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Review

The FRAIL-NH Scale: Systematic Review of the Use, Validity and Adaptations for Frailty Screening in Nursing Homes

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Abstract

OBJECTIVES: To investigate frailty prevalence, cross-sectional associations, predictive validity, concurrent validity, and cross-cultural adaptations of the FRAIL-NH scale.

DESIGN: Systematic review.

SETTING AND PARTICIPANTS: Frail residents living in nursing homes.

METHODS: MEDLINE, EMBASE, CINAHL, and Cochrane Library were searched from January 2015 to June 2021 for primary studies that used the FRAIL-NH scale, irrespective of study designs and publication language.

RESULTS: Overall, 40 studies conducted across 20 countries utilized the FRAIL-NH scale; majority in Australia (n=14), followed by China (n=6), United States (n=3), and Spain (n=3). The scale has been translated and back-translated into Brazilian Portuguese, Chinese, and Japanese. Various cut-offs have been used, with ≥2 and ≥6 being the most common cut-offs for frail and most frail, respectively. When defined using these cut-offs, frailty prevalence varied from 15.1-79.5% (frail) to 28.5-75.0% (most frail). FRAIL-NH predicted falls (n=2), hospitalization or length of stay (n=4), functional or cognitive decline (n=4), and mortality (n=9) over a median follow-up of 12 months. FRAIL-NH has been compared to 16 other scales, and was correlated with Fried's phenotype (FP), Frailty Index (FI), and FI-Lab. Four studies reported fair-to-moderate agreements between FRAIL-NH and FI, FP, and the Comprehensive Geriatric Assessment. Ten studies assessed the sensitivity and specificity of different FRAIL-NH cut-offs, with ≥8 having the highest sensitivity (94.1%) and specificity (82.8%) for classifying residents as frail based on FI, while two studies reported an optimal cut-off of ≥2 based on FI and FP, respectively.

CONCLUSION: In seven years, the FRAIL-NH scale has been applied in 20 countries and adapted into three languages. Despite being applied with a range of cut-offs, FRAIL-NH was associated with higher care needs and demonstrated good agreement with other well-established but more complex scales. FRAIL-NH was predictive of adverse outcomes across different settings, highlighting its value in guiding care for frail residents in nursing homes.

Key words: FRAIL-NH, frailty, frail older adults, nursing homes, residential facilities.

Introduction

Frailty is a potentially reversible state of health characterized by decreased physiological reserve and increased vulnerability to adverse outcomes including falls, hospitalization and mortality (1-6). The pooled prevalence estimates of frailty are 10.7% in community settings (7), and 52.3% in nursing home (NH) settings (8). The International Association of Gerontology and Geriatrics has advocated for increased research in NHs (9). Timely identification of residents who are frail or at risk of frailty may assist with early implementation of interventions to prevent adverse outcomes, as well as improve care planning and resource use. There is emerging evidence that residents who are frail are more susceptible to adverse drug events (ADEs) and therefore have a different benefit-to-risk ratio for long-term preventative medications (10-12). Additionally, assessing residents' frailty status may facilitate timely advance care planning and provision of palliative services to avoid unnecessary hospitalization and exposure to futile interventions at the end of life (13).

Currently, there is no international gold standard for screening or diagnosing frailty in NHs. Despite the plethora of frailty tools available, most have been developed for use in community or clinical settings (14). Fried's phenotype (FP) (15) and the Frailty Index (FI) (16) remain among the most commonly used diagnostic measures but are challenging to administer in NHs. The FRAIL-NH scale is a 7-item screening tool specifically designed for NHs (17). It includes domains related to potentially reversible variables including: fatigue; resistance; ambulation; incontinence or illness; loss of weight; nutritional approach; and help with dressing (17). Each item is assigned a score of up to 2 points, generating a total score of 0 (non-frail) to 14 (most frail) (17). The FRAIL-NH scale is gaining popularity but no reviews have critically evaluated the literature on the use of the scale. The aim of this systematic review was to investigate the use, validity and adaptations of the FRAIL-NH scale.

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Table 1. Characteristics of Included Studies

Author, Year	Country	Study Description	Year(s) of Data Collection	Setting	Study Sample	Mean Age ± SD	Female, %
Archibald, 2020 (21, 34)	Australia	Interpretive descriptive qualitative study	2017	2 NHs	17*	-	-
Buckinx, 2018 (53)	Belgium	Baseline and 1-year follow-up analysis of SENIOR study	2013	28 NHs	662	83.2 ± 9.0	73
Chen, 2019 (22); Dugré, 2021 (32); Sharma, 2021 (33); Sluggett, 2020 (27, 28)	Australia	Cross-sectional analyses of baseline and 12-month follow-up data from SIMPLER RCT	2017	8 NHs	242	86	74
Chong, 2021 (52)	Singapore	Secondary analysis of a prospective cohort study	2015	1 HD	210	89.4 ± 4.6	70
Chu, 2021 (54)	Canada	Cross-sectional analysis of baseline data from a development study	2018-2019	2 NHs	13†	83.23	62
Contreras Escámez, 2020 (41)‡	Spain	Longitudinal cohort study	2015-2018	2 NHs	110	86.3 ± 7.3	72
de Barros, 2021 (48)	Brazil	Cross-sectional seroepidemiological study	2020	15 NHs	209	Median 81	65
De Silva, 2018 (56)	France	Baseline and 1-year follow-up analysis of INCUR study	2012	13 NHs	788	86.2 ± 7.5	75
Ga, 2018 (59)	South Korea	Retrospective review of medical records	2011-2017	1 LTCH	100	Male 76.5 ± 8.0 Female 81.5 ± 7.2	47
Ge, 2019 (35-37)§	China	Cross-sectional study	2018	6 NHs	302	82.7 ± 8.5	71
Greco, 2021 (58)	Italy	Nested case-control study	2019-2020	2 NHs	152	85.3 ± 7.3	74
Gutiérrez-Valencia, 2018 (42); Martínez-Velilla, 2017 (43)	Spain	Cross-sectional analyses of baseline data from a longitudinal cohort study	2015	2 NHs	110	86.3 ± 7.3	72
Hendrix, 2019 (23); Theou, 2016 (29); Wang, 2021 (31)	Australia	Cross-sectional analyses of baseline data from a prospective cohort study	2014	6 NHs	383	87.5 ± 6.2	78
Ho, 2020 (51)	Singapore	Retrospective review of case records	2015	1 HD	189	84.3 ± 8.6	57
Jadczak, 2021 (24)	Australia	Cross-sectional analysis of baseline data from FIRST study	2019-2020	12 NHs	561	87.7 ± 7.3	73
Kaehr, 2016 (44)	US	Retrospective study using MDS & chart review	2014	2 NHs	270	-	76
Kerry, 2020 (25)	Australia	Secondary analysis of a prospective cohort study	2014	6 NHs	239	88.1 ± 6.3	79
Korhonen, 2018 (26); Theou, 2018 (30)	Australia	Prospective cohort study	2014	6 NHs	383	87.5 ± 6.2	78
Little, 2021 (46)	US	Descriptive observational study	2016-2017	2 NHs	247	-	72
Luo, 2015 (57)	Hong Kong	Longitudinal follow-up study	2005-2013	6 NHs	2380	82.8 ± 8.1	68
Papadopoulos, 2021 (50)	England & Japan	Baseline cross-sectional screening for resident eligibility in CARESSES RCT	2019	9 NHs	33	81.9 ± 9.8	67
Peng, 2020 (60)	Taiwan	Cross-sectional study	-	1 NH	34	83.9 ± 10.8	53
Sakata, 2021 (49)‖	Japan	Methodological study	-	-	-	-	-
Si, 2020 (38)	China	Cross-sectional study	2015-2016	23 NHs	305	79.3 ± 8.4	57
Vasconcellos Romanini, 2020 (47)	Brazil	Longitudinal cohort study	2018	6 NHs	293	80.3 ± 8.8	65
Villani, 2021 (55)	Europe & Israel	Cross-sectional analysis of baseline data from SHELTER study	2009-2011	57 NHs	4121	84.6 ± 9.2	76
Yang, 2018 (39)	China	Prospective study	2016-2017	4 NHs	329	85.2 ± 3.4	68
Yuan, 2021 (45)	US	Retrospective longitudinal study	2014-2016	15,551 NHs	571,139	82.5 ± 8.5	67
Zhao, 2020 (40)	China	Methodological and cross-sectional study	2018	27 NHs	353	79.0 ± 8.8	56

CARESSES, Culture-Aware Robots and Environmental Sensor Systems for Elderly Support; FIRST, Frailty In Residential Sector over Time; HD, hospital department; INCUR, Incidence of Pneumonia and Related Consequences in Nursing Home Residents; LTCH, long-term care hospital; MDS, Minimum Data Set; NH, nursing home; RCT, randomized controlled trial; SD, standard deviation; SENIOR, Sample of Elderly Nursing home Individuals: an Observational Research; SHELTER, Services and Health for Elderly in Long TERm care; SIMPLER, SImplification of Medications Prescribed to Long-tErm care Residents; US, United States; *17 NH residents of 39 participants; †13 NH residents of 28 participants; ‡Spanish publication §Chinese publication (36); ‖Japanese publication

Methods

The systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (18). The review protocol was published on PROSPERO (CRD42020185159) (19).

Search Strategy

MEDLINE, EMBASE, CINAHL, and Cochrane Library were searched from January 2015, when the FRAIL-NH scale was first published, to June 2021 (Supplement 1). For the purpose of this review, the term NH was considered synonymous with long-term care facilities and residential aged care services. Where relevant conference abstracts were identified, an author and title search were conducted to locate potential full-text articles. Reference lists of included articles were screened for additional relevant studies. A keyword search was conducted on PubMed and Google Scholar to identify additional studies.

Study Selection

Title and abstract screening were performed by two independent investigators (SJL, LAD), followed by a full-text review. Primary studies using the FRAIL-NH scale were eligible for inclusion. Although FRAIL-NH was developed for use in NHs, studies using FRAIL-NH in other settings including hospitals were not excluded. Non-primary studies (e.g. literature reviews) and studies that did not use the FRAIL-NH scale were excluded. There were no restrictions on study designs and publication language. For non-English studies, the original authors and/or bilingual researchers were contacted to extract data in English.

Data Extraction

Data extraction was performed independently by the same two investigators using a standardized table. Data extracted included study design, country, setting, and resident characteristics. The following FRAIL-NH data were extracted: cut-off points, prevalence, cross-sectional associations, predictive validity, concurrent validity, and adaptations. All study outcomes and variables that assessed for a relationship with FRAIL-NH were recorded. Cross-sectional associations examined the relationship between frailty and other variables of interest in the population. Predictive validity was defined as the ability of FRAIL-NH scores to predict health outcomes. Concurrent validity assessed the performance of FRAIL-NH in comparison to other scales. Cross-cultural adaptations were defined as translations and validations of FRAIL-NH for use in different linguistic, cultural and geographical regions. Authors were contacted in the event of missing data.

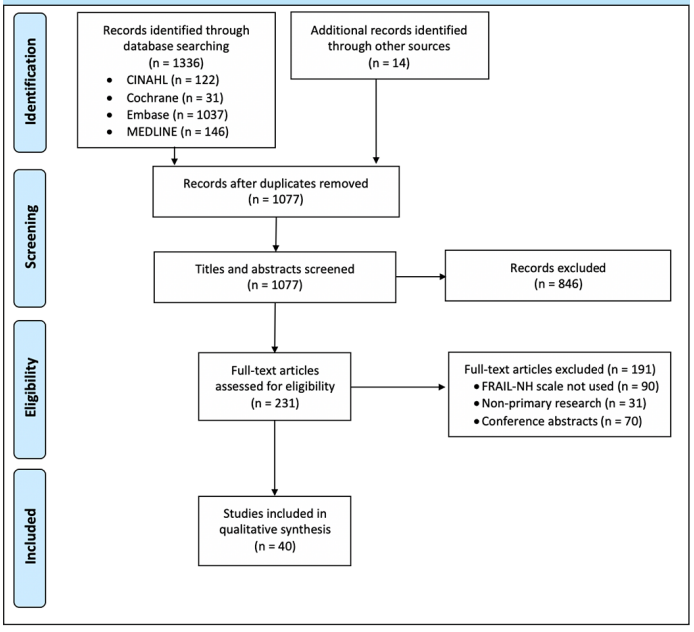
Quality Assessment

Quality assessment was conducted independently by the same two investigators using adapted versions of the Joanna Briggs Institute checklists for analytical cross-sectional studies and cohort studies (Tables S1 to S4) (20). The checklists were used to appraise the quality of how frailty was assessed using the FRAIL-NH scale (i.e. not the overall quality of study), irrespective of whether frailty was the primary focus of these studies. FRAIL-NH was deemed to be measured in a valid and reliable way where clear descriptions of FRAIL-NH application, or how FRAIL-NH was computed from other valid datasets were provided. Quality assessment was not applicable to studies that did not investigate cross-sectional associations or longitudinal outcomes according to frailty status. Any disagreements were resolved by discussion with additional investigators (JSB, SL).

Results

A total of 1,350 studies were retrieved, of which, 40 studies applied the FRAIL-NH scale (Figure 1). Studies were published in English (n=37), Chinese (n=1), Japanese (n=1), and Spanish (n=1) (Table 1).

Figure 1. PRISMA flow diagram of literature search and study selection



Study and Resident Characteristics

The FRAIL-NH scale was applied in studies across 20 countries; the majority in Australia (n=14) (21-34), followed by China (n=6) (35-40), Spain (n=3) (41-43), United States (US) (n=3) (44-46), Brazil (n=2) (47, 48), Japan (n=2) (49, 50), Singapore (n=2) (51, 52), Belgium (n=1) (53), Canada (n=1) (54), England (n=1) (50), Europe and Israel (n=1) (55), France (n=1) (56), Hong Kong (n=1) (57), Italy (n=1) (58), South

Table 2. Characteristics of FRAIL-NH, Frailty Prevalence, and Cross-Sectional Associations with Frailty

Author, Year	Mean FRAIL-NH Score	FRAIL-NH* Cut-Off (Frailty Prevalence, %)	Cross-Sectional Associations
Archibald, 2020 (21, 34)	-	Non-frail 0-1; Frail 2-5; Most frail 6-14	-
Buckinx, 2018 (53)	-	Non-frail 0-6; Frail 7-14	-
Chen, 2019 (22); Dugré, 2021 (32); Sharma, 2021 (33); Sluggett, 2020 (27, 28)	Median 7, IQR 3-10	Non-frail 0-1; Frail 2-5; Most frail 6-14	• Frailty was associated with multiple medication administration times (OR 1.13, 95% CI 1.03–1.24) and MRCI score (OR 1.26, 95% CI 1.13–1.41) (22). • Among residents prescribed pro re nata (PRN) medication(s) at baseline, frailty was associated with PRN medication administration (OR 1.10, 95% CI 1.02-1.18) (33).
Chong, 2021 (52)	6.5 ± 4.6	Non-frail 0-1 (20.5); Frail 2-14 (79.5)	• FRAIL-NH was associated with greater comorbidities, functional dependence, and cognitive impairment (dementia, delirium) (p<0.05).
Chu, 2021 (54)	3.6 ± 2.4	Non-frail 0-5 (61.5); Pre-frail 6-7 (38.5); Frail 8-14 (0)	-
Contreras Escámez, 2020 (41)	6.2 ± 5.4	Non-frail 0-1 (29.1); Frail 2-14 (70.9)	-
de Barros, 2021 (48)	-	Robust 0-1 (27.8); Pre-frail 2-5 (29.7); Frail 6-14 (42.6)	-
De Silva, 2018 (56)	6.0 ± 3.4	Non-frail 0-1 (11.2); Frail 2-5 (34.6); Most frail 6-14 (54.2)	• FRAIL-NH was correlated with age (r=0.141, p<0.001). • Women were frailer than men (p=0.027).
Ga, 2018 (59)	10.0 ± 2.0	Less frail 0-10 (51.0); More frail 11-14 (49.0)†	• MMSE score was lower in the more frail than the less frail group (p=0.048).
Ge, 2019 (35)	4.1 ± 3.7	Non-frail 0-1.4 (30.5); Frail 1.5-7.4 (48.0); Frailest 7.5-14 (21.5)	• Multimorbidity and poor self-reported health were associated with the frail and frailest categories, while age was only associated with the frailest category.
Ge, 2019 (36)	4.1 ± 3.7	Non-frail 0-1.4 (30.5); Frail 1.5-14 (69.5)	-
Ge, 2019 (37)	4.1 ± 3.7	1. Non-frail + Pre-frail 0-3 (56.6); Frail 4-14 (43.4) 2. Non-frail + Pre-frail 0-1 (30.5); Frail 2-14 (69.5) 3. Non-frail + Pre-frail 0-7 (78.5); Frail 8-14 (21.5) 4. Non-frail 0 (12.6); Pre-frail 1-4 (53.3); Frail 5-14 (34.1) 5. Non-frail 0-1 (30.5); Pre-frail 2-9 (56.0); Frail 10-14 (13.6)	-
Greco, 2021 (58)	7.6 ± 3.3	1. Non-frail 0-7 (34.9); Frail 8-14 (65.1) 2. Non-frail 0-1 (9.9); Mild-moderate frail 2-5 (15.1); Most frail 6-14 (75.0)	• There were marginally significant differences in baseline frailty prevalence between symptomatic and asymptomatic COVID-19 cases (p=0.05).
Gutiérrez-Valencia, 2018 (42)	6.2 ± 5.4	Robust 0-1 (29.1); Pre-frail 2-5 (28.2); Frail 6-14 (42.7)	• FRAIL-NH was not associated with polypharmacy and underprescription.
Hendrix, 2019 (23)	4.7 ± 4.1	Non-frail 0-1 (26.7); Frail 2-5 (37.5); Most frail 6-14 (35.9)	• High-dose PPI use was not associated with frailty.
Ho, 2020 (51)	7.3 ± 3.4	Robust 0-1 (9.3); Pre-frail 2-6 (27.3); Frail 7-14 (63.4)	-
Jadzcak, 2021 (24)	6.3 ± 3.2	Non-frail 0-2 (12.3); Frail 3-6 (42.0); Most frail 7-14 (45.7)	-
Kaehr, 2016 (44)	6.6 ± 2.6	Non-frail 0-5; Pre-frail 6-7; Frail 8-13 (48.7)‡	-
Kerry, 2020 (25)	-	Non/mild/moderate frail 0-5 (71.5); Most frail 6-14 (28.5)	-
Korhonen, 2018 (26)	4.7 ± 4.1	Non-frail 0-1 (26.7); Mild-moderate frail 2-5 (37.5); Most frail 6-14 (35.9)	• Residents who were most frail were less likely to be statin users (p=0.0004).
Little, 2021 (46)	6.4 ± 3.6	Non-frail 0-5; Pre-frail 6-7; Frail 8-14 (47)	-
Luo, 2015 (57)	-	1. Robust 0 (9.0); Intermediate 1-4 (32.5); Frail 5-14 (58.5)§ 2. Robust 0 (9.0); Intermediate 1-6 (50.8); Frail 7-14 (40.2)§	• Frail residents were more likely older, had worse cognitive impairment, and more health conditions at baseline (diabetes, dementia, stroke) (p for trend<0.001).
Martínez-Velilla, 2017 (43)	6.2 ± 5.4	Robust 0-1 (29.1); Pre-frail 2-5 (28.2); Frail 6-14 (42.7)	• FRAIL-NH was associated with functional dependence, multimorbidity, malnutrition or risk of malnutrition, and poorer cognitive impairment (p<0.001).
Papadopoulos, 2021 (50)	-	Lower frailty 0-10; Higher frailty 11-14	-

Table 2 (continued). Characteristics of FRAIL-NH, Frailty Prevalence, and Cross-Sectional Associations with Frailty

Author, Year	Mean FRAIL-NH Score	FRAIL-NH* Cut-Off (Frailty Prevalence, %)	Cross-Sectional Associations
Peng, 2020 (60)	5.8 ± 3.7	1. Robust 0-1 (20.6); Frail 2-5 (17.7); Most frail 6-14 (61.8)‖ 2. Robust 0-1 (20.6); Frail 2-5 (29.4); Most frail 6-14 (50.0)** 3. Robust 0-1 (20.6); Frail 2-14 (79.4)‖ 4. Robust 0-5 (38.2); Frail 6-14 (61.8)‖ 5. Robust 0-1 (20.6); Frail 2-9 (67.7); Most frail 10-14 (11.8)‖	• The frail group had a higher prevalence of males than females (p=0.028).
Si, 2020 (38)	1.9 ± 2.7	Non-frail 0-1 (63.3); Frail 2-14 (36.7)	-
Theou, 2016 (29)	4.7 ± 4.1	Non-frail 0-1 (26.7); Frail 2-5 (37.5); Most frail 6-14 (35.9)	• Women were frailer than men (p=0.03). • FRAIL-NH was associated with poorer performance on resident satisfaction score, nurse-reported quality of life, neuropsychiatric symptoms, and occupational disruptiveness.
Theou, 2018 (30)	4.7 ± 4.1	Non-frail 0-1 (26.7); Mild-moderate frail 2-5 (37.5); Most frail 6-14 (35.9)	-
Vasconcellos Romanini, 2020 (47)	6.9 ± 3.6	Robust 0-5 (34.1); Pre-frail 6-7 (18.5); Frail 8-14 (47.4)	• Frailty was more common among the oldest old (≥80 years) (p=0.03).
Villani, 2021 (55)	6.5 ± 3.4	Non-frail 0-7 (52.5); Frail 8-14 (46.6)	• Age, female sex, history of falls, delirium, history of stroke, Parkinson's disease, and cognitive impairment were associated with frailty. • Frailty was associated with higher prevalence of symptomatic medication use and lower prevalence of preventive medication use. • Polypharmacy (≥5) and hyperpolypharmacy (≥10) were associated with lower likelihood of frailty.
Wang, 2021 (31)	4.7 ± 4.1	Non-frail 0-1 (26.7); Frail 2-5 (37.5); Most frail 6-14 (35.9)	• Residents at high falls risk were more likely to be most frail (ASD>0.2).
Yang, 2018 (39)	6.4 ± 2.3	1. Non-frail 0-4 (17.9); Frail 5-14 (82.1) 2. Non-frail 0-5 (41.3); Frail 6-14 (58.7) 3. Non-frail 0-6 (59.3); Frail 7-14 (40.7) 4. Non-frail 0-1 (2.4); Frail 2-5 (38.9); Most frail 6-14 (58.7)	• FRAIL-NH was associated with age (r=0.329, p<0.001).
Yuan, 2021 (45)	7.7 ± 2.0	Robust 0-5 (11.0); Pre-frail 6-7 (25.4); Frail 8-13 (63.6)‡	• Female sex, racial/ethnic minority, presence of pain, use of anxiolytics or antidepressants, admission to NH from hospitals, and a range of conditions (arthritis, diabetes, cancer, cerebrovascular events, heart failure, Parkinson's disease, depression, hip fracture, multiple sclerosis, and epilepsy) were associated with frailty. • At NH admission, cognitive impairment was associated with frailty (moderate impairment, AOR 1.35, 95% CI 1.33–1.37; severe impairment, AOR 1.74, 95% CI 1.72–1.77).
Zhao, 2020 (40)	2.3 ± 2.5	Non-frail 0-1 (50.6); Frail 2-14 (49.4)	-

AOR, adjusted odds ratio; ASD, absolute standardized difference; CI, confidence interval; IQR, Interquartile range; MRCI, Medication Regimen Complexity Index; MMSE, Mini-Mental State Examination; NH, nursing home; OR, odds ratio; *FRAIL-NH range: 0-14; †6-item FRAIL-NH: excluded F=Fatigue domain; ‡FRAIL-NH range: 0-13 only; §8-item FRAIL-NH: used both I=Incontinence and Illness domains; ‖7-item FRAIL-NH: used I=Incontinence domain; **7-item FRAIL-NH: used I=Illness domain

Korea (n=1) (59), and Taiwan (n=1) (60). One study was an international multicenter study based on data from the Services and Health for Elderly in Long TERm care (SHELTER) study, conducted in 8 countries including Czech Republic, England, Finland, France, Germany, Israel, Italy, and the Netherlands (55).

Study designs included observational studies (n=31), experimental studies (n=6), qualitative studies (n=2), and a methodological study (n=1) (Table 1). Six articles utilized data from an Australian cohort study (23, 25, 26, 29-31), five from an Australian randomized controlled trial (RCT) (22, 27, 28, 32, 33), three from a Spanish longitudinal study (41-43), and three from a Chinese cross-sectional study (35-37). The number of participants ranged from 13 to 571,139, with a mean age range of 79.0 ± 8.8 to 89.4 ± 4.6 years. Of the 40 studies, 36 studies were conducted in NHs, three studies in hospital settings, and one study reported the scale translation (Table 1).

Frailty Prevalence

Frailty prevalence was reported in 30 of 40 studies, with FRAIL-NH cut-offs ranging from 1.5 to 11 (Table 2). The most frequent cut-off for defining frail and most frail residents were ≥2 (n=21) (21-23, 26-34, 37-41, 52, 56, 58, 60) and ≥6 (n=13) (21, 22, 25, 26, 29, 30, 32-34, 39, 56, 58, 60), respectively. When applying these definitions, between 15.1% and 79.5% of residents were frail, while 28.5% to 75.0% of residents were most frail. Other common cut-offs used to define frailty were ≥6 (n=5) (39, 42, 43, 48, 60) and ≥8 (n=8) (37, 44-47, 54, 55, 58). Ten studies assessed the sensitivity and specificity

Table 3. Predictive validity of the FRAIL-NH scale

Author, Year	Predictive validity of FRAIL-NH
Buckinx, 2018 (53)	• Not predictive of falls and mortality at 1 year.
Chong, 2021 (52)	• Predictive of mortality at 6 months (OR 13.6, 95% CI 1.80-103.12) and 12 months (OR 6.62, 95% CI 1.91-22.94). • Predictive of NH admission at 6 months (OR 4.98, 95% CI 1.45-17.13) and 12 months (OR 6.03, 95% CI 2.01-18.09). • Associated with functional decline at 6 months (OR 2.57, 95% CI 1.23-5.35) and 12 months (OR 2.22, 95% CI 1.07-4.62).
Contreras Escámez, 2020 (41)	• Predictive of functional and cognitive decline at 3 years (p<0.001), but not predictive of mortality. • Frail residents more often died at their NHs (p=0.004) and had shorter hospitalization (p=0.005) compared to robust residents.
De Silva, 2018 (56)	• Predictive of mortality at 1 year (adjusted HR for frail 1.15, 95% CI 0.55-2.41; most frail 2.14, 95% CI 1.07-4.27).
Ga, 2018 (59)	• Associated with earlier mortality in more frail patients admitted to a long-term care hospital (HR 1.29, 95% CI 1.29-2.98). • Within the last 6 months of hospital stay, tube feeding was more common in the more frail group than in the less frail group (p=0.034). • Mean survival duration was shorter in the more frail group than in the less frail group (p=0.002).
Greco, 2021 (58)	• Frailty was associated with cognitive decline from pre- to post-COVID assessment (OR 2.76, 95% CI 1.07-7.12).
Ho, 2020 (51)	• Despite similar frailty status, young-old (65–79 years) patients had higher healthcare utilization than old-old patients (≥80 years). • Not predictive of recurrent hospital admissions in the terminal phase.
Kaehr, 2016 (44)	• Pre-frail residents were associated with an increased 6-month risk of falls (AOR=2.63, 95% CI=1.25-5.54). • Frail residents were associated with 6-month mortality or hospice enrolment (AOR=3.96, 95% CI=1.44-10.87). • Combining pre-frail and frail categories, FRAIL-NH predicted 6-month mortality or hospice enrolment (AOR=3.36; 95% CI=1.26-8.98). • FRAIL-NH was not predictive of hospitalization.
Kerry, 2020 (25)	• Among residents who were most frail, multiple antihypertensive use was associated with an increased risk of mortality (HR 2.52, 95% CI 1.13–5.64).
Korhonen, 2018 (26)	• Among statin users, the risk of fall-related hospitalizations was greater among mild-moderate and most frail residents. • Among non-users of statin, most frail residents were nearly 70% less likely to experience a fall-related hospitalization compared to robust residents.
Luo, 2015 (57)	• Among residents with no ADL dependence, frailty (scores 5-14) was associated with incident falls (HR 2.00, 95% CI 1.41-2.83), hospitalization (HR 2.35, 95% CI 1.57-3.54), worsening ADL (HR 3.73, 95% CI 2.69-5.16), and mortality (HR 2.00, 95% CI 1.41-2.83). • Intermediate frailty (scores 1-4) was also predictive of incident falls (HR 1.57, 95% CI 1.20- 2.06), hospitalization (HR 1.78, 95% CI 1.32-2.41), and mortality (HR 1.57, 95% CI 1.20-2.06) in residents with no baseline ADL dependence.
Theou, 2018 (30)	• Mild-moderately frail residents had higher numbers of hospitalizations (adjusted IRR 1.57, 95% CI 1.11–2.20) and hospital days (IRR 1.48, 95% CI 1.32–1.66) than non-frail residents. • Most frail residents were at higher risk of mortality (adjusted HR 2.96, 95% CI 1.50–5.83), but had lower numbers of hospitalizations (IRR 0.65, 95% CI 0.42–0.99) and hospital days (IRR 0.39, 95% CI 0.33–0.46) than non-frail residents. • Over 12 months, more than 20% of most frail residents but less than 3% of non-frail residents died at the NH without hospitalization.
Vasconcellos Romanini, 2020 (47)	• Predictive of mortality at 12 months (OR=1.31, 95% CI=1.18-1.48).
Yang, 2018 (39)	• Frailty defined by FRAIL-NH ≥6 (adjusted HR 2.00, 95% CI 1.18-3.42) or ≥7 (adjusted HR 2.31, 95% CI 1.41-3.76) was associated with 1-year mortality. • Each one-score increment of FRAIL-NH was associated with an increased risk of mortality (adjusted HR 1.32, 95% CI 1.19-1.46).

ADL, activities of daily living; CI, confidence interval; COVID-19, coronavirus disease 2019; HR, hazard ratio; IRR, incidence rate ratio; OR, odds ratio.

of different cut-offs (24, 29, 35-40, 47, 52), with ≥8 having the highest sensitivity (94.1%) and specificity (82.8%) for classifying residents as frail based on FI (37), while two studies reported an optimal cut-off of ≥2 using FI and FP, respectively (29, 40). Optimal cut-offs were primarily established based on FI, FP, or the Comprehensive Geriatric Assessment (CGA), and determined using Youden Index or receiver operating characteristic curves. Ten studies described how FRAIL-NH scores were computed from a combination of other validated scales and datasets (Table S5). All but two studies used the original score range of 0-14 and the complete seven domains (57, 59).

Cross-Sectional Associations

Cross-sectional associations were described in 18 studies (Table 2). Fifteen studies reported univariate or bivariate associations (23, 26, 29, 31, 33, 39, 43, 45, 47, 52, 56-60); while four studies adjusted analyses for age, sex, and other variables (22, 35, 42, 55). FRAIL-NH scores were associated with older age (35, 39, 47, 55-57), female sex (29, 45, 55-57), multimorbidity (35, 43, 52, 57), cognitive impairment (43, 45, 52, 55, 57, 59), and functional dependence (43, 52).

A longitudinal study of 571,139 residents in 15,551 US NHs found an association between frailty and diabetes, cancer, stroke, heart failure, Parkinson's disease, and depression (45). Residents experiencing pain, and those receiving anxiolytics or antidepressants at admission were more likely frail (45). Conversely, residents receiving hypnotics and antipsychotics were less likely frail (45). A cohort study of 383 residents in six Australian NHs found residents at high falls risk were more likely to be most frail compared with residents at low falls risk (31). Polypharmacy (42, 55), underprescription (42), preventive medication use (26, 55), and high-dose proton pump inhibitor use (23), were found to have no associations or were inversely associated with frailty.

Predictive Validity

Predictive validity was investigated in 14 studies (Table 3). FRAIL-NH scores were predictive of mortality (25, 30, 39, 44, 47, 52, 56, 57, 59), falls (44, 57), hospitalization (26, 30, 57), length of hospitalization (30, 41), and functional or cognitive decline (41, 52, 57, 58) over a median follow-up of 12 months.

Table 4. Concurrent validity of the FRAIL-NH scale

Author, Year	Comparison between FRAIL-NH and other frailty scales	Concurrent validity of FRAIL-NH
Buckinx, 2018 (53)	CFS, EFS, FRAIL, FI, FP, GFI, SEGA, SHARE-FI, SQ, TFI	• None of the 11 scales were predictive of falls and deaths at 1 year.
Chong, 2021 (52)	FRAIL, FI*	• FRAIL-NH and FRAIL had good diagnostic performance (both AUC>0.8, p<0.001) against FI, with FRAIL-NH identifying more patients as frail. • FRAIL-NH had less ceiling effect than FRAIL in discrimination of severe frailty. • FRAIL-NH was a better predictor of mortality (OR 6.62, 95% CI 1.91-22.94) and admission to NHs (OR 6.03, 95% CI 2.01-18.09). • FRAIL was superior for predicting in-hospital mortality (OR 9.29, 95% CI 1.09-79.20) and length of stay (p=0.043).
Contreras Escámez, 2020 (41)	IF, FI, FP	• Only FP predicted falls (p<0.001). • Only IF demonstrated a relationship between frailty and mortality at 3 years (HR=3.3, 95% CI 1.5-7.1). • Using FRAIL-NH and IF, frail residents were associated with shorter hospitalizations, functional and cognitive decline.
Ga, 2018 (59)	FI	• Distribution of FRAIL-NH was in accordance with FI (β=0.571, p<0.001, r=0.572). • Both scales showed a high prevalence of frailty in patients admitted to a long-term care hospital. • Both scales were associated with earlier mortality (FRAIL-NH, HR 1.29, 95% CI 1.29-2.98; FI, HR 1.39, 95% CI 1.10-1.76).
Ge, 2019 (35)	FI	• FRAIL-NH and FI were strongly correlated (r=0.743, p<0.001). • Agreement between both scales were modest (κ=0.392, p<0.001), with FI classifying more residents as frail. • Age was associated with an increased FI classification of frail or frailest, but was only associated with a FRAIL-NH classification of frailest. • Both scales found that multimorbidity and poor self-reported health were associated with an increased risk of frail and frailest status.
Ge, 2019 (36)	TFI, FI*	• FRAIL-NH (AUC=0.861) had better diagnostic performance than TFI (AUC=0.776) (Z=3.455, p<0.001).
Ge, 2019 (37)	FI	• FI tended to classify residents as frail, whereas FRAIL-NH tended to classify residents as pre-frail. • Agreement between both scales ranged from fair to moderate (κ=0.33 to 0.55) regardless of the cut-offs used.
Gutiérrez-Valencia, 2018 (42)	FP, IF, FI	• No associations between frailty and polypharmacy based on all 4 scales. • No associations between frailty and underprescription, except for FP where the limit of significance was reached. • No significant differences in specific START criteria according to frailty status based on all 4 scales.
Jadczak, 2021 (24)	FI	• FRAIL-NH was correlated with FI (r=0.77, p<0.001).
Kaehr, 2016 (44)	FI	• FRAIL-NH showed a positive correlation with FI (r=0.623). • FRAIL-NH was superior to FI at predicting falls in pre-frail residents (AOR=2.42, 95% CI 1.11-5.92), and mortality or hospice enrolment in frail residents (AOR=3.25, 95% CI 1.04-10.86). • Combining pre-frail and frail categories, both scales predicted 6-month mortality or hospice enrolment; however, FI was a more modest predictor (FRAIL-NH, AOR=3.36, 95% CI=1.26-8.98; FI, AOR=2.28; 95% CI=1.01-5.15). • Both scales were not predictive of hospitalization.
Martínez-Velilla, 2017 (43)	IF, FI, FP	• Age was only associated with FP and FI (p<0.05), but not IF or FRAIL-NH. • Based on all 4 scales, frail residents had more geriatric syndromes and a higher degree of cognitive impairment. • Based on all 4 scales, no significant associations were found between frailty and depression or the level of education. • Using IF, FI, and FRAIL-NH, frail residents had a higher percentage of malnutrition or risk of malnutrition.
Si, 2020 (38)	FP, FRAIL, GFI, TFI, CGA*	• FRAIL-NH, FRAIL, FP, GFI, and TFI showed similarly good diagnostic accuracy in identifying frailty against CGA (χ^2=0.0003-1.38, p>0.05). • At the original cut-offs, all scales had: slight to moderate agreement with the CGA (κ=0.168-0.407); low sensitivity and high specificity; and high positive predictive values and low negative predictive values. • At the optimal cut-offs of FRAIL-NH, FRAIL and FP: the agreement increased (κ=0.465-0.523); sensitivity and specificity were more balanced; and correctly classified rates increased.
Theou, 2016 (29)	FI	• FRAIL-NH was associated with FI (r=0.81, p<0.001). • FI was associated with age (r=0.11, p=0.03), whereas FRAIL-NH was not. • Women were frailer than men when assessed using both tools (FI, p=0.006, d=0.34; FRAIL-NH, p=0.03, d=0.26). • Both scales were associated (p<0.001) with health measures indicative of higher care needs (total resident satisfaction score, nurse-reported quality of life, neuropsychiatric symptoms, and occupational disruptiveness), with FI having stronger associations.
Theou, 2018 (30)	FI	• In contrast to FRAIL-NH, FI was only associated with a higher number of hospital days, but not number of hospitalizations. • Both scales found that most frail residents had a higher risk of mortality than non-frail residents (FRAIL-NH, adjusted HR 2.96, 95% CI 1.50–5.83; FI, HR 5.28, 95% CI 2.05–13.59). • Among the lowest frailty subset in both scales, about a quarter of residents were hospitalized and were alive at 12 months; whereas among the most frail subset, a smaller proportion was hospitalized and alive at 12 months. • Both scales found that among residents who died at the NH without hospitalization, this occurred to almost a quarter of the most frail subset, but only to a small number of the lowest frailty subset.
Yang, 2018 (39)	FI-Lab	• FI-Lab was associated with FRAIL-NH (r=0.799, p<0.001). • Both scales found that frailty was related to an increased risk of 1-year mortality (FRAIL-NH ≥6, adjusted HR 2.00, 95% CI 1.18–3.42; FI-Lab ≥0.3, adjusted HR 2.26, 95% CI 1.32–3.85). • FI-Lab (AUC 0.700, 95% CI 0.647–0.750) was slightly better than FRAIL-NH (AUC 0.676, 95% CI 0.622–0.727) at predicting mortality. • Each increment of score in both scales were associated with mortality (FRAIL-NH, adjusted HR per 1-score increment 1.32, 95% CI 1.19–1.46; FI-Lab, adjusted HR per 0.01-score increment 1.07, 95% CI 1.05–1.09).
Zhao, 2020 (40)	FI-35, SOF index, SPPB, FP*	• FRAIL-NH was associated with FP (r=0.61, p<0.001), but only showed fair agreement (κ=0.46, p<0.001). • FP identified more individuals with frailty than FRAIL-NH (p<0.001). • FRAIL-NH was moderately correlated to SOF index, FI-35, and SPPB.

AUC, area under curve; AOR, adjusted odds ratio; CFS, Clinical Frailty Scale; CGA, Comprehensive Geriatric Assessment; CI, confidence interval; EFS, Edmonton Frail Scale; FI, Frailty Index; FI-35, Frailty Index 35; FI-Lab, Frailty Index based on common laboratory tests; FP, Fried's phenotype; GFI, Groningen Frailty Indicator; HR, hazard ratio; IF, Imputed Fried; NH, nursing home; OR, odds ratio; SEGA, Short Emergency Geriatric Assessment; SHARE-FI, Survey of Health, Ageing and Retirement in Europe-Frailty Instrument; SOF, Study of Osteoporotic Fracture; SPPB, Short Physical Performance Battery; SQ, Strawbridge questionnaire; START, Screening Tool to Alert to Right Treatment; TFI, Tilburg Frailty Indicator; *Used as reference standard

Among residents with no activities of daily living (ADL) dependence in a Hong Kong study (n=2,380), FRAIL-NH predicted falls, worsening ADL, hospitalization, and mortality (57). A Chinese study (n=329) reported that each one-score increment in FRAIL-NH increased the hazard ratio for 1-year mortality by 32% (39).

An Australian study (n=383) reported that mild-moderately frail residents had higher numbers of hospitalizations and hospital days compared to non-frail residents, whereas most frail residents had lower numbers but were at higher risk of death (30). Over 12 months, more than 20% of most frail residents, but less than 3% of non-frail or vulnerable residents, died at the NH without hospitalization (30). Multiple antihypertensive use was associated with increased mortality among most frail residents in the same cohort (25). Statin use was associated with fall-related hospitalizations in mild-moderate and most frail residents (26). Conversely, among non-users of statins, fall-related hospitalizations were lowest in the frailest subset (26). Five studies reported contrasting outcomes whereby FRAIL-NH scores did not predict falls (53), hospitalization (44, 51), and mortality (41, 53).

Concurrent Validity

The FRAIL-NH scale has been compared to 16 other scales (Table 4). FRAIL-NH was correlated with FI (24, 29, 35, 44), FP (40), and FI-Lab (39). Four studies reported fair to moderate agreements between FRAIL-NH and FI (35, 37), FP (40), and CGA (38). A Chinese study (n=305) reported that FRAIL-NH, FRAIL, FP, Groningen Frailty Indicator, and Tilburg Frailty Indicator demonstrated similarly good diagnostic properties against CGA (38). Of these scales, FRAIL-NH, FRAIL and FP had moderate agreements with CGA at the optimal cut-offs (38). In a Singaporean geriatric hospital (n=210), FRAIL-NH and FRAIL had good diagnostic performance against FI (52). FRAIL-NH had less ceiling effect and had greater discriminatory ability for severe frailty than FRAIL (52).

Seven studies compared the predictive validity between FRAIL-NH and 12 other scales for mortality (30, 39, 41, 44, 52, 53, 59), falls (44, 53), hospitalization (30, 44), length of hospitalization (30, 41, 52), NH admission (52), functional and cognitive decline (41, 52). A US study (n=270) reported that FRAIL-NH was superior to FI at predicting death in frail residents, and falls in pre-frail residents at 6-month follow-up (44). Conversely, FI-Lab was a better predictor of 1-year mortality than FRAIL-NH in a Chinese study (n=329) (39). An Australian study (n=383) found that residents with mild-moderate frailty based on FRAIL-NH and FI had longer hospitalization than non-frail residents (30). In contrast, a Spanish study (n=110) reported that FRAIL-NH and Imputed Fried (IF) had similar predictive validity for shorter hospitalization, functional and cognitive decline (41). Although FRAIL was superior for in-hospital mortality and length of hospitalization in a Singaporean tertiary hospital study, FRAIL-NH better predicted mortality and NH admission up to 12-month follow-up (52).

Cross-Cultural Adaptations

At present, the FRAIL-NH scale has been translated into Brazilian Portuguese (47), Chinese (40), and Japanese (49). The scale was also applied to data from Italy (58), Korea (59), and Spain (41-43), although the translations and adaptations were not specifically reported. The Brazilian Portuguese version was generated through a process of translation by a geriatrician and a physical therapist, cross-cultural adaptation through consensus meetings, and back-translation by a native English speaker (47). The Chinese version was translated by two native bilingual speakers, back-translated by two US researchers, pilot trialed in a sample of NH residents (n=38), and subsequently conducted a post-study interview to ascertain comprehensibility of the translated version (40). Similarly, the Japanese version was translated by two geriatricians and one pharmacist, back-translated by a translation agency with designated expertise on geriatrics and gerontology, followed by a pilot NH trial, and a post-study evaluation (49).

Other Applications

The FRAIL-NH scale was used to investigate the impact of coronavirus disease 2019 (COVID-19) on changes in 152 Italian residents' frailty status over time (58). COVID-19 accelerated deterioration in frailty by 21%, and COVID-19 survivors had a 4-fold higher chance of developing frailty (58). Frailty was associated with cognitive decline from pre- to post-COVID assessment (58). A large US study (n=571,139) reported that 23% of pre-frail residents at admission improved to robust by three months, whereas 30.5% of pre-frail residents transitioned to frail (45). At admission, residents with severe cognitive impairment were 74% more likely to be frail (45). By 6 months, those with severe impairment were over twice as likely to be frail (45). Other applications of FRAIL-NH include: establishing baseline comparability of participants in studies (24, 27, 28, 32, 33, 54); baseline screening as proxy to physical health for RCT recruitment (50); describing COVID-19 seroprevalence in frail residents (48); characterizing frailty status in residents interviewed on perceptions of frailty (21, 34); examining changes in FRAIL-NH scores at annual routine screening (46); and the prospective use of FRAIL-NH in acute care (52).

Methodological Quality of Studies

Of the 18 cross-sectional studies, 15 studies provided clear inclusion criteria (Table S3) (22-24, 29, 31, 33, 35-38, 40, 42, 43, 45, 54). All studies described resident characteristics and settings in detail (22-24, 29, 31, 33, 35-38, 40, 42, 43, 45, 48, 54, 55, 60). Cross-sectional associations with frailty were not investigated in seven studies (24, 36-38, 40, 48, 54), therefore criteria related to confounding factors were not assessed in these studies. Residents with different frailty status were recruited from the same population, free of outcomes at the start of study, and follow-up time was reported in all 14 outcome studies (Table S4) (25, 26, 30, 39, 41, 44, 47, 51-53,

56-59). Confounding factors were identified and adjusted for in 13 outcome studies (25, 26, 30, 39, 44, 47, 51-53, 56-59). Overall, two studies did not provide adequate information on how FRAIL-NH was computed, which precluded assessment on whether the measurement was valid (48, 53).

Discussion

This was the first review of the use, validity and adaptations of the FRAIL-NH scale. FRAIL-NH has become widely used in Australia, Asia, Europe and North America. Frailty prevalence varied depending on the cut-off used. The optimal cut-off is dependent on the FRAIL-NH domains included, reference scale used, purpose of screening, setting, resident characteristics, structure and resources available. While a universal cut-off permits direct comparison across studies, it is not clear that optimal cut-offs are generalizable to all NHs. Although FI was commonly used as the reference for determining the optimal FRAIL-NH cut-off, FI scores were originally continuous instead of categorical, and the commonly applied FI cut-off of ≥0.22 was based on studies analyzing different deficits in community instead of NH settings (61). The wide range in proportion of frail residents likely reflects differences in NH services in different countries. Lower cut-offs with higher sensitivity could improve frailty detection, whereas higher cut-offs with higher specificity could reduce misdiagnosis and enhance resource allocation (38, 52).

FRAIL-NH was associated with resident and clinical characteristics indicative of higher care needs. One study included in the review suggested frail residents had the most complex medication regimens (22). This is important because frail residents are susceptible to ADEs, and regimen complexity has been linked to medication errors and hospitalizations (62-65). Frailty may also be overlooked in residents with chronic multimorbidity in conventional disease-based treatment decision-making (11, 62, 66). Use of a straightforward screening tool such as FRAIL-NH may assist in rapid identification of frailty to target clinical services (e.g. regimen simplification, medication reviews, CGA) to residents who may benefit most. Given that most NH residents have some degree of frailty, determining different levels of frailty (e.g. pre-frail, most frail) may allow assessment of residents most at risk of adverse outcomes for better care planning and resource allocation.

In addition, the FRAIL-NH scale may be useful for identifying residents at risk of various adverse outcomes such as hospitalization, functional decline, and ADEs. Among the five studies investigating all-cause hospitalization (26, 30, 44, 51, 57), three studies reported an association and two did not (44, 51), while another study reported FRAIL-NH scores further predicted fall-related hospitalization (26). Discrepancies in predictive validity may reflect different thresholds for hospitalization and differences in the extent to which clinical in-reach services are provided in NHs. Further studies on cause-specific hospitalizations are warranted to determine the reasons why frail residents are hospitalized and to develop preventive strategies. FRAIL-NH could guide development of individualized care plans to prevent falls, hospitalization and mortality. It is possible that the frailest residents may have advance care plans with do not hospitalize orders (30).

FRAIL-NH scores predicted functional decline in all three studies that examined this parameter (41, 52, 57). Frail residents with no baseline ADL dependence were at increased risk of worsening ADLs in a 9-year longitudinal study (57). Functional independence is an important outcome measure that has been prioritized by residents and carers (62). Using FRAIL-NH to detect pre-frail residents may help direct interventions to prevent functional dependence. FRAIL-NH can be applied on a regular or as needed basis to ensure care goals are updated in alignment with shifts in frailty transition. Two studies demonstrated that frailty modified the risk-benefit ratio of preventive medications (25, 26). Statin users with mild-moderate frailty or who were most frail were at higher risk of fall-related hospitalization (26), whereas residents who were most frail and using multiple antihypertensives were at increased risk of mortality (25). FRAIL-NH could be used to identify residents at increased risk of ADEs and assist with tailoring medication regimens accordingly.

Overall, the FRAIL-NH scale demonstrated good agreement with other well-established but more complex frailty scales. FRAIL-NH had similar diagnostic and predictive properties as FI, FI-Lab, FP, IF, and FRAIL. Unlike FP, FRAIL-NH does not require use of specific instruments (e.g. dynamometer to measure handgrip strength) and measurement of gait speed which can be challenging in NHs. As many residents have functional dependence, assessing walking speed may be impractical. Although FI may be more comprehensive for care planning, it is resource intensive to manually code residents' deficits in the absence of electronic software. In contrast, FRAIL-NH is a simple and rapid scale that utilizes routinely collected data in NHs. The ease of administration makes FRAIL-NH a good candidate as a routine screening tool in NHs. Specialist training is not required to administer FRAIL-NH. This is supported by 24 studies reporting that care workers, technicians, or nurses effectively applied the scale (21-37, 39, 41-43, 49, 56, 59). Furthermore, FRAIL-NH can often be retrospectively applied to existing datasets as demonstrated by nine studies in this review (44, 45, 51-53, 55-57, 59). This is feasible because most items in FRAIL-NH can be adapted from other validated scales that are routinely applied in NHs (Table S5).

Strengths, Limitations and Implications for Future Research

A key strength is the inclusion of all full-text primary studies from 20 countries that have used the FRAIL-NH scale from inception to present irrespective of study designs and publication language. The review provides a snapshot of the use of FRAIL-NH globally, excluding results from a Japanese abstract reporting that FRAIL-NH predicted NH admissions (67), and a Mexican abstract using the Spanish version of FRAIL-NH (68). To our knowledge, full-text articles for these abstracts have not been published. Extensive variability in

study samples and FRAIL-NH cut-offs limited comparability of included studies. Findings from individual studies are not necessarily representative or generalizable to all frail NH residents in the corresponding countries. Cross-sectional study designs limit the prospect of exploring causal relationships. A meta-analysis was not performed due to heterogeneity in study objectives and outcomes investigated.

None of the RCTs in this review investigated frailty as the primary outcome. However, an emerging application of FRAIL-NH may be to monitor changes in frailty status over time as an outcome in RCTs and cohort studies. This highlights the dynamic state of frailty and assists with identifying risk factors influencing shifts in frailty transitions. Future studies are needed to explore whether targeted interventions can delay or reverse frailty transitions. Similarly, FRAIL-NH may be used to describe frailty status of RCT participants. This is important because frail older people are often under-represented in RCTs (12, 62). FRAIL-NH can facilitate by establishing frailty profiles and examining potential differences in characteristics between intervention versus control groups. Since poor health status among frail residents may also contribute to lower rates of follow-up, another potential use of FRAIL-NH is to model characteristics of residents who drop-out of prospective intervention studies.

Given that the FRAIL-NH scale is predictive of hospitalization, mortality, and other important clinical outcomes, it may be useful as a routine screening tool in NHs. According to the World Health Organization's guide on screening programs (69), FRAIL-NH fulfills the criteria for a clinically meaningful screening method to reduce the incidence and severity of a condition by early detection and treatment. Mass population screening of frailty may not be the most cost-effective approach and requires further research to establish its feasibility and effectiveness at improving outcomes (66). However, frailty screening in adults ≥70 years when accessing health care is recommended by major international frailty consensus groups across Europe, North America and Asia-Pacific (1, 70, 71).

The New Zealand Frailty Care Guides recommended the use of the FRAIL-NH scale to assess gradual deterioration in residents (72). Future studies should explore the potential integration of FRAIL-NH screening into routine care planning and whether this translates to improved outcomes for residents and NHs. The Australian National Aged Care Classification describes frailty as a factor driving NH resource use (73). Consideration of frailty status can assist clinicians and NH providers to identify residents at risk of harm, and implement strategies to prevent the onset and development of frailty. FRAIL-NH may have a potential role in identifying and accounting for care burden associated with frailty to better estimate funding and staff allocation.

Conclusion

In seven years, the FRAIL-NH scale has been applied in 20 countries and adapted into three languages. Despite being applied with a range of cut-offs, FRAIL-NH was associated with various factors indicative of higher care needs. FRAIL-NH demonstrated good agreement and had similar predictive properties as other well-established but more complex frailty scales. FRAIL-NH was predictive of falls, cognitive or functional decline, hospitalization, and mortality across different settings. The association with adverse health outcomes highlights its value in guiding care for frail residents in NHs.

Ethical standards: This study did not include any animal or human experiments.

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Conflicts of interest: RV was previously a board member of Resthaven Inc. and is currently on the clinical governance committee. In the recent past, she has received honoraria, speakers and educational grants in various combinations from Nutricia, Abbott and Nestlé. JSB has received research grants paid to his employer from NHMRC, Dementia Australia Research Foundation, Yulgilbar Foundation, Dementia Centre for Research Collaboration, Victorian Government Department of Health and Human Services, GlaxoSmithKline Independent Medical Education, Aged Care Quality and Safety Commission, and several aged care provider organizations. SJL, SL and LAD declare no conflicts of interest.

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