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REVIEW ARTICLE

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Review of frailty measurement of older people: Evaluation of the conceptualization, included domains, psychometric properties, and applicability

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Abstract

The purposes of this review are to describe the existing research on frailty measurement of older people and to understand their characteristics, with a focus on conceptual definitions, psychometric properties, and diagnostic accuracies. We reviewed the published literature to explore if cross-cultural studies of different types of frailty measurements have been conducted and to determine their applicability in the community setting. Narrative review with limited electronic database search and cross reference searching of included studies was performed. Studies published after year 2001 were searched for using MEDLINE and CINAHL Plus databases with keywords. A total of 5144 search results were obtained, but only 42 frailty measurements were identified in 68 studies. For the type, three different measurements were indicated, namely, self-report instrument (n = 17), clinical observation assessment (n = 19), and mixed frailty assessment instrument (n = 6). Only 12 (29%) measurements examined reliability and validity. Nevertheless, over 35% did not perform any psychometric testing before applying. For diagnosis accuracies, 35 (83%) frailty measurements reported the cut-off value(s) for determining level of the frailty. However, the sensitivity (56%-89.5%) and specificity (52%-91.3%) varied. The applicability was also diverse and some frailty instruments should be only used in some specific population and mode of administration. This review provides an overview of three major types of frailty measurements used in different settings with different purposes. For estimating the prevalence of frailty of older people in a community, the self-report type may be appropriate. The psychometric properties of many reviewed instruments are reported insufficiently. The cut-off value(s) are usually suggested with diverse sensitivity and specificity. Self-report instruments, such as Groningen Frailty Indicator (GFI) and Tilburg Frailty Indicator (TFI), are the most extensively examined in terms of satisfactory psychometric properties. Thus, GFI and TFI, with the current evidence, are recommended to be used in the community setting for frailty screening tools.

KEYWORDS
conceptual definitions, diagnostic accuracies, frailty measurements, instruments, older people, psychometric properties

1 | INTRODUCTION

Frailty is widely noted as a status of increased vulnerability to stressors and reduced physiologic reserves and resilience of a person, more likely for an older person.[1] We are currently facing a progressive and an exponential aging population over the past decades. Furthermore, the demographic phenomenon of an absolute and a relative increased number of old and very old population is expected to continue for the coming 30 years. An accumulating evidence proves that due to the rapid growth of an aging population, frailty may become one of the most serious health issues in the world.[1] It is a multi-dimensional geriatric condition often known to be caused by cumulative cellular damage over one's life course. In addition, it has been proven to be one of the leading causes of premature mortality and morbidity for older people.[2] Moreover, frailty leads to high risk of negative health outcomes. With advancing age, the occurrence of frailty increases incrementally and shows a gender imbalance, occurring more often in women than in men, and a social class imbalance, occurring more often in those with a low socio-economic status. Older frail people are at high risk of adverse health outcomes, such as falls, morbidity, institutionalization, hospitalization, dependency, and mortality.[3-5] Approximately 3%-5% of mortality among older people can be delayed if frailty is prevented.[6] In addition, frailty profoundly influences the longevity of community-dwelling older people and impacts their quality of life by inducing functional decline.[6-8]

Estimating the prevalence of frailty in a population is clearly one of the heterogeneous ways of measuring frailty, which provides a partial vision of the phenomenon. As expected, the aging society substantially contributes to the growing prevalence of frailty. A systematic review on 21 studies has indicated that frailty is not only common among western and developed countries but also in high prevalence in developing countries. At some point, the prevalence of frailty was at a wide range from 4% to 59.1%, and a difference between countries was noted.[9] Considering the weight of clinical conditions when measuring the prevalence of frailty is important, the prevalence of frailty can be different from clinical settings because of the common sense that a sicker person is more likely to be frail when using an independent instrument to assess it.

Given the high prevalence of frailty and related burden of adverse health outcomes for frail older people, the early identification of frailty, especially for community-dwelling older people, should be the priority in primary care network. The concept of frailty is close to resilience, which is described as the ability to adapt when a traumatic life stressor suddenly occurs in a human. A meta-analysis of association of frailty and mortality in patients with Coronavirus disease 2019 (COVID-19) has demonstrated that it is a significant association between frailty status and higher odds of mortality in patients of COVID-19.[8] Using the theoretical resilience for explaining, a poorly resilient individual (a frail COVID-19 patient) will struggle to restore than to a non-frail one. The early diagnosis of frailty is essential in promoting a novel and comprehensive approach to older people and in integrating necessary healthcare service, especially when a worldwide public health event suddenly happen like COVID-19.

Although the early identification of frailty is important, frailty management has not received adequate attention in gerontological nursing practice. Healthcare interventions for ameliorating or improving this condition have been scarcely researched. Some studies have even indicated that nurses cannot recognize frailty among the older population.[9] The inadequate attention to frailty management among the older population may be related to the confusion surrounding the phenomenon of frailty itself. First, no internationally recognized definition of frailty exists, and it is not easily recognized by older people themselves.[1] Second, although frailty has been proven to be one of the leading causes of premature mortality and morbidity for older people, some reports in literature characterize frailty as a protective bodily response to prevent the overtaxing of functional reserve.[1,6] All of these inconsistencies may affect the proper assessment of symptoms and add difficulties to the recognition and management of the condition. In another aspect, if we consider the high prevalence ratio of frailty, then its prevention in older people seems to be cost-effective, especially in developing countries with large populations. Screening and early detection of frailty and its correlated factors should be a key concern. Twelve systematic reviews regarding frailty measurements have been published to date. Some of them are focused on the validation of frailty evaluation instruments, others aim for the clinimetric properties of instruments. However, most of these reviews are for clinical and primary care settings. One review has determined the diagnostic test accuracy of community-dwelling older people, mentioning that many kinds of self-reported frailty measurements exist in the world by now, such as Groningen Frailty Indicator (GFI), Edmonton Frailty Scale (EFS), and Tilburg Frailty Indicator (TFI).[10-12] Although four reviews of frailty measurements have addressed validation aspects, only one has tackled the psychometric properties of instruments for the detection of the frailty syndrome. Furthermore, none of them have provided comprehensive information and comparison data on the conceptual definitions, psychometric properties, and diagnostic accuracies of frailty measurement.[2,13]

How many frailty measurement tools are available? How about their quality and operation? In China, older people aged over 60 accounts for 18.70% of the total population from the updated data in 2021. Considering the prevalence of frailty and the adverse events due to the frailty syndrome in existing literature, the demand for the knowledge of frailty measurement tools or the community-dwelling

setting is high. Furthermore, the choice of researchers for frailty instruments should be guided by the issues related to the translation and validation for different locations and contexts. Therefore, the purposes of this review are to provide a comprehensive overview of comparison data about frailty measurement tools and to identify what frailty measurement tools are measured and whether they are used in the community-dwelling setting. Specifically, the research question of this review is which frailty measurement tools can be applied in the community-dwelling setting to assess the frailty of older people in China? It (a) examines international research on frailty measurement among older people; (b) presents the names, response modalities, domains, processes of instrumentation, and psychometric properties of frailty measurements; (c) highlights the needs of an evidence about which frailty measurement is appropriate for screening frailty in the community older population in China.

2 | METHODS

2.1 | Searching strategies

To identify studies that report frailty measurements, MEDLINE and CINAHL Plus databases were searched. Titles and abstracts were obtained using the following search phrases: [Frailty*] AND [assessment OR measurement OR instrument OR tool OR scale] AND [old OR older people OR elderly].

The search was performed for articles published from January 1, 2001 to December 31, 2020. Year 2001 was used as the start because the most well-known assessment of frailty with a clear conceptual definition of multidimensional nature was developed in 2001 by Fried et al.[3] Potential relevant articles were identified by screening titles and abstracts against the following inclusion criteria. Only full-text academic journals were considered. Secondary search was also performed on the basis of the citation of the reference list of potentially relevant articles, if necessary.

2.2 | Inclusion criteria

The following inclusion criteria for selecting relevant studies were used:

- The study sample was older people (age ≥65 years old).
- The study aimed to develop a quantitative frailty measurement.
- The measurement is preferred with frailty classification or frailty prognosis as a kind of outcome prediction.

2.3 | Data analysis

Frailty measurements were reviewed, tabulated, and discussed using the following standards:

- Nature of the measurement (ie, description of item generation, conceptual definition of frailty, and target population).
- Included domains (ie, physical, psychological, social, and cognitive)
- Response modalities and scoring (ie, number of items, response format, and scoring method).
- Psychometric properties (ie, reliability, validity, and diagnostic accuracy).
- Operation of the measurement (ie, time of completion, way of administration, requirement of special device(s) or training and applicable setting).

3 | RESULTS

A total of 5144 relevant studies were found. Through the application of the above inclusion criteria, 475 full text articles were eligible. Two researchers independently finished data extraction from every eligible paper. We included English-language studies that met the three inclusion criteria. We excluded studies that did not examine frailty measurements used for older people. All disagreements of the two researchers were resolved with consensus. Finally, only 42 frailty measurements were identified in 68 studies (Figure 1). The suitability of the studies included studies was evaluated in terms of the two researchers' agreement with the search string.

Table 1 presents the detailed information about the names, response modalities, domains, processes of instrumentation, and psychometric properties of the reviewed measurements. Major findings from the included articles were compared one to another for similarities and differences.

3.1 | Conceptual definition of frailty

Although no consensual definition of frailty is identified, the literature in general indicates that frailty is of multidimensional nature and associates with geriatric syndrome. Reducing morbidity, quality of life, and cognitive function of older people is important, and the definition of frailty has gained the attention of many scholars worldwide.[14-17] How the frailty is defined as an important issue for geriatric studies. The earliest definition of frailty is "a decrease in physiologic reserve and an increase in probability of disability."[18] However, no consensual definition of frailty exists to date. International groups, such as the World Health Organization (WHO) and the International Association of Geriatrics and Gerontology (IAGG), are working on an internationally accepted definition of frailty.[19,20] The starting point of an integral conceptual definition of frailty is a dynamic state affecting an individual who experiences losses in one or more domains of human functioning (ie, physical, psychological, and social), which is caused by the influence of a range of variables and which increases the risk of adverse outcomes.[21] This definition emphasizes that frailty interacts with three domains of human functioning and opens a new page for research on how many

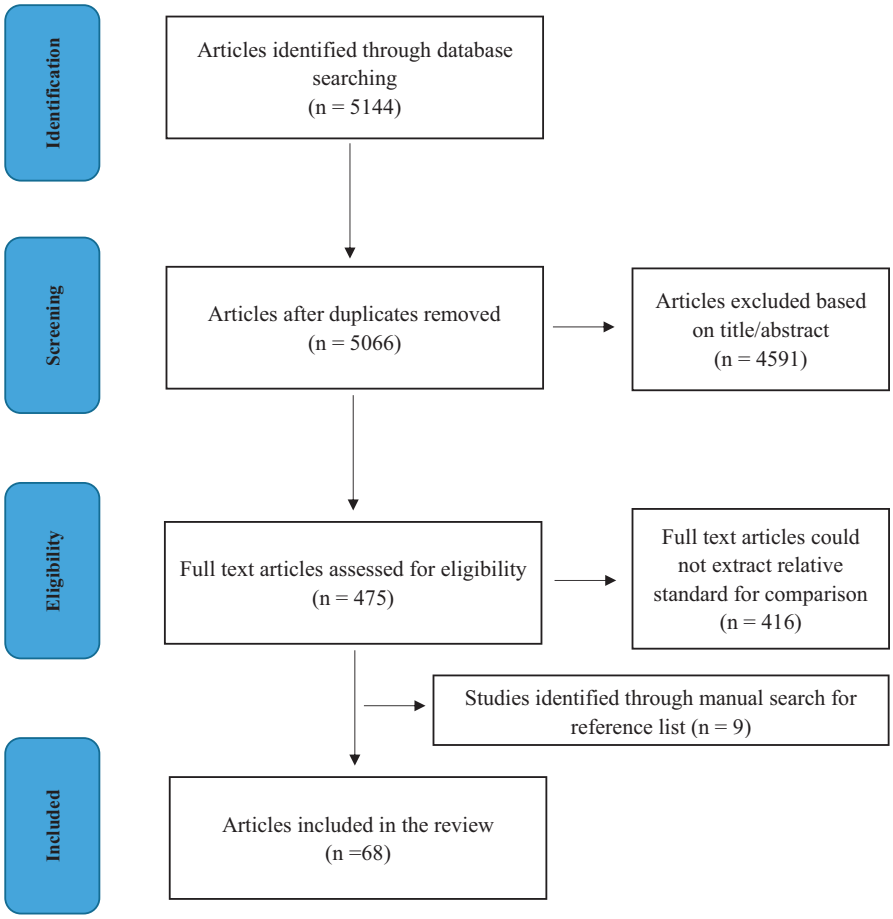

FIGURE 1 The procedure of selecting studies for inclusion in this review

domains should be considered and which are the essential domains for measuring frailty in older people.

3.2 | Domains of frailty

As mentioned, no international agreed definition of frailty exists until now, leading to various definitions worldwide. Hence, identifying the domains that contribute to frailty is difficult.[1] Most traditional definitions of frailty only focus on the physical domain of human functioning, and an increasing number of researchers have criticized this one-sided domain focus on frailty.[1,3,22-28] Researchers have begun to consider that frailty is of multidimensional nature.[27-31] Numerous studies have started investigating and reviewing the "domains contributing to frailty." A review of 17 different definitions of frailty has concluded that the common contributing domains can be grouped into physical, cognitive, psychological, nutritional, social, aging, and disease domains.[1] Another well-accepted study has found more domains contributed to frailty, including strength, nutrition, endurance, mobility, physical activity, balance, cognition, sensory function (hearing, visual acuity), mood (depressive functions, anxiety), coping, social relations, and social support.[21] Other researchers have added that sociodemographic domains, such as living alone, poverty, low education and area deprivation, polypharmacy domains, diseases (cancer, endocrine disorders, dementia) and their associated complications, and low physical activity, should also be considered when defining frailty.[32-35]

Frailty serves as a conceptual basis of a heath-based, integrative approach.[36] Taking the WHO concept of health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity," Gobbens et al defined frailty with human functioning losses of one or more domains of "Physical," "Psychological" and "Social."[21] Those mentioned above in different studies can almost be grouped into these three domains; for example, aging, disease, nutritional, strength, endurance, mobility, physical activity, polypharmacy, balance, and sensory function may be grouped into physical domains[37-42]; social relations and support, poverty, low education, area deprivation, and living alone may be grouped into social domains[43-47]; coping and mood may be grouped into psychological domains[48-50]; but cognitive may not be grouped into psychological domains or any of the two other domains. In 2013, the International Academy of Nutrition and Aging (IANA) and IAGG held a meeting in France about the rational and definition of "cognitive Frailty;" it emphasized that human functioning frailty coexists with cognitive impairment.[51] Such meeting intentionally included cognitive function as one of the major domains in shaping frailty. In conclusion, frailty was comprehensively shaped by these four recommended domains, which are physical, psychological, social, and cognitive aspects.

TABLE 1 Names, response modalities, domains, processes of instrumentation and psychometric properties of reviewed frailty measures (n = 42)

	Nature of the measurement		Response modalities and scoring	Psychometric properties in measuring older people	Operation of measurement
Names of instruments; Developer	**Item generation; Conceptual definition; Target population**	**Included domains (numbers of items)**	**Numbers of items; Response format; Scoring method**	**Reliability; Validity; Cutoff-value (sensitivity, specificity)**	**Time for completion; Way of administration; Requirement of special device(s) or training; Applicable setting**
Carriere's Instrument; Carriere et al (2005)	Unclear; Physical view of frailty; Older Women	Physical (6)	6; Translated into predictive score of 0-1; Summation of 6 items' score, range 25-165	Nil; Nil; Continual score, no cut-off point	>30 min; Combination of performance tests and self-report; Need special equipment and assessor training; Used in population based
Chin's Instrument; Chin et al (1999)	Unclear; Physical view of frailty; Older people	Physical (2)	2; Yes/no; Summation of 2 items, range 0-2	Nil; Nil; Dichotomous, frail or not frail	<10 min; Self-report; Nil; Used in population based
Clinical Frailty Scale (CFS); Rockwood et al (2005)	Unclear; Physical view of frailty; Elderly patients	Physical (1)	1; Visual and written chart for frailty with 9 graded pictures; Summation of score, 1 = very fit; 9 = terminally ill	Intra-class correlation coefficient 0.97, $P < .001$; Construct validity, Pearson coefficient 0.80, $P < .01$; Continual score, cut-off point ≥5	<5 min; Assessor tests; Need assessor training; Used in clinical based
Clinical Global Impression of Change in Physical Frailty (CGIC-PF); Studenski et al (2004)	Unclear; Multidimensional view on frailty; Elderly patients	Physical (7), social (2) & psychological (4)	13; Score 1-7; Summation of score	Inter-rater Reliability = 0.97-0.98; Content Validity and Feasibility: 75% or more of the geriatricians rated as very important and very feasible; Score = 4 No change, score = 7 Marked improvement; score = 1 Marked worsening	<10 min; Assessor tests; Need assessor training; Used in clinical based
Comprehensive Frailty Assessment Instrument (CFAI); Witte et al (2013)	Unclear; Multidimensional view on frailty; Older people	Physical (4), psychological (8), Social (6) & environment (5)	23; Yes/no; Summation of 23 items	$\alpha = 0.812$; Construct validity by CFA (6-factor model explained 63.6% of the variance); Factor loading = 0.32-0.80; Using a second-order confirmatory factor analysis. In a second-order factor analysis, all measurements are simultaneously introduced	<30 min, Assessor tests; Need assessor training; Used in population based

(Continues)

TABLE 1 (Continued)

Names of instruments; Developer	Nature of the measurement: Item generation; Conceptual definition; Target population	Included domains (numbers of items)	Response modalities and scoring: Numbers of items; Response format; Scoring method	Psychometric properties in measuring older people: Reliability; Validity; Cutoff-value (sensitivity, specificity)	Operation of measurement: Time for completion; Way of administration; Requirement of special device(s) or training; Applicable setting
Edmonton Frailty Scale (EFS); Rolfson et al (2006)	Unclear; Multidimensional view on frailty; Elderly patients	Physical (4), Social (2), Cognitive (2) & psychological (2)	9; Yes/no & score; Summation of score	Inter-rater reliability: $\kappa = 0.77$; $\alpha = 0.62$; Construct validation: EFS correlated with GCIF ($r = .64$) and Barthel Index ($r = -.58$), but not correlated with MMSE; Frailty = score ≥7	<5 min; Assessor tests; Need assessor training; Used in clinical based
Fatigue, Resistance, Ambulation, Illness and Loss of Weight (FRAIL) Index; Morley et al (2012)	Unclear; Physical view on frailty; People aged 45-60	Physical (5)	5; Yes/no; Summation of 5 items	Nil; The FRAIL scale showed strong convergent and predictive validity in this population of late middle-aged African Americans; Frailty ≥3 items, pre-frail 1-2 items, robust = 0 item	<10 min; Assessor tests; Need assessor training; Used in clinical & population based
Frail Elderly Functional Assessment (FEFA) Questionnaire; Gloth et al (1995)	Unclear; Physical view on frailty; Older people	Physical (19)	19; Yes/no with 4 choices; Summation of score	Test-retest reliability: $\kappa = 0.82$; Validity: $\kappa = 0.90$ (FAFA/direct observation tasks); Range 0-55 type, ordinal, no cut-offs points	10-20 min; Self-reports; Nil; Used in population based
Frail Non-Disabled (FiND) Instrument; Cesari et al (2014)	Unclear; Physical& psychological view on frailty; Older people.	Physical (4) & psychological (1).	5; Yes/no with 2 choices. Summation of score	Nil; Validity: $\kappa = 0.748$ (FiND/Frailty phenotype + 400-meter walk test), 84.4% participants were correctly categorized; Frail = score ≥1	<5 min; Self-reports; Nil; Used in clinical & population based
Frailty Index derived from Comprehensive Geriatric Assessment (FI-CGA); Jones et al (2004)	Unclear; Multidimensional view on frailty; Older frail people	10 domains of cognitive, mood, communication, mobility, balance, physical, nutrition, IADL/ADL, social & co-morbidity	52; A continuous score; Summation of score	Inter-rater reliability: 0.95-0.96; Predictive Validity: Adj HR = 1.23 (1.01-1.45); The area under the ROC curve for the FI-CGA with the IADL/ADL items was 5% higher than that for the disability score. Without the IADL items, it was 3% higher than that for the disability score; Frailty cut-off suggested >0.25	<15 min; Assessor tests; Need assessor training; Used in clinical based

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TABLE 1 (Continued)

Names of instruments; Developer	Nature of the measurement: Item generation; Conceptual definition; Target population	Included domains (numbers of items)	Response modalities and scoring: Numbers of items; Response format; Scoring method	Psychometric properties in measuring older people: Reliability; Validity; Cutoff-value (sensitivity, specificity)	Operation of measurement: Time for completion; Way of administration; Requirement of special device(s) or training; Applicable setting
Frailty Index of Accumulative Deficits (FI-CD); Mitnitski et al (2001)	Unclear; Multidimensional view on frailty; Elderly people	92 variables of health deficits include physical, psychological & social	92; A continuous score; Accumulated health deficits: score of 0-1.0 (all deficits)	Nil; Construct validity was examined through its relationship to chronological age (CA), ($r = .91$, $P < .001$); Frailty cut-off suggested >0.25 Mitnitski et al (2002)	<30 min; Assessor tests; Need assessor training; Used in clinical based
Frailty Risk Score (FRS); Pijpers et al (2009)	Unclear; Multidimensional view on frailty; Psychogeriatric older patients	5 characteristics of study population: socio-demographic, medical, nutritional, physical function & cognitive function	5; A continuous score; Summation of score	Nil; The AUC of the risk score was 0.78 (95% CI 0.73-0.82), $R^2 = 38\%$, indicating good discriminative performance; Cut-off value ≥56 points may be identifying those patients having a "poor" or "very poor" prognosis	>30 min; Assessor tests; Need special equipment and assessor training; Used in clinical based
Frailty Trail Scale (FTS); Garcia-Garcia et al (2014)	Unclear; Physical view on frailty; Older people	7 frailty dimensions: energy balance—nutrition, physical activity, nervous system, vascular system, strength, endurance & gait speed	12; A continuous score; Summation of score	Nil; Compared with Fried et al's definition, the FTS showed a better predictor for hospitalization in persons younger than 80 (area under the curve [AUC] = 0.65 vs 0.62, $P = .01$), and for mortality in the oldest group (AUC = 0.77 vs 0.72, $P = .02$). FTS showed similar predictive value to the Frailty Index Frailty: scores ≥50 (68%, 72%)	>30 min; Assessor tests; Need special equipment and assessor training; Used in clinical based & population based

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TABLE 1 (Continued)

Names of instruments; Developer	Nature of the measurement: Item generation; Conceptual definition; Target population	Included domains (numbers of items)	Response modalities and scoring: Numbers of items; Response format; Scoring method	Psychometric properties in measuring older people: Reliability; Validity; Cutoff-value (sensitivity, specificity)	Operation of measurement: Time for completion; Way of administration; Requirement of special device(s) or training; Applicable setting
Fried's Frailty Phenotype—Cardiovascular Health Study Index (CHS); Fried et al (2001)	Unclear; Physical& psychological view on frailty; Older people	Physical (4) & psychological (1)	5; Yes/no with some choices; Summation of 5 items	Nil; Predictive validity was evaluated with its association prospectively using Cox proportional hazards models, ranging from 1.82 to 4.46 and 1.28 to 2.10 for the frail and intermediate groups, respectively, over 3 or 7 y; Frailty ≥3 items; pre-frail 1-2 items; robust = none	<10 min; Assessor tests; Need special equipment and assessor training; Used in clinical based & population based
Functional Independence Measure (FIM); Kidd et al (1995)	Unclear; Physical& cognitive view on frailty; Patients undergoing neuro-rehabilitation	Motor (13) & cognition (2)	18; Scored on a seven-point scale; Summation of score	Mean difference (FIM change) = 3.20 (−6.67 to 13.07); Kappa statistic (FIM change) = 0.78 (0.49-1.0); Frailty: scores ≥50	<20 min; Self-reports; Nil; Used in population based
G8; Baitar et al (2013)	Unclear; Physical& psychological view on frailty; Older patients with cancer	Loss of appetite, loss of weight; mobility, neuropsychological problems, body mass index; take ≥3 prescription drugs per day, age & status	7; Possible answers/scores; Summation of score	Nil; The AUC compared to the reference standard MGA (Multidimensional geriatric assessment) was 0.804, 95% CI 0.78-0.83; Total score range 0-17, cut-off value G8 score ≤14 to define an abnormal screening tool Soubeyran et al (2014)	<10 min; Performance test; Need assessor training; Special for cancer patients
Gait Speed; Abellan Van Kan et al (2009)	Unclear; Physical view on frailty; Older people	5 s to perform a 4 m course	1; Performance test; Check the time	Nil; The ROC curves showed very similar areas under the AUC curve for gait speed (0.67) and SPPB (0.69) showing a non-significant *P*-value ($P = .18$); Gait speed <0.8 ms^{-1} is a cut-off point for health adverse outcomes	<5 min; Performance test; Need special equipment and assessor training; Used in clinical based & population based

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TABLE 1 (Continued)

Names of instruments; Developer	Nature of the measurement: Item generation; Conceptual definition; Target population	Included domains (numbers of items)	Response modalities and scoring: Numbers of items; Response format; Scoring method	Psychometric properties in measuring older people: Reliability; Validity; Cutoff-value (sensitivity, specificity)	Operation of measurement: Time for completion; Way of administration; Requirement of special device(s) or training; Applicable setting
Gealey's Instrument; Gealey (1997)	Unclear; Physical view on frailty; Elderly people	ADL/IADL Scale	10 OR 14; Possible answers; Summation of items	Nil; Nil; Combination of ADL/IADL: 0-24. Dichotomous (frail—not frail)	<20 min; Self-report; Nil; Used in population based
Geriatric Functional Evaluation (GFE); Scarcella et al (2005)	Unclear; Multidimensional view on frailty; Older people	Physical (2), psychological (1) & social (4)	7; A continuous score; Summation of scores	Nil; Nil; Range: −118 to +91 types: ordinal, 3 level (not self-sufficient, partially self-sufficient & self-sufficient)	<20 min; Self-report; Nil; Used in population based
Gérontopôle Frailty Screening Tool (GFST); Vellas et al (2013)	Unclear; Multidimensional view on frailty; Older persons	Physical (4), cognitive (1) & social (1)	6; Yes/no & performance test; Summation of items & scores	Nil; Nil; 95.2% participants were correctly categorized as pre-frail (31.1%) or frail (64.1%)	<5 min; Self-report & clinical judgment; Need assessor training; Used in clinical based
Groningen Frailty Indicator (GFI); Steverink et al (2001)	Unclear; Multidimensional view on frailty; Older people	Physical (9), cognitive (1), social (3) & psychological (2)	15; Yes/no; Summation of 15 items	α = 0.68-0.77; Convergent validity = 0.45-0.61; Discriminant validity = 0.08-0.50; Construct validity by Known-group method (significant difference score obtained from community and institutionalized older people); Construct validity by factor analysis (3-factor model explained 50.6% of the variance); Frailty = scores >4 (66%, 87%) Peters et al (2012) Baitar et al (2012) Bielderman et al (2013)	<15 min; Self-reporting; Nil; For community screening
Guilley's Instrument; Guilley et al (2015)	Unclear; Physical& cognitive view on frailty; Older people	Physical (4) & cognitive (1)	5; Yes/no with some choices; Summation of score	Nil; Nil; Frailty = score ≥4	<10 min; Self-report; Nil; For community screening

(Continues)

TABLE 1 (Continued)

Names of instruments; Developer	Nature of the measurement: Item generation; Conceptual definition; Target population	Included domains (numbers of items)	Response modalities and scoring: Numbers of items; Response format; Scoring method	Psychometric properties in measuring older people: Reliability; Validity; Cutoff-value (sensitivity, specificity)	Operation of measurement: Time for completion; Way of administration; Requirement of special device(s) or training; Applicable setting
Hospital Admission Risk Profile (HARP); Seger et al (1996)	Unclear; Physical& cognitive view on frailty; Older patients who were hospitalized for acute medical illness	Age, cognitive function, IADL function prior to admission & risk categories	4; Possible answers; Summation of score	Nil; The relationship between increasing functional decline in higher risk categories was significant in both the development ($\chi^2 = 47.9$, $P < .001$) and the validation ($\chi^2 = 28.3$, $P < .001$) cohort. The area under the ROC curve was 0.65 in the validation cohort, indicating a moderate degree of predictive discrimination; Low risk = HAPP score 0-1; intermediate risk = HAPP score 2 or 3; high risk = HAPP score 4 or 5	<20 min; Assessor tests; Need special equipment and assessor training; Used in clinical based
Identification of Seniors at Risk (ISAR) Score; Mccusker et al (1998)	Unclear; Multidimensional view on frailty; Older people who came to the Emergency Department during 3 mo	Physical (8), personal data (2), psychological (2), cognitive (1), social/ medical (11)	24; Yes/no with some choices; Summation of items and scores	Test-Retest Reliability: $\kappa = 0.78$; Concurrent Criterion Validity: Several screening questions showed moderately good agreement with the appropriate criterion standard; The best subset of 9 screening questions explained 49% of the variance in the total disability score; The ISAR scale can be used with different cut-points, depending on the resources available	<5 min; Self-report; Nil; Used in clinical based especially used in Emergency Department (ED)
Kihon Checklist (KCL); Satake et al (2016)	Unclear; Multidimensional view on frailty; Older people	25 items of cognitive, mood, communication, mobility, balance, physical, nutrition, IADL/ADL, social & co-morbidity	25; A continuous score; Summation score of 0-1.0	Nil; Frailty: ≥7/8 of total scores (89.5%, 80.7%); Pre-frailty: ≥3/4 of total scores (70.3%, 78.3%); Frailty cut-off suggested >0.25	<10 min; Assessor tests; Need assessor training; Population level screening

(Continues)

TABLE 1 (Continued)

Names of instruments; Developer	Nature of the measurement: Item generation; Conceptual definition; Target population	Included domains (numbers of items)	Response modalities and scoring: Numbers of items; Response format; Scoring method	Psychometric properties in measuring older people: Reliability; Validity; Cutoff-value (sensitivity, specificity)	Operation of measurement: Time for completion; Way of administration; Requirement of special device(s) or training; Applicable setting
Handgrip Strength (HS); Garcia-Pena et al (2013)	Unclear; Physical view on frailty; Older patients who were admitted in acute care unit during a two-year period	Performance tests	1; Performance test; Check the kilogram	$\alpha = 0.871$ (BI); Intra-class correlation coefficient: 0.861 (BI/HS); Frailty: HS <20.65 kg (56%, 91.3%)	<5 min; Performance test; Need special equipment and assessor training; Used in clinical based & population level screening
Multidimensional Prognostic Instrument (MPI); Pilotto et al (2008)	Unclear; Multidimensional view on frailty; Elderly hospitalized patients	Co-morbidity, nutrition, cognition, poly-pharmacy, pressure sore risk, living status, ADL & IADL	8; A continuous score; Summation score of 0-1.0	Nil; AUC = 0.781(0.70-0.80); Frailty >0.66, pre-frail = 0.34-0.66, robust <0.34	<15 min; Assessor tests; Need assessor training; Used in clinical &population based
PRISMA-7 Questionnaire; Raiche et al (2007)	Unclear; Multidimensional view on frailty; Older people	ADLs & social support	7; A continuous score; Summation of score	Nil; Both the PRISMA-7 and nine-question tools had a ROC curve with an area different from the null area of 0.5, AUC = 0.840 (0.797-0.882), no significant; Frailty: ≥3 positive answers (78.3%, 74.7%)	<10 min; Self-report; Nil; Used in clinical based
Puts' Instrument; Puts et al (2005)	Unclear; Physical& psychological view on frailty; Older people	Body weight, peak expiratory flow, cognition, vision, hearing problems, incontinence, sense of mastery, depressive symptoms, physical activity	9; A continuous score; Summation of score	Nil; Nil; Frailty cut-off: frailty markers ≥3	>30 min; Combination of performance tests & self-report; Need special equipment and assessor training; Used in clinical & population based
Ravaglia's Instrument; Ravaglia et al (2008)	Unclear; Physical view on frailty; Older people	Age, gender, low physical activity, co-morbidity, sensory deficit, calf circumference, gait, performance test score, pessimism about one's health	9; Performance tests/ possible answers; Check record & summation of items	Nil; Nil; Range: 0-9 type: ordinal, no cut-off points	<30 min; Combination of performance tests & self-report; Need special equipment and assessor training; Used in population based

(Continues)

TABLE 1 (Continued)

Names of instruments; Developer	Nature of the measurement: Item generation; Conceptual definition; Target population	Included domains (numbers of items)	Response modalities and scoring: Numbers of items; Response format; Scoring method	Psychometric properties in measuring older people: Reliability; Validity; Cutoff-value (sensitivity, specificity)	Operation of measurement: Time for completion; Way of administration; Requirement of special device(s) or training; Applicable setting
Rothman's Instrument; Rothman et al (2008)	Unclear; Multidimensional view on frailty; Older people	Physical (4), psychological (2) & cognitive (1)	7; Performance tests/ possible answers; Check record & summation of items	Nil; Nil; Frailty ≥3 items, pre-frail = 1-2 items, robust = none	<15 min; Combination of performance tests & self-report; Need special equipment and assessor training; Used in clinical & population based
Score Hospitalierd'Evaluation du Risque de Perted'Autonomie (SHERPA); Cornette et al (2005)	Unclear; Physical & cognitive view on frailty; Older hospitalization patients	Fall in the previous year, MMSE <15/21; bad self-perceived health, age & pre-admission IADL score	5; A continuous score; Summation of score	The intra-class correlation coefficients were 0.89 for IADL, 0.86 for ADLs and 0.77 for MMSE; The area under the ROC curve was 0.734; Frailty: score <5 positive answers (67.9%, 70.8%)	<10 min; Assessor tests; Need special equipment and assessor training; Used in clinical based especially for medical impatient population
Self-rated Health Deficits Index (SRHDI); Lucicesare et al (2009)	Unclear; Physical view on frailty; Older people	Physical (4)	4; Possible answer; Summation of score	Nil; Convergent construct validation was tested by correlating the SRHDI with measures of several characteristics that have been associated with worse health—and thus with frailty; SrHS range 0-14, number of deficits possible (N/14), to yield a SRHDI range 0-1, cut-offs suggested SrHS ≥5; SRHDI ≥0.43	<5 min; Self-rated health response; Nil; Used in population based

(Continues)

TABLE 1 (Continued)

Names of instruments; Developer	Nature of the measurement: Item generation; Conceptual definition; Target population	Included domains (numbers of items)	Response modalities and scoring: Numbers of items; Response format; Scoring method	Psychometric properties in measuring older people: Reliability; Validity; Cutoff-value (sensitivity, specificity)	Operation of measurement: Time for completion; Way of administration; Requirement of special device(s) or training; Applicable setting
Self-report Screening Instrument; Brody et al (1997)	Unclear; Multidimensional view on frailty; Older people	Self-report questionnaire on health status & health service utilization	16; Possible answers; Summation of percentage	Nil; Comparison of Empiric HSF Models to Administrative Data Model for Predicting Frail Elderly Member (Validated on 1/3 sample, n = 1937, $P = .50$), Empiric Model 13 Variables (percent frail = 14.6, sensitivity = 54.6, specificity = 97.9); Range: 0%-100% type: dichotomous (not frail, frail)	<20 min; Self-report; Nil; Used in population based
Sherbrooke Postal Questionnaire (SPQ); Hebert et al (1996)	Unclear; Multidimensional view on frailty; Older people	Physical (3), cognitive (1) & social (2)	6; A continuous score; Summation of score	Inter-rater reliability study showed mean Cohen's weighted Kappas of 0.75; Test-retest reliability was done and Kappa coefficients for the individual items ranged from 0.64 to 1.00; Validity was tested comparing SMAF scores ($r = .88$); Frailty: score ≥2 (75%, 52%)	<20 min; Self-report; Nil; Used in population based
Short Physical Performance Battery (SPPB); Guralnik et al (1994)	Unclear; Physical view on frailty; Older people	Physical performance measures: balance, gait, strength and endurance; Self-reported physical functioning—activities of daily living (ADLs)	8+; Performance test record & possible answers; Summation of score	$\alpha = 0.76$; Nil; Nil	<15 min; Performance test & self-report; Need special equipment and assessor training; Used in clinical based
Study of Osteoporotic Fracture (SOF) Index; Ensrud et al (2007)	Unclear; Physical & psychological view on frailty; Older women	Physical (2) & psychological (1)	3; Possible answers; Summation of items	Nil; Nil; Frailty ≥2 items, pre-frail = 1 item, robust = 0 item	<5 min; Self-report; Nil; Used in population based

(Continues)

TABLE 1 (Continued)

Names of instruments; Developer	Nature of the measurement: Item generation; Conceptual definition; Target population	Included domains (numbers of items)	Response modalities and scoring: Numbers of items; Response format; Scoring method	Psychometric properties in measuring older people: Reliability; Validity; Cutoff-value (sensitivity, specificity)	Operation of measurement: Time for completion; Way of administration; Requirement of special device(s) or training; Applicable setting
Strawbridge frailty questionnaire; Matthews et al (2003)	Unclear; Physical & cognitive view on frailty; Older outpatients from a geriatric practice	Physical (12) & cognitive (4)	16; Yes/no; Summation of items	The 8-week test-retest agreement of physician frailty judgments was 94%; Agreement between physician frailty assessment & Strawbridge classification was modest at 67% ($\kappa = 0.294$); Nil; Range: 0-16 type: dichotomous (not frail, frail)	<20 min; Self-report; Nil; Used in population based
Triage Risk Screening Tool (TRST); Fan et al (2006)	Unclear; Multidimensional view on frailty; Older patients of an Emergency Department	Physical (1), cognitive (1) & social/medical (3)	5; Possible answers; Summation of score	Nil; At 30 & 120 days, the positive Likelihood ratios (LRs) were 1.4% (95% CI, 0.9-2.0) & 1.4 (95% CI, 1.0-1.9), respectively, the negative LRs were 0.7 (95% CI, 0.4-1.3) & 0.7 (95% CI, 0.4-1.0), respectively; Patient defined as high-risk by the TRST (score ≥2)	<15 min; Assessor tests; Need assessor training; Used in clinical based
Tilburg Frailty Indicator (TFI); Gobbens et al (2010)	Unclear; Multidimensional view on frailty; Older people	Physical (8), psychological (4), social (3)	15; Yes/no & possible choices; Summation of score	$\alpha = 0.73$; Construct Validity: $r = .42, .19, .18$ (the frailty domains between the physical and psychological, the physical and social, the psychological and social, respectively); Frailty: score ≥5 (84%, 76%)	<15 min; Self-report; Nil; Used in clinical based & population level screening
Vulnerable Elders Survey (VES-13); Saliba et al (2001)	Unclear; Physical view on frailty; Older Medicare beneficiaries	Physical (13)	13; Yes/no & possible choices; Summation of score	Nil; Nil; Frailty: score ≥4 (67%, 79%)	<5 min; Self-report; Nil; Used in population level screening

(Continues)

TABLE 1 (Continued)

Names of instruments; Developer	Nature of the measurement: Item generation; Conceptual definition; Target population	Included domains (numbers of items)	Response modalities and scoring: Numbers of items; Response format; Scoring method	Psychometric properties in measuring older people: Reliability; Validity; Cutoff-value (sensitivity, specificity)	Operation of measurement: Time for completion; Way of administration; Requirement of special device(s) or training; Applicable setting
Winograd's Instrument; Winograd et al (1991)	Unclear; Multidimensional view on frailty; Older male patients admitted to the Medical and Surgical services	Physical (7), psychological (3), social/disease (5)	15; Possible answers; Summation of items	Inter-rater reliability was determined with a sample of 53 admissions which were screened independently by the project coordinator & the research assistant during a 1-week period; Nil; Range: 0-15 type: dichotomous (frail, not frail)	<15 min; Assessor tests; Need special equipment & assessor training; Used in clinical based especially for elderly hospitalized patients

3.3 | Characteristics of the reviewed measurements

Of the 5144 relevant studies, 42 frailty measurements were identified. For the type, three different measurements were indicated, namely, self-report instrument (n = 17), clinical observation assessment (n = 19), and mixed frailty assessment instrument (n = 6). The self-reporting type was mainly applied for screening community older people. The latter two were used for older patients in clinical or institutionalized settings.

The item numbers ranged from 1 (ie, Clinical Frailty Scale) to 52 (ie, Frailty Index derived from Comprehensive Geriatric Assessment [FI-CGA]). Most clinical observation frailty assessments conceptualized frailty as a physical deficit for diagnosis, whereas the self-report and mixed one employed multidimensional perspectives, namely physical, psychological, social, and cognitive domains (eg, GFI). Only 12 (29%) measurements examined reliability and validity. Nevertheless, over 35% did not perform any psychometric testing before applying. For diagnosis accuracies, 35 (83%) frailty measurements reported the cut-off value(s) for determining the level of frail. However, the sensitivity (56%-89.5%) and specificity (52%-91.3%) varied. The lowest sensitivity (56%) was tested in the measurement of "Handgrip Strength (HS),"[52] whereas the highest sensitivity (89.5%) was tested in the measurement of "Kihon Checklist (KCL)."[53] The lowest specificity (52%) was tested in the measurement of "Sherbrooke Postal Questionnaire (SPQ),"[54] whereas the highest specificity (91.3%) was tested in the measurement of "HS."[52]

The details of comparisons of the 42 reviewed frailty instruments are displayed in Table 2.

4 | DISCUSSION

This thorough review of studies about frailty measurements on older people provides a comprehensive picture of frailty measurements. We are the first studies evaluating and grouping the types of frailty measurement that facilitated the appropriate application in different research.

Although no international definition of frailty and no international standard frailty measurements are available, a large number of frailty measurements exists, and some of them include comprehensive domains corresponding to WHO's definition of "health". However, none of these identified frailty measurements were developed in developing countries; most of them were developed in western countries. Given that large-population countries are mostly in Asia, and the rapid aging problem has switched from developed countries to developing countries since the 21st century,[55] cross-cultural studies of different types of frailty measurements or research on the frailty measurement development of older Asian people should be considered in the future.

TABLE 2 Comparisons of reviewed frailty instruments

Name of instruments	Self-reported	Multi-dimensional including physical, psychological, social and cognitive domains	Satisfactory psychometric properties		Items	Used in Chinese people or not
			Reliability	Validity		
Carriere's Instrument	✗	✗	✗	✗	6	✗
Chin's Instrument	✓	✗	✗	✗	2	✗
Clinical Frailty Scale (CFS)	✗	✗	✓	✓	1	✓
Clinical Global Impression of Change in Physical Frailty (CGIC-PF)	✗	✗	✓	✓	13	✗
Comprehensive Frailty Assessment Instrument (CFAI)	✗	✗	✓	✓	23	✗
Edmonton Frailty Scale (EFS)	✗	✗	✓	✓	9	✓
Fatigue, Resistance, Ambulation, Illness and Loss of Weight (FRAIL) Index	✗	✗	✗	✓	5	✗
Frail Elderly Functional Assessment (FEFA) Questionnaire	✓	✗	✓	✓	19	✓
Frail Non-Disabled (FiND) Instrument	✓	✗	✗	✓	5	✗
Frailty Index derived from Comprehensive Geriatric Assessment (FI-CGA)	✗	✓	✓	✓	30+	✓
Frailty Index of Accumulative Deficits (FI-CD)	✓	✗	✗	✓	30+	✓
Frailty Risk Score (FRS)	✗	✗	✗	✓	5	✗
Frailty Trail Scale (FTS)	✗	✗	✗	✓	12	✗
Fried's Frailty Phenotype—Cardiovascular Health Study Index (CHS)	✗	✗	✓	✓	5	✓
Functional Independence Measure (FIM)	✓	✗	✓	✓	6	✓
G8	✗	✗	✗	✓	7	✗
Gait Speed	✗	✗	✗	✓	1	✓
Gealey's Instrument	✗	✗	✗	✗	10 OR 14	✗
Geriatric Functional Evaluation (GFE)	✓	✗	✗	✗	7	✗
Gérontopôle Frailty Screening Tool (GFST)	✓	✗	✗	✗	6	✗
Groningen Frailty Indicator (GFI)	✓	✓	✓	✓	15	✓
Guilley's Instrument	✓	✗	✗	✗	5	✗
Hospital Admission Risk Profile (HARP)	✗	✗	✗	✓	3	✓
Identification of Seniors at Risk (ISAR) Score	✓	✗	✓	✓	6	✗
Kihon Checklist (KCL)	✗	✗	✗	✓	25	✓
Handgrip Strength (HS)	✗	✗	✓	✓	1	✓
Multidimensional Prognostic Instrument (MPI)	✗	✗	✗	✓	8	✗
PRISMA-7 questionnaire	✓	✗	✗	✓	7	✗
Puts' Instrument	✗	✗	✗	✗	9	✗
Ravaglia's Instrument	✗	✗	✗	✗.	9	✗
Rothman's Instrument	✗	✗	✗	✗	7	✗

(Continues)

TABLE 2 (Continued)

Name of instruments	Self-reported	Multi-dimensional including physical, psychological, social and cognitive domains	Satisfactory psychometric properties		Items	Used in Chinese people or not
			Reliability	Validity		
Score Hospitalierd'Evaluation du Risque de Perted'Autonomie (SHERPA)	✗	✗	✓	✓	5	✗
Self-rated Health Deficits Index (SRHDI)	✓	✗	✗	✓	4	✓
Self-report Screening Instrument	✓	✗	✗	✓	16	✗
Sherbrooke Postal Questionnaire (SPQ)	✓	✗	✓	✓	6	✗
Short Physical Performance Battery (SPPB)	✓	✗	✓	✗	2	✓
Study of Osteoporotic Fracture (SOF) Index	✓	✗	✓	✓	3	✗
Strawbridge Frailty Questionnaire	✓	✗	✓	✗	16	✗
Triage Risk Screening Tool (TRST)	✗	✗	✗	✓	5	✗
Tilburg Frailty Indicator (TFI)	✓	✗	✓	✓	15	✓
Vulnerable Elders Survey (VES-13)	✓	✗	✗	✗	13	✗
Winograd's Instrument	✗	✗	✗	✓	15	✗

4.1 | Types of frailty measurement

As stated above, frailty measurements have three main types.[56] First is the self-report frailty instrument, which allows the collection of a large amount of data to well estimate the prevalence of frailty in the community setting because of the nature of self-reporting. Approximately 41% of identified instruments (eg, GFI,[57] TFI,[21] SPQ,[54] Vulnerable Elders Survey,[58] Strawbridge Frailty Questionnaire,[59] and Identification of Seniors at Risk [ISAR])[60] are self-reporting frailty measurements. This kind of measurement is appropriately used for the purpose of screening because of the absence of the assessment by medical or healthcare professionals. Therefore, for performing a population-based frailty estimation, these instruments would be helpful to efficiently obtain a large amount of data within a short period of time.

Second is the clinical observation frailty assessment instrument. It allows the collection of data of medical or healthcare professional assessments about frailty. Moreover, it is more objective. Approximately 45% of identified instruments (eg, Clinical Frailty Scale,[61] Clinical Global Impression of Change in Physical Frailty [CGID-PF],[62] and Short Physical Performance Battery)[63] measure the frailty from physical and psychological perspectives. However, this kind of measurement is mostly used in the clinical field, rather than in the community setting; the reason is that the nature of clinical judgment and the special equipment needed (eg, CGIC-PF require geriatricians to assess patients).[64,65] Hence, it is anticipated that data collection would be more expensive and it takes longer time to obtain a sufficient frailty information of the target population. However, the high objectivity indicated a high diagnostic accuracy, which would be beneficial to be used for clinical judgment and hence treatment.

Third is the mix frailty assessment instrument, which is based on a broad definition that includes multinature domains. Approximately 14% of those identified instruments (eg, EFS,[66] FI-CGA,[67] Triage Risk Screening Tool)[68] measure the frailty through self-report and clinical observation assessment. The number of items is almost over a hundred for the sake of a comprehensive frailty diagnosis. Obtaining a large amount of data from a population-based approach is thus seldom feasible. However, like FI-CGA, it is used as a clinical standard for frailty assessment for it has proven to predict patient response in multiple fields (eg, orthopedics, immunology, oncology, and etc).[2]

4.2 | Applicability for screening

Considering the rapid aging population problem in the whole world, a fast and valid frailty measurement for frailty prevalence screening on older people is effective, particularly for developing countries with large population. However, the world's most commonly used frailty measurement with high validity and reliability is Frailty Index,[69] which is clinically used and time-consuming and thus cannot be easily used for cross-sectional large-population prevalence research.[70-73] Hence, self-reported frailty measurements are needed to be tested in different cultures of older people; their testing diagnosis accuracies must also be determined before use.[74-76]

Moreover, geriatric researchers must agree on a brief, effective frailty measurement, which can help establish an international or a gold standard of frailty measurement in the future.[77-80] The health

electronic large data or Health Cloud Platform may play a role in the development of frailty measurements and in the creation of an international definition of frailty integration.[73]

4.3 | Research implications

Table 2 shows 12 self-reported frailty measurements/screening tools and only seven reported satisfactory psychometric properties, which include satisfactory reliability, and validity. These instruments are Frail Elderly Functional Assessment (FEFA) Questionnaire, Functional Independence Measure (FIM), GFI, ISAR Score, SPQ, Study of Osteoporotic Fracture Index, and TFI. These frailty instruments are brief and have less than 20 items each. Among the seven frailty instruments, four have been used in the Chinese population (GFI, TFI, FEFA, and FIM). Moreover, GFI and TFI have been the most extensively examined in terms of psychometric properties. Furthermore, GFI encompasses all four essential domains of "physical," "psychological," "cognitive," and "social."

Many frailty instruments have been developed, but only some of them have been tested on reliability and validity. All of the frailty instruments existing now are from developed countries, and a few of them have been validated in the Chinese population. Regarding the different cultures and living environments of older people, a context-relevant, reliable, valid and self-reported frailty instrument for the Chinese older population is recommended. The implication of this review is to find a sound and multidimensional frailty instrument for older Chinese people and to validate among them. Furthermore, this contextual-specific and valid frailty instrument can help fill the literature gap of cultural differences and interpretations of frailty between different populations of developed and developing countries.

From the literature review of the 42 existing frailty instruments, in terms of the characteristic and type of the reviewed frailty instruments, GFI and TFI have a self-reporting nature, satisfactory psychometric properties, and are embedded with the essential domains, which are recommended as screening tools for frailty in community-dwelling older people.

4.4 | Limitations

We performed a narrative review, which lacks, rigorous search methodology, quality assessment, an analysis and quality appraisal section, synthesis methods of searching results, and reports of risks or biases of a systematic review. We think that a formal COSMIN systematic review should be important to expand our work once the gold criteria of frailty are developed.[70]

5 | CONCLUSIONS

This review reveals the three major types of frailty measurements used in different settings with different purposes. For estimating the frailty of older people in the community setting, the self-report type may be appropriate. The psychometric properties are reported insufficiently. The cut-off value(s) are usually suggested with diverse sensitivity and specificity. National health departments and nursing homes or medical care centers for older people should pay greater attention to frailty.

CONFLICT OF INTEREST

The authors declare no conflict of interest to disclose regarding the publication of this article.

AUTHOR CONTRIBUTIONS

Emma Yun-zhi HUANG conceived the idea of this narrative review, and designed, conducted the study and drafted the manuscript. Simon Ching LAM was the secondary reviewer of this narrative review and involved with screening, data analysis, and provided important intellectual facts to revise the manuscript.

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