odds ratios associated with the clinical variables could support the assessment of urgency in the event of acute deterioration.

3 | How Could the Findings be Used to Influence Policy or Practice or Research or Education?

- These findings could be used to develop a deterioration early warning tool sensitive to the unique needs of older people living in residential aged care
- These findings could be used to enhance triage practices applied to older people living in residential aged care and may reduce the risk if underestimating clinical urgency.

4 | Introduction

The accurate and timely identification of acute deterioration in people living in residential aged care (RAC) is critical to avoiding or reducing rates of adverse health events such as Emergency Department (ED) presentation, hospitalisation or death [1–4]. Also, importantly for this cohort, the timely identification of acute deterioration supports the implementation of appropriate end-of-life care, particularly for those whose death is anticipated and/or those who have decided in advance to restrict their treatment options using tools such as 'do not hospitalise' or 'do not resuscitate' orders [5]. Regardless of any advance directive, the first step in the clinical decision-making process is the identification of acute deterioration. However, the identification of acute deterioration in people living in RAC is complex due to the physiological effects of advanced age, multiple morbidity and frailty.

RAC services are specialized; they focus on providing care for people assessed as having long-term high and complex health needs [6] related to advanced age, physiological, psychosocial, cognitive and functional limitations [7–10]. Frailty affects a high proportion of people living in RAC. A 2015 meta-analysis [7] reported a 52% pooled prevalence of frailty in RAC populations. A 2021 systematic review reported prevalence rates ranging from 15% to 80%, across 20 countries, measured with the Frail-Nursing Home tool [11]. Longitudinal studies [12, 13] confirm that the rate of frailty in RAC populations has been steadily increasing over time.

Frailty increases the vulnerability of older people impacting their ability to cope with relatively minor stressors [14]. The likelihood of those living with frailty experiencing disability or death is increased compared to those of the same age without frailty [6, 15, 16]. Advanced age and frailty together mean that not only do this population have a higher risk of death than those without frailty, but they are also more likely to have nonspecific symptoms (clinical indicators) of illness when they are acutely unwell [17–19]. Nonspecific clinical indicators of acute deterioration are those that are not easily attributable to a particular underlying condition. They are also known in the literature as 'nonspecific complaints' 'atypical' symptoms, 'general decline' and 'home care impossible' events [20–22]. Older people with nonspecific clinical indicators of ill health are some of the most vulnerable individuals presenting to ED services [23]. They are triaged as less urgent than people with specific complaints, yet they have higher mortality rates, spend more time in ED and have more frequent hospital admissions with longer lengths of stay than their similarly aged counterparts [23–26]. There is a growing sense of clinical concern about this group of older people. So much so, that there are calls for presentations to ED of older adults with nonspecific symptoms to be considered major emergencies [24] or red flag issues [27].

Collectively, the clinical indicators of acute deterioration described in ED-based research, closely resemble the definition of acute deterioration in the RAC population namely; "a sudden, clinically important deviation from the person's baseline cognitive, behavioural, functional or physical domains... that without intervention, may result in complications or death." [28] Specifically, ED research names these clinical indicators as, loss of consciousness, altered mental status, speech disorders, dizziness (cognitive domain), not eating and drinking (behavioural domain), functional decline, mobility changes and falls (functional domain), new urinary incontinence, weakness, fatigue and dyspnoea (physical domain) [17, 20, 26, 29]. These are consistent with RAC reports that clinical indicators of acute deterioration are unresponsiveness, altered mental status, behaviour change, reduced food or fluid intake, functional decline, falls, continence changes, fatigue, dyspnoea, uncontrolled pain, nausea and vomiting and vital sign abnormalities [9, 18, 19, 30].

The phenomenon of acute deterioration is under-explored [31], with little evidence describing the strength of the relationship between the presentation of clinical indicators in this population and the deterioration events of ED presentation, hospitalisation or death.

Two recent literature reviews reported international evidence identifying the clinical indicators associated with acute deterioration in the RAC population [18, 19] (see Table 1). Three RAC studies [38, 44, 48] conducted more than two decades ago reported mental status change, lethargy, change in mood and behaviour, reduced food intake, functional loss, mobility dependence, falls, faecal incontinence, skin ulcers, weakness,

TABLE 1 | Matching clinical indicators of acute deterioration for the literature with available interRAI variables.

Clinical indicator acute deterioration (literature)	InterRAI™ Long Term Care Facility Assessment		
	icode	Variable	Most severe outcome
Cognitive domain			
Altered mental status [32–37] Confusion [38–41] Disorientation [36, 41] Disorganised thinking [42]	iC4	Acute change in mental status from usual functioning	1: Yes
	iC3b	Disorganised speech	2: Behaviour present, appears different from usual functioning
	iC5	Change in decision making	2: Declined
Difficulty following instruction [43]	iD2	Ability to understand others	4: Rarely or never understands
Inattention [42]	iC3a	Easily distracted	2: Behaviour present, appears different from usual functioning
Fluctuation [42]	ic3c	Mental function varies over day	2: Behaviour present, appears different from usual functioning
Drowsy or tired [38, 40] Drowsy [43] Lethargy [44] Altered level of consciousness [42] Unresponsive [33, 34] Loss of conciousness [36]	iS3	Time asleep during the day	3: Largely asleep or unresponsive
Mood [39] Depressed [44]	iE2c	Sad depressed or hopeless	3: Daily in the last 3 days
	iE2a	Little interest or pleasure in things you normally enjoy	3: Daily in the last 3 days
Behavioural domain			
Restless [41] Anxious [36]	iE1e	Repetitive anxious complaints	3: Daily in last 3 days
	iE2b	Anxious restless or uneasy	3: Daily in the last 3 days
Participated less in activity [38, 40]	iE1i	Withdrawal from activities of interest	3: Daily in last 3 days
	iE1j	Reduced social interaction	3: Daily in last 3 days
Aggression [36, 41, 44]	IE3e	Resists care	3: Daily in last 3 days
	iE1b	Persistent anger with self/others	3: Daily in last 3 days
	IE3c	Physical abuse	3: Exhibited daily in last 3 days
Ate less [38, 40, 41] Decreased appetite [32, 44] Decreased food/fluid [33, 37]	iK2e	One or fewer meals a day	1: Yes
	iK2f	Decrease in food or fluid	1: Yes
Drank less [40] Hydration [39] Decreased fluid [32]	iK2c	Dehydrated	1: Yes
	iK2b	Fluid intake reduced	1: Yes
Seems different to usual [32]		No match available	
Talks/communicates less [38, 40]		No match available	
Agitated/nervous [38, 40] Agitation [44]		No match available	
Functional domains			
More help dress/toilet/transfer [38, 40] Functional decline [32, 33, 36, 37]	iG2c	Dressing upper body	6: Total dependence
	iG2b	Personal hygiene	6: Total dependence
	iG2g	Toilet transfer	8: Activity did not occur during entire period
Overall needs more help [40]	iG8a2	Change in ADL status	2: declined

(Continues)

TABLE 1 | (Continued)

Clinical indicator acute deterioration (literature)	InterRAI™ Long Term Care Facility Assessment		
	icode	**Variable**	**Most severe outcome**
Reduced mobility [38]	iG2e	Walking	6: Total dependence
Movement slowed [43]		No match available	
Physical domain			
Tired, feeble [41]	iJ4	Fatigue: inability to complete normal daily activities	4: Unable to commence any normal day-to-day activities-due to diminished energy
Pain [39, 41] Pain (new or increased) [40] Pain (uncontrolled) [32–37]	ij5a	Pain frequency	3: Exhibited daily in last 3 days
	ij5b	Pain intensity	4: Times when pain is horrible or excruciating
	ij5c	Pain consistency	3: Constant
	iJ5d	Break through pain	1: Yes
Bowel not opened for 3 days or diarrhoea [40] Constipation [45] Diarrhoea [32, 46] Toilet/bowel habit [39] New urinary incontinence [33] Urinary incontinence or urinary symptoms	ij2k	constipation	4: Exhibited daily in last 3 days
	ij2l	diarrhoea	4: Exhibited daily in last 3 days
	iH1	Bladder continence	5: Incontinent
	iH3	Bowel continence	8: Did not occur (no BM)
Weight change Weight loss [44]	iK2a	Weight loss	1: Yes
Swollen leg/feet [40] Leg pain/swelling [45]	iJ2s	peripheral oedema	4: Exhibited daily in last 3 days
Falls [32–35, 37, 44, 45]	iJ1	Falls	3: two or more falls in last 30 days
	iJ2	Difficulty standing	4: Exhibited daily in last 3 days
Dizziness [44]	ij2c	Problem frequency dizziness	4: Exhibited daily in last 3 days
Change skin colour or condition [40] Wound infection [41] Skin [39]	iL1	Most severe pressure ulcer	5: Not codeable
	iL5	Skin tear	1: Yes
Breathing [39] Respiratory infection [35, 41] Breathing difficulty [32–34, 36, 45]	iJ34	Dyspnoea	3: Present at rest
Pyrexia [41] Rigour [41] Fever [32–34, 37]	iJ2q	Problem frequency - fever	4: Exhibited daily in last 3 days
Urinary incontinence or urinary symptoms [32, 34, 35, 37, 41]	iI1r	Urinary tract infection	2: Diagnosis present, receiving active treatment
Weak [38, 40, 44, 45]		No match available	
Abnormal vital signs [47]		No match available	

dizziness and weight loss positively predicted hospitalisation. One recent study [32] reported a change in mental status, consciousness, behaviour or function and dyspnoea, fever and pain, were associated with hospital transfer. Other more recent RAC hospital transfer studies split their analysis into subgroups. They either examined transfers to hospital for admission in 'potentially preventable' versus 'not preventable' groups [32, 49–52] or categorised hospital transfers by diagnostic group [53]. Due to the subgroup analysis, it is not possible to draw conclusions about the strength of the relationship between clinical indicators and the combined acute events of ED presentation, or hospitalisation or death from these studies. There is a need to understand the strength of the relationship between the literature-reported clinical indicators of acute deterioration and all acute events in older people living in RAC.

In practice, the identification of acute deterioration is the first step in a series of escalation processes that are required to establish a treatment plan (including end-of-life treatments) for the affected person. In RAC healthcare assistants ((HCA)

unregulated healthcare workers) provide the majority of day-to-day care and therefore have the most opportunity to notice small clinical changes that could indicate acute deterioration [31]. Research suggests that registered nurses (RN) depend on HCA reports of change to initiate their own assessment of the situation, triage and subsequent escalation for medical evaluation and diagnostic decision-making [31, 54]. There is a paucity of RAC population and service-specific tools to support HCAs and RNs to identify and respond to acute deterioration [18, 31]. The first step towards the development of such evidence based tool(s) requires the confirmation that clinical indicators of acute deterioration reported in the international literature are reflected in the New Zealand Aotearoa (NZ) RAC population. As well as quantifying the strength of that relationship. Therefore, in this study we aimed to a) confirm whether clinical indicators of acute deterioration described in the international literature were correlated with the event of ED presentation or hospitalisation or death (acute deterioration) in the NZ RAC population and b) calculate the strength of that relationship.

5 | Methods

5.1 | Study Design and Data Sources

We used a retrospective cohort study design, analysing routinely collected health data from RAC facilities across all regions in Aotearoa NZ. This was secondary analysis of an existing database [55] that linked sixteen administrative health data sets for all deaths in the period of 1 January to 31 December 2015. This study used a subset of that entire data base including only people with evidence of living in residential aged care. The administrative data sets included: the National Minimum Data set (hospital admissions), National Non-Admitted Patients Collection (ED admissions), Mortality Collection (deaths) and the International Resident Assessment Instrument-Long Term Care Facility (interRAI-LTCF) assessment. Independent variables for this study were drawn from interRAI-LTCF assessments. Informed consent for research use of interRAI-LTCF data is provided at first patient assessment. InterRAI-LTCF is the only nationally available data set containing RN (primarily) observations of the cognitive, behavioural, functional and physical domain status of people living in RAC. In this study the interRAI-LTCF assessment is being used as a data source as it contains complete data of routine standardised clinical assessment of people living in long term care settings [56]. It was mandated for use in NZ RAC in 2015. The first interRAI-LTCF assessment is required to be completed within 21 days of admission to RAC. Follow up assessments are completed at 6-monthly intervals (routinely) and when the person requires a different level of care due to a permanent and stable (as possible) change in their condition [57]. InterRAI-LTCF assessments are conducted exclusively by trained health professionals who complete an annual competency review to maintain interrater reliability [58]. Designed to evaluate people's needs, strengths and preferences interRAI-LTCF provides health professionals with outcome scales and Clinical Assessment Protocols (CAPS) to assist with long-term care planning [59]. The interRAI-LTCF was not intended to provide information about acute deterioration.

All data used in this study were deidentified at source and trace back to individuals was not possible. Ethical approval was provided by The University of Auckland Human Ethics Committee (024202). The Strengthening the REporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for Reporting Observational studies were followed [60].

5.2 | Study Participants

Our cohort included all people who died and had their death registered in Aotearoa NZ from 1 January to 31 December 2015 (inclusive), who lived RAC, were aged 65 years or older, and who had a completed interRAI-LTCF assessment in the last 12 months of life. Those making use of RAC without an interRAI-LTCF assessment, with an incomplete interRAI-LTCF assessment or younger than 65 years of age were excluded.

5.3 | Defining the Dependant Variable: Acute Deterioration

The research cohort was created from a combination of nationally available health administration data sets that enabled 'deterioration' to be defined in the data as ED presentation or admission to hospital or death. Conceptually, 'acute deterioration' is a rapidly changing (decline) in health status that without intervention may result in complication or death. The interRAI-LTCF was not intended to assess acute deterioration however it does contain data from the cognitive, behavioural, functional and physical health domains that determine a person's overall wellbeing. It was reasoned that an interRAI-LTCF assessment completed 'close to' a deterioration event may have unintentionally captured a clinical picture of acute deterioration. 'Close to' was determined to be a period of 7 days after the assessment. Clinical judgement was used to set this observation window and is an approach consistent with other RAC studies [44, 49]. The final 'acute deterioration' dependant variable for analysis was defined as any ED presentation or admission to hospital or death that occurred 7 days or less after the last completed interRAI-LTCF assessment.

5.4 | Independent Variable Selection Interrai-LTCF

The interRAI-LTCF has an extensive range of individual cognitive, behavioural, functional and physical assessment points. Selection of independent variables from interRAI-LTCF was determined by matching them to clinical indicators of acute deterioration reported in the literature. First, a list of clinical indicators was produced from the international evidence [18, 19] then, variables available in interRAI-LTCF were matched with those clinical indicators (Table 1). Variable matching was completed independently by senior clinicians who practice in RAC (a geriatrician & two gerontology nurse practitioners). Matched variable lists were compared, and differences were resolved by discussion to minimise bias. Matching was based on clinical judgement and Australasian frailty index research [61]. Where multiple potential independent variables were available (e.g., activities of daily living measures) authors selected variables that were readily observable by HCAs in day-to-day practice. Forty-five independent variables from the interRAI-LTCF were

matched with clinical indicators of acute deterioration reported in the literature.

Where there were no exact matches, but the indicator was clinically important, e.g., a change in the level of consciousness (LOC) the best available variable was selected. In this case, iS3 'time asleep during the day' had two outcome levels 'asleep most of the time, but some periods awake and alert' and 'largely asleep or unresponsive' that approximated changed consciousness levels. Each variable selected for analysis from interRAI-LTCF had a number of outcome levels increasing in severity, for example, 'dyspnoea' outcome levels ranged from 'absent' to the most severe 'present at rest'. This study focused on acute events and researchers hypothesised that the most severe outcome levels were the most likely to be associated with acute deterioration. However, variables selected from interRAI-LTCF were not transformed for the analysis. Table 1 (column 2) identifies the variables and column three the outcome levels of most interest to this study, a complete list of outcome levels can be found in Supporting Information File A. There were no variables in interRAI-LTCF that could be reasonably matched to, 'abnormal vital signs', having 'slowed movement' and 'seeming different to usual' all clinical indicators of acute deterioration reported in the literature.

The interRAI-LTCF has a large selection of composite measures such clinical rating scales, CAPs and health status indicators that predict risk and support care planning. Composite scales and protocols were not considered as candidates for independent variables as they cannot be directly observed as a single item by the healthcare team in day-to-day clinical practice. Individuals with advance directives were not treated separately in the analysis as the focus of this study is to identify acute deterioration regardless of the treatment decision.

5.5 | Statistical Analysis

Initial exploration of interRAI-LTCF variables was conducted using STATA SE version 13.1, from StataCorp and a summarised extract was provided for further analysis using IBM SPSS Statistics for Windows, Version 28.0 (IBM Corp. Armonk, NY, USA). Statistical analysis was used to describe the association between the independent variables (matched interRAI-LTCF clinical variables) and ED presentation or hospital admission or death occurring 7 days or less from the date of the last completed interRAI-LTCF, from now referred to as 'acute deterioration'. Demographic information was assessed using descriptive statistics (Chi-Squared). Univariate logistic regression assessed the association between the acute deterioration and each interRAI-LTCF variable. A p value ≤ 0.05 was considered to indicate statistical significance and unadjusted odds ratios (OR) and their 95% confidence intervals (CI) identified the strength of that association. All interRAI-LTCF variables with a p value ≤ 0.05 and a 95% confidence interval for an OR that did not include one were entered into a multivariable forward stepwise logistic regression. The variables included in the regression model were assessed for multicollinearity using variance inflation factor. A two-sided p value ≤ 0.05 was considered statistically significant. Adjusted OR and their 95% CI were reported to consider the strength of association.

6 | Results

A total of 5372 individuals who died in 2015 were identified for this study. Excluded from the analysis were 134 individuals because 107 were aged under 65 years and 27 had incomplete data. Final study cohort included 5238 individuals aged 65 to 107 years (Figure 1) of whom 62% ($n = 3238$) were female, mean (SD) age was 86.6 (7.4) years, and ages ranged from 65 to 107 years (Table 2). Most people ($n = 4906$, 94%) identified as NZ European and 4% ($n = 185$) identified as Māori (Indigenous New Zealanders). These proportions of gender, age, and ethnicity are consistent with currently reported population distributions in RAC in Aotearoa NZ [62]. Overall, 531 people (10% of the cohort) experienced acute deterioration. There were no significant demographic differences between those who met the definition of acute deterioration and those who did not.

6.1 | Univariate Analysis

Of the 45 interRAI-LTCF variables that were matched to the clinical indicators of acute deterioration reported in the literature, 40 had a statistically significant association with acute deterioration at the outcome level of interest. Table 3 presents these variables in cognitive, behavioural, functional and physical health domains that are consistent with the definition of acute deterioration in older people living in RAC. Odd ratios compare the 531 people who experienced acute deterioration with the rest of the cohort.

In the cognitive domain, level of consciousness and mental status variables had the greatest odds ratios. InterRAI-LTCF variable, 'time asleep during the day: largely asleep or unresponsive' (proxy for level of consciousness) had an OR of 28.91 (95% CI: 18.34–43.63, $p < 0.001$). This was followed by

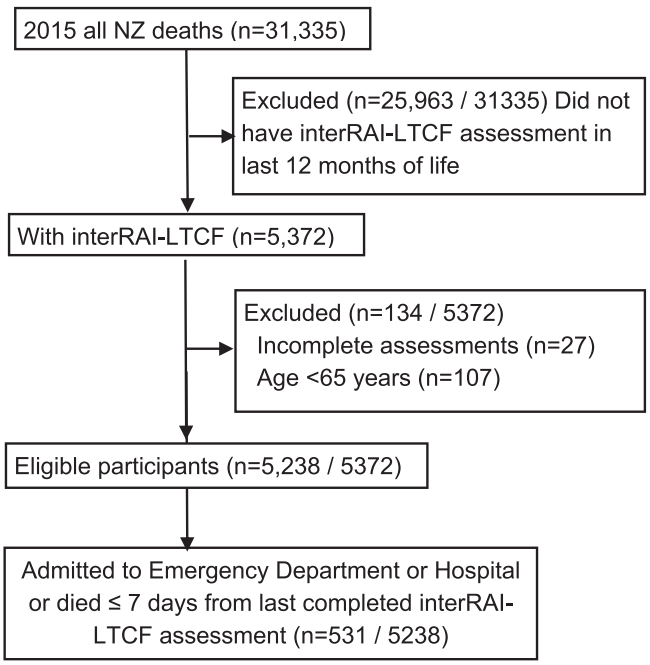

FIGURE 1 | Study participant flow chart. Selection of study cohort from existing data set.

TABLE 2 | Cohort characteristics.

Variable	Number residents (%)	
	Number	(%)
Overall	5238	(100)
Gender		
Female	3238	(61.8)
Male	2000	(38.2)
Age (y)		
65–69	124	(2.4)
70–74	266	(5.0)
75–79	491	(9.4)
80–84	930	(17.6)
85–89	1449	(26.7)
90–94	1316	(25.1)
95–104	656	(12.5)
≥ 105	6	(0.1)
Ethnicity		
NZ European	4906	(93.7)
Maori	185	(3.5)
Asian	79	(1.5)
Pacific	68	(1.3)

being, 'easily distracted: different to usual' (OR: 3.45, 95% CI: 2.56–4.50, $p < 0.001$) having an 'acute change in mental status' (OR: 3.30, 95% CI: 2.69–4.03, $p < 0.001$) and a 'mental fluctuation: different to usual' (OR: 2.36, 95% CI: 1.83–3.05, $p < 0.001$).

Eating and drinking variables predominated in the behavioural domain. Eating 'one or fewer meals a day' (OR: 4.53, 95% CI: 3.70–5.59, $p < 0.001$) having a 'decrease in food or fluid intake' (OR: 3.15, 95% CI: 2.63–3.79, $p < 0.001$) and being 'dehydrated' (OR: 4.44, 95% CI: 3.27–6.14, $p < 0.001$) were most highly correlated with acute deterioration.

Functionally, having a 'decline in activities of daily living status (ADL)' and 'toilet transfer that did not occur' in the 3 days preceding the assessment was the most notable, (OR: 4.17, 95% CI: 2.32–7.50, $p < 0.001$; OR: 5.09, 95% CI: 3.64–7.11, $p < 0.001$). Physically, having 'fatigue: daily impact' on routine activities (OR: 4.74, 95% CI: 3.60–6.23, $p < 0.001$) and experiencing 'dyspnoea: at rest' (OR: 2.84, 95% CI: 2.18–3.70, $p < 0.001$) were highly correlated with acute deterioration.

6.2 | Acute Deterioration Multivariable Analysis

The multivariable analysis (Table 4) produced a list of nine interRAI-LTCF variables that had a statistically significant relationship with the acute deterioration at the outcome level of interest. Multivariable regression assumptions were met and the maximum variance inflation factor was 1.32 (between change in ADL status & daily pain) suggesting overall multicollinearity was unlikely to be a confounding factor [63]. There was at least one variable from each heath domain, supporting the definition of acute deterioration. The consciousness variable 'time asleep during the day: largely asleep or unresponsive' conferred an eight-fold increase in odds of acute deterioration (OR: 7.95, 95% CI: 4.72–13.39, $p < 0.001$) and 'easily distracted: different to usual' (OR: 1.78, 95% CI: 1.28–2.49, $p < 0.001$) continued to feature. The behavioural domain included eating 'one or fewer meals a day' (OR: 2.13, 95% CI: 1.67–2.73, $p < 0.001$). Functionally a 'change in ADL status: declined' (OR: 2.06, 95% CI: 1.11–3.82, $p = 0.02$) and a 'toilet transfer that did not occur' in the 3 days preceding the interRAI-LTCF assessment (OR: 1.95, 95% CI: 1.24–3.03, $p = 0.004$) doubled the odds of acute deterioration. While all the physical variables had lower ORs, that is 'dyspnoea: at rest' (OR: 1.81, 95% CI: 1.32–2.49, $p < 0.001$) having 'falls: two or more in the last 30 days' (OR: 1.53, 95% CI: 1.15–2.03, $p = 0.003$) or 'peripheral oedema: daily' (OR: 1.37, 95 CI: 1.07–1.77, $p = 0.014$) and 'pain frequency: daily' (OR: 1.37, 95% CI: 1.05–1.77, $p = 0.019$). Clinical indicators and outcome levels that did not reach statistical significance can be found in Supporting Information File B.

6.3 | Sensitivity Analysis

The odds ratio for 'time asleep during the day: largely asleep or unresponsive' was considerably higher than the other variables in both univariate and multivariate analysis. Removing this variable and repeating the analysis did not substantially change the results. As a change in level of consciousness is a key clinical indicator reported in the literature and this study is focused on acute deterioration this variable was retained in the final model. Comparison of analysis with and without sleep variable can be found in Supporting Information File B.

7 | Discussion

Using routinely collected health data, this study confirmed that the clinical indicators of acute deterioration described in the literature were correlated with ED presentation or hospitalisation or death within 7 days of the last completed interRAI-LTCF assessment in the RAC population in Aotearoa NZ. We were also able to develop a short list of nine clinical variables that were independently associated with acute deterioration and estimate the strength of that relationship. The clinical variables included at least one from each of the health domains, aligning with the definition of acute deterioration in RAC populations [28].

This study confirmed the clinical importance of nonspecific indicators of acute deterioration as described in both ED [17, 20, 26, 29] and RAC [38, 44, 48] studies. The doubling of ORs for ED admission, hospitalisation or dying found in this study adds weight to the argument that nonspecific indicators of acute deterioration in older people [17, 20, 26, 29] should be considered red-flag presentations [24, 27]. Our study differed from ED-based studies in that weakness and fatigue were not in the final list of nine independent clinical variables associated with acute deterioration. Fatigue was eliminated during the multivariable analysis and the interRAI-LTCF database did not include weakness, so no data was available. Multivariable analysis eliminates variables with multicollinearity, and it is

TABLE 3 | Univariate analysis: clinical indicators (interRAI-LTCF) association with acute deterioration.

Clinical indicator (interRAI-LTCF)	Most severe outcome level	Rest of cohort $n = 4707$ (%)	Acute deterioration $n = 531$ (%)	Odds Ratio (95% CI), p
Cognitive domain				
Time asleep during the day	3: Largely asleep or unresponsive	36 (0.8)	73 (13.7)	28.91 (18.34, 43.63), < 0.001
Easily distracted	2: Different from usual functioning	263 (5.6)	94 (17.7)	3.45 (2.65, 4.50), < 0.001
Acute change in mental status	1: Yes	593 (12.6)	171 (32.2)	3.30 (2.69, 4.03), < 0.001
Disorganised speech	2: Different from usual	271 (5.8)	86 (16.2)	3.04 (2.32, 3.97), < 0.001
Change in decision-making	2: Declined	1524 (32.4)	294 (55.4)	2.44 (1.59, 3.72), < 0.001
Mental function varies over day	2: Different from usual functioning	398 (8.5)	98 (18.5)	2.36 (1.83, 3.05), < 0.001
Sad depressed or hopeless	3: Daily in the last 3 days	270 (5.7)	52 (9.8)	2.20 (1.59, 3.06), < 0.001
Little interest or pleasure in things you normally enjoy	3: Daily in the last 3 days	332 (7.1)	57 (10.7)	1.97 (1.44, 2.70), < 0.001
Ability to understand others	4: Rarely or never understands	313 (6.6)	58 (10.9)	1.72 (1.25, 2.38), 0.001
Behavioural domain				
Repetitive anxious complaints	3: Daily in last 3 days	267 (5.7)	36 (6.8)	1.19 (0.83, 1.71), 0.34
Anxious restless or uneasy	3: Daily in the last 3 days	368 (7.8)	64 (12.1)	2.04 (1.51, 2.75), < 0.001
Withdrawal from activities of interest	3: Daily in last 3 days	555 (11.8)	117 (22)	2.11 (1.68, 2.64), < 0.001
Reduced social interaction	3: Daily in last 3 days	719 (15.3)	152 (28.6)	2.16 (1.78, 2.66), < 0.001
Resists care	3: Daily in last 3 days	320 (6.8)	69 (13)	1.92 (1.45, 2.55), < 0.001
Persistent anger with self/others	3: Daily in last 3 days	290 (6.2)	42 (7.9)	1.06 (0.74, 1.53), 0.75
Physical abuse	3: Exhibited daily in last 3 days	86 (1.8)	15 (14.9)	1.55 (0.89, 2.71), 0.121
One or fewer meals a day	1: Yes	490 (10.4)	183 (34.5)	4.53 (3.70, 5.59), < 0.001
Decrease in food or fluid	1: Yes	1000 (21.2)	244 (46)	3.15 (2.63, 3.79), < 0.001
Dehydrated	1: Yes	135 (2.9)	62 (11.7)	4.48 (3.27, 6.14), < 0.001
Fluid intake reduced	1: Yes	528 (11.2)	158 (29.8)	3.35 (2.73, 4.12), < 0.001
Functional				
Dressing upper body	6: Total dependence	1135 (24.1)	190 (35.8)	2.33 (1.55, 3.50), < 0.001
Personal hygiene	6: Total dependence	1177 (25)	199 (37.5)	2.77 (1.88, 4.21), < 0.001
Toilet transfer	8: Did not occur during entire period	268 (5.7)	95 (17.9)	5.09 (3.64, 7.11), < 0.001
Change in ADL status	2: Declined	2193 (46.6)	393 (74)	4.17 (2.32, 7.50), < 0.001
Walking	8: Did not occur during entire period	1332 (28.3)	221 (41.6)	2.57 (1.87, 3.53), < 0.001

(Continues)

TABLE 3 | (Continued)

Clinical indicator (interRAI-LTCF)	Most severe outcome level	Rest of cohort $n = 4707$ (%)	Acute deterioration $n = 531$ (%)	Odds Ratio (95% CI), p
Physical domain				
Fatigue: inability to complete normal daily activities	4: Unable to commence any normal day-to-day activities	459 (9.8)	137 (25.8)	4.74 (3.60, 6.23), < 0.001
Pain frequency	3: Exhibited daily in last 3 days	843 (17.9)	168 (31.6)	2.23 (1.78, 2.80), < 0.001
Pain intensity	4: Horrible or excruciating at times	81 (1.7)	18 (3.4)	2.58 (1.52, 4.38), < 0.001
Pain consistency	3: Constant	221 (4.7)	52 (9.8)	2.77 (1.99, 3.86), < 0.001
Break through pain	1: Yes	570 (12.1)	110 (20.7)	1.88 (1.50, 2.36), < 0.001
Constipation	4: Exhibited daily in last 3 days	143 (3)	39 (7.3)	2.41 (1.66, 3.51), < 0.001
Diarrhoea	4: Exhibited daily in last 3 days	50 (1.1)	6 (1.1)	1.06 (0.45, 2.49), 0.89
Bladder continence	5: Incontinent	1342 (28.5)	185 (34.8)	1.72 (1.29, 2.29), < 0.001
Bowel continence	5: Incontinent	1035 (22.0)	156 (29.4)	1.53 (1.23, 1.93), < 0.001
Weight loss	1: Yes	859 (18.2)	152 (28.6)	1.80 (1.47, 2.20), < 0.001
Peripheral oedema	4: Exhibited daily in last 3 days	732 (15.6)	126 (23.7)	1.81 (1.45, 2.25), < 0.001
Falls	3: Two or more falls in last 30 days	587 (12.5)	108 (20.3)	2.05 (1.61, 2.62), < 0.001
Difficulty standing	4: Exhibited daily in last 3 days	2396 (50.9)	314 (59.1)	1.52 (1.24, 1.85), < 0.001
Problem frequency dizziness	4: Exhibited daily in last 3 days	153 (3.3)	35 (6.6)	2.13 (1.46, 3.12), < 0.001
Most severe pressure ulcer	5: Not codable	27 (0.6)	10 (1.7)	3.16 (1.48, 6.77), 0.003
Skin tear	1: Yes	632 (13.4)	90 (16.9)	1.32 (1.32, 1.68), 0.026
Dyspnoea	3: Present at rest	336 (7.1)	87 (16.4)	2.84 (2.18, 3.70), < 0.001
Problem frequency - fever	4: Exhibited daily in last 3 days	6 (0.1)	4 (0.8)	6.19 (1.74, 22.00), 0.005
Urinary tract infection	2: Receiving active treatment	241 (5.1)	43 (8.1)	1.69 (1.20, 2.37), 0.002

TABLE 4 | Multivariable analysis; clinical indicators independently associated with acute deterioration.

Variable	Outcome level	Rest of cohort $n = 4707$ (%)	Acute Deterioration[a] cohort $n = 531$ (%)	Odds Ratio (95% CI), p
Cognitive domain				
Time asleep during the day	3: Largely asleep or unresponsive	36 (0.8)	73 (13.7)	7.95 (4.72, 13.39), < 0.001
Easily distracted	2: Different from usual functioning	263 (5.6)	94 (17.7)	1.78 (1.28, 2.49), < 0.001
Behavioural domain				
One or fewer meals a day	1: Yes	490 (10.4)	183 (34.5)	2.13 (1.67, 2.73), < 0.001
Functional domain				
Change in ADL status	2: Declined	2193 (46.6)	393 (74)	2.06 (1.11, 3.82), 0.02
Toilet transfer	8: Did not occur during entire period	268 (5.7)	95 (17.9)	1.95 (1.24, 3.03), 0.004
Physical domain				
Dyspnoea	3: Present at rest	336 (7.1)	87 (16.4)	1.81 (1.32, 2.49), < 0.001
Pain frequency	3: Exhibited daily in last 3 days	587 (12.5)	108 (20.3)	1.53 (1.15, 2.03), 0.003
Falls	3: Two or more falls in last 30 days	732 (15.6)	126 (23.7)	1.37 (1.07, 1.77), 0.014
Oedema	3: Exhibited on 2 of last 3 days	26 (0.6)	7 (1.3)	2.50 (1.01, 6.14), 0.047
Oedema	4: Exhibited daily in last 3 days	843 (17.9)	168 (31.6)	1.37 (1.05, 1.77), 0.019

[a]Defined as Emergency Department presentation, hospitalisation or death ≤7 day for last completed interRAI-LTCF assessment

possible in an RAC cohort that a decline in ADL status is a consequence of fatigue.

The acute deterioration variable in this study included death was well as hospital transfers and this likely explains why our ORs are higher than the ORs reported in the RAC studies that focus on hospitalisations and ED presentations [32]. The inclusion of death in the dependent variable of this study was deliberate and has added some information to the evidence describing the presentation of end-of-life in the population living with frailty [64]. However, further studies focusing exclusively on clinical indicators associated with dying for people living with frailty would be needed to draw robust conclusions. It was beyond the scope of this study to consider the consumer perspective on the separate outcomes of hospitalisation versus ED presentation versus death however this would be an interesting area of further study.

It is important to acknowledge that this study used interRAI-LTCF as a research data set not as a clinical practice tool. In practice, the interRAI-LTCF contains validated scales, such as Changes in Health, End-stage disease Signs and Symptoms (CHESS) that are designed to identify people with an increased risk of dying in the near future [65]. This does encourage advance care planning (ACP) conversations that are important in the event of acute deterioration. However, regardless of ACP, the identification of acute deterioration is the first step in accessing a medical evaluation of the presenting condition which may or may not be reversible. In RAC, it is the HCA who is most likely to notice changes of condition that could be acute deterioration [31, 54]. That no special equipment is required to observe the clinical indicators identified in this study makes them ideal for HCAs to assess during routine care [18]. Furthermore, indicators of acute deterioration that can be 'measured' unobtrusively have the potential to be incorporated into clinical practice without disturbing the home-like ideology of RAC [66].

One advantage of a small final model (nine variables) is that in time-pressured health care environments, quick-to-assess shortlists are more likely to be translated into day-to-day practice [67]. Coupled with education and support from responding health professionals this has the potential to maximise the use of the healthcare workforce in identifying acute deterioration.

To the best of our knowledge, this is the first study of its kind to draw on interRAI-LTCF data in this way. Using routinely collected health data from an internationally available data set (interRAI-LTCF) means this study could be replicated in other localities and may validate these findings. This novel use of the data has provided first-step evidence for the future development of a tool or tools to support RAC staff with the identification of acute deterioration.

8 | Limitations

This analysis is based on retrospective cross-sectional data from an existing data set. Use of InterRAI-LTCF data in a cross-sectional manner means that, other than 'decline in ADL status' and 'easily distracted; different to usual' it is unknown whether these indicators represent a change in the person's baseline health status. Prospective analysis of several assessments for the same individual would be needed to assess this and was not possible in the data set used for this study. The available data set included everyone living in RAC in NZ in who died in 2015, this is not the complete RAC population. Further, study with the complete NZ RAC population and prospective methodology and would improve the reliability and generalisability of results.

The use of interRAI-LTCF was mandated for use in NZ in July 2015 and although a rolling implementation was happening, implementation was not complete and some data is likely to be missing. Furthermore, some consumers withhold consent for use of their data, although this number is not reported so remains unknown. The older nature of the available data means characteristics of the current RAC population may differ from those in this study.

The selection of independent variables for analysis by matching clinical indicators of acute deterioration reported international literature with interRAI-LTCF variables called for clinical judgement. Although this was completed by three senior clinicians with experience in RAC and was based on Australasian frailty research this process was open to bias. Similarly, the 7-day observational window labelled 'acute' was based on a 'clinically reasonable' period and may have missed important developments that occurred on day eight. InterRAI-LTCF data is not intended to be used to identify variables associated with acute deterioration. Consequently, variables that may have been useful for this purpose, such as vital signs and 'weakness', could not be assessed. Also, while interRAI-LTCF assessments are completed by trained assessors to ensure interrater reliability, this requirement has led to some assessors being specially contracted to complete assessments. There is the potential for error in the collected data due to assessments by staff who are unfamiliar with residents.

Finally, it is important to remember that cohort studies report association, it is not possible to infer casual effects from these results.

9 | Conclusion

With the exception of vital signs, we confirmed that the majority of clinical indicators of acute deterioration reported in the literature are correlated with ED presentation, hospitalisation, and death in the last year of life in the Aotearoa NZ RAC population. Furthermore, we found a short list of nine clinical indicators that were independently associated with those outcomes and increased the odds of occurrence by between 1.4 and 8 times. The observable nature of those clinical indicators means there is potential to use them in practice without disturbing the home-like experience of people living in RAC. Healthcare assistants in particular are ideally placed to monitor people for the presence of these indicators as an early warning of possible acute deterioration. This evidence is a first step towards the future development of tools to support residential aged care staff with the identification of acute deterioration.

Author Contributions

All authors meet the criteria for authorship stated in the Uniform Requirements for Manuscripts Submitted to Biomedical Journals.

Authors specific contributions were, study concept and design. J.F.D., and M.K.B. Acquisition of data and preliminary analysis, H.M. Analysis and interpretation of data: Z.W., H.M., J.F.D., M.K.B., V.B., and K.B. Drafting of the manuscript, J.F.D. and critical revision of the manuscript for important intellectual content and approval of final manuscript J.F.D., M.K.B., V.B., Z.W., H.M., J.R., and K.B.

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Ethics Statement

Ethical approval was provided by The University of Auckland Human Ethics Committee (024202).

Consent

This is a cohort study used national routinely collected health data. Individual informed consent from the competent individual or their Enduring Power of Attorney for personal care and welfare (legal representative) for the use of deidentified routinely collected health data, is obtained at the point of data collection. The de-identification of data used in this study was undertaken at source (before it was received by researchers) and trace back to individuals via the data was not possible.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data may be obtained from a third party and are not publicly available. Any data made available to other parties upon reasonable request would need ethics approval from the New Zealand Health and Disability Ethics Committees (https://ethics.health.govt.nz) and the prior consent of all the primary data sources, which for this project would include Te Whatu Ora (Ministry of Health) (data-enquiries@health.govt.nz) and interRAI (interRAI.Data@tas.health.nz). Contact corresponding author for data requests related to this study.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.