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Review

Outcome instruments to measure frailty: A systematic review

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ABSTRACT

Frailty is one of the greatest challenges for healthcare professionals. The level of frailty depends on several interrelated factors and can change over time while different interventions seem to be able to influence the level of frailty. Therefore, an outcome instrument to measure frailty with sound clinimetric properties is needed. A systematic review on evaluative measures of frailty was performed in the databases PubMed, EMBASE, Cinahl and Cochrane. The results show numerous instruments that measure the level of frailty. This article gives a clear overview of the content of these frailty instruments and describes their clinimetric properties. Frailty instruments, however, are often developed as prognostic instruments and have also been validated as such. The clinimetric properties of these instruments as evaluative outcome measures are unclear.

1. Introduction

Frailty is one of the greatest challenges for healthcare professionals in societies faced with ageing populations (Levers et al., 2006). It is associated with adverse health outcome, dependency, institutionalization and mortality (Fried et al., 2001, 2004). Since the population of (frail) elderly is still growing and health care utilization among this population is increasing, prevention of frailty or maintenance/reduction of the level of frailty should have priority among geriatric health care professionals. While frailty is known to be changeable over time (Hubbard et al., 2009a; Gill et al., 2010) it is, at this point, still unclear to what extent the level of frailty can be influenced by interventions. Therefore, an evaluative outcome instrument to measure frailty with sound clinimetric properties is needed (De Lepeleire et al., 2009). The aim of this systematic review is to find the best available frailty instrument that could be used as an evaluative outcome measure in clinical situations and observational and experimental studies.

The causes of frailty are not fully understood. A pathophysiological pathway that shows similarities with, but is not identical to the ageing process, is suggested. A chronic inflammation process, impaired immunity, neuroendocrine dysregulations and metabolic alterations seem to be related to frailty but true comprehension of the involved pathway is still lacking (Fulop et al., 2010). Even though the underlying mechanism of frailty is not fully understood, frailty is, since early publications, considered to be a physiologic loss of reserve capacity and resistance to stressors (Fried et al., 2001; Rockwood et al., 1994). As a result, environmental factors have more influence on the decline of wellbeing (Strawbridge et al., 1998). A remarkable finding in frailty is that not all frail elderly experience the same symptoms and that frailty can be present in the absence of specific diseases, but more likely in combination with or as a consequence of co-morbidity (Fried et al., 2004; Fulop et al., 2010). This means that frailty is not identical to co-morbidity. Because of similarities and inter relationships between the biological pathways of frailty, ageing and age related chronic disease, a definitive differentiation between these pathways is difficult to make (Fulop et al., 2010). Such an interacting process also applies to disability, one of the main consequences of frailty. Frail elderly with the same number of co-morbidities can suffer from very different levels of disability (Fried et al., 2004). The reason for this is that disability is also influenced by other than biological or physiological factors, for example personal characteristics including psychological state, emotional state and coping style. There is also an interaction with the physical and social environment, which can stimulate or hinder participation in activities.

Therefore, in the last few years, frailty is acknowledged to be not only a biological or physiological state, but also a multidimensional concept (Walston et al., 2006). There are multiple interrelated

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(risk) factors with great variety that can disrupt the physiological equilibrium of elderly. A complicating factor in understanding and defining frailty is that some (risk) factors that are involved in frailty can primary be seen as causes of the physiological process while other factors are merely consequences of the disturbed equilibrium which, however, also indirectly have an influence on the state of the physiological system (Fulop et al., 2010). This is obvious in the extent of disability: frailty causes disability, but when activity increases and disability decreases this slows down the frailty process (De Lepeleire et al., 2009). This means that there seems to be a dynamic system in which interrelated causes and consequences remain to be clarified.

Most authors consider examining risk factors associated with frailty, as an important item in prevention and curative care. However, the used definitions of frailty differ subtly and also the conceptualization of the multiple domains (Strawbridge, Rockwood, Fried, Jones, Mitnitski etc.). Recently, an integral conceptual model of frailty was presented that reflects current thinking on frailty and is based on the following definition of frailty: 'Frailty is a dynamic state affecting an individual who experiences losses in one or more domains of human functioning (physical, psychological, and social), which is caused by the influence of a range of variables and which increases the risk of adverse outcomes' (Gobbens et al., 2010a, p. 85). Because this definition reflects the changeability of frailty over time and emphasizes that the interacting factors in the physical, psychological and social domain are part of a complex dynamic system, we take this definition as a starting point.

Within each of the physical, psychological and social dimension various (risk) factors or determinants for frailty exist. The complex interaction between these factors determines and influences the level of frailty. The total level of frailty is therefore not equivalent to the sum of its components. The actual level (the state at a certain point of time) of frailty can be positioned on a continuum between frail and not frail (Gobbens et al., 2009). But this level of frailty can change over time in either direction, meaning that one can become more or less frail. Evidence suggests that there are opportunities to influence the level of frailty positively by means of interventions like hormone replacement, nutrition or physical activity (Hubbard et al., 2009a; De Lepeleire et al., 2009; Chin A Paw et al., 2008; Peterson et al., 2009). To explore the extent to which interventions can influence the level of frailty, an evaluative outcome measure on frailty is needed (De Lepeleire et al., 2009). Such an instrument should incorporate the multiple dimensions of frailty to reflect the complex interaction of multiple (risk) factors that, in this interaction, attribute to the total level of frailty and should be able to distinguish multiple levels of frailty and therefore be able to measure change.

Based on recent studies (Gobbens et al., 2009, 2010b,c; Karunananthan et al., 2009; Sourial et al., 2009) and after ample discussion we composed a list of eight frailty (risk) factors that are mentioned to be of great importance to the concept of frailty. These factors include in the physical dimension: nutritional status, physical activity, mobility, strength and energy, in the psychological dimension: cognition and mood, and in the social dimension: lack of social contacts and social support (Markle-Reid and Browne, 2003; Gobbens et al., 2007).

Measuring the level of frailty is problematic for several reasons. Multiple theoretical and operational definitions have been suggested in the last decade. Numerous functional tests, questionnaires and indexes to categorize frailty are available and these instruments aim at highly different sub-populations of elderly people (Cigolle et al., 2009; Van Iersel and Rikkert, 2006; Hubbard et al., 2009b). The clinimetric properties of these instruments, such as validity, reliability and agreement, responsiveness and interpretability for general elderly populations are unclear. Furthermore, it is not generally known whether these instruments include one or more frailty dimensions or a multiple level scoring system to be sensitive enough to measure changes over time.

In conclusion, to use frailty as an outcome in clinical trials, a measurement instrument on frailty should be available that is multidimensional and captures the dynamic nature of this concept by means of a multiple level scoring system. Also, as applies to any measurement instrument, the instrument has to show sound clinimetric properties. The aim of this systematic review is to assess frailty instruments on clinimetric properties and to search for the best available frailty instrument that can be used as an evaluative outcome measure in clinical practice and that is useful in observational and experimental studies.

2. Methods

2.1. Literature search and inclusion

A broad systematic literature search was performed in the bibliographic databases PubMed, EMBASE, Cinahl and Cochrane. We used the following search terms to search for measurement instruments: 'questionnaire', 'self-report', 'self-assessment', 'outcome measure' and 'outcome assessment' in combination with 'frail elderly'. The search was performed for articles published from the start date of the involved database until 23 February 2010. Potentially relevant articles were identified by reading the abstract and if necessary by reading the full text version of the article. Also, references were checked on potential relevance.

We used the following inclusion criteria for the selection of relevant studies:

- The main purpose of the study was the development of an instrument for the assessment of frailty and/or the clinimetric evaluation of such an instrument (i.e. a study on the reproducibility, agreement, validity and/or responsiveness of this instrument). An instrument was interpreted being a frailty instrument when the authors explicitly defined that the instrument intends to measure the level of frailty. The theoretical definition used in a study was not considered for inclusion.
- Studies should explicitly and operationally describe a measurement instrument (questionnaire, index, performance measure or a combination of these instrument types).

The first and second author (NdV and JBS) independently selected frailty instruments. The included instruments of both raters were compared in a consensus meeting of NdV and JBS and agreement on final in- or exclusion was reached by discussion (Fig. 1). Initial agreement was determined by means of an agreement score.

2.2. Content of the instruments

In the next step two assessors (NdV and JBS) assessed the frailty instruments independently on their content. In this study we chose to focus on the physical, psychological as well as the social domain of frailty to reflect the multidimensionality of the concept. Based on earlier publications (Gobbens et al., 2009, 2010b,c; Karunananthan et al., 2009), the factors nutritional status, physical activity, mobility, strength, energy (physical domain), cognition, mood (psychological domain) and social relations/social support (social domain) were selected as essential factors in a frailty instrument.

It was judged whether the frailty instruments covered these frailty factors. Table 1 describes the operationalization of the frailty factors used in this study. These operationalizations were set by

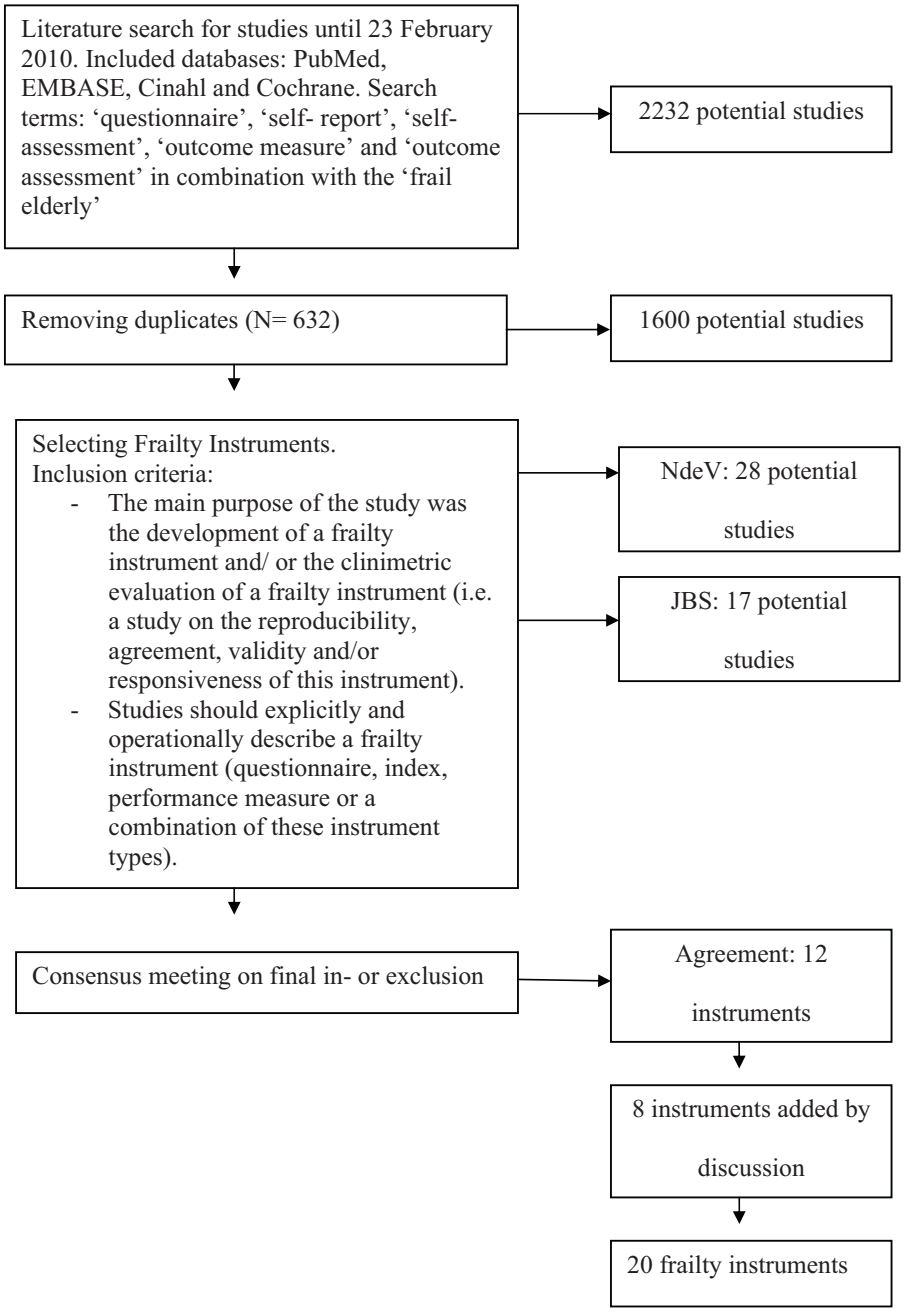

Fig. 1. Review procedure.

consensus among the research group of this study. It was also judged whether the frailty instruments measured frailty on a dichotomous, ordinal or continuous scale. The ratings were subsequently compared and both raters aimed to reach consensus on eventual disagreements in a consensus meeting. If disagreement persisted, a third reviewer (RN) advised on the final rating. An agreement score was computed to indicate initial agreement.

2.3. Clinimetric properties

Instruments were subsequently scored on an assessment scale for clinimetric properties (Terwee et al., 2007). This was also done by the first and second author. The following criteria were used: content validity (extent to which the domain of interest is comprehensively sampled by the items in the instrument), internal consistency (extent to which items in a subscale are intercorrelated), construct validity (extent to which scores relate to measures in a manner that is consistent with theoretically derived hypothesis concerning the concept that is being measured, agreement (extent to which scores on repeated measures are close to each other), reliability (extent to which patients can be distinguished from each other), responsiveness (ability of an instrument to detect clinically important changes over time), floor and ceiling effects (number of respondents who achieved the lowest or highest possible score) and interpretability (degree to which one can assign qualitative meaning to quantitative scores). The operationalizations of these items are described in a publication by Terwee et al. (2007).

Table 1
Operationalization of the frailty factors.

Frailty factor	Operationalization
Nutritional status	- Body weight - Appetite - Body Mass Index (BMI)
Physical activity	- Level of physical activity - Leisure time physical (group) activity
Mobility	- Difficulty or needing help walking/moving in and around the house - Gait speed
Energy	- Tiredness - Energy level (for example exhaustion/fatigue)
Strength	- Lifting an object that weighs over 5 kg - Weakness in arms and/or legs - Performing chair stands - Climbing stairs - Grip strength - Calf muscle circumference
Cognition	- Memory problems - Diagnosed dementia or cognitive impairment
Mood	- Depression/depressed mood - Sadness - Anxiety - Nervousness
Social relations/social support	- Social recourses (when help is needed, can someone provide this?) - Emptiness/missing people around

3. Results

3.1. Literature search and inclusion

The literature search resulted in a total number of 2232 hits. In PubMed, 1270 articles were found, in EMBASE 464, in Cinahl 256 and 242 in Cochrane. After duplicate removal, 1600 articles were left. The first rater (NdV) included 28 studies from the database after scanning title and abstract on our predefined inclusion criteria, 17 articles were included by the second rater (JBS). There was initial agreement on 12 instruments between both raters. Another 8 instruments were added by discussing the full text articles of the remaining included studies. This means that a number of 20 frailty instruments, that met our predefined criteria, were extracted from literature.

3.2. Content of the instruments

The two raters independently assessed the instruments on content and agreed on 86% of the scorings. Disagreement was solved by discussion. Table 2 gives an overview of the ratings of these instruments regarding the eight frailty factors and the type of scoring scale used.

With regard to the frailty factors, only one instrument, the Frailty Index (Cigolle et al., 2009; Mitnitski et al., 2001; Rockwood et al., 2007; Rockwood, 2006), includes items on all eight factors. Fourteen instruments (70%) include items on nutritional status (Fried et al., 2001; Mitnitski et al., 2001; Carlson et al., 1998; Carriere et al., 2005; Schuurmans et al., 2004; Rothman et al., 2008; Studenski et al., 2004; Kiely et al., 2009; Chin A Paw et al., 1999; Puts et al., 2005; Winograd et al., 1991; Matthews et al., 2004; Scarcella et al., 2005; Jones et al., 2004), eight instruments (42%) pay attention to physical activity (Fried et al., 2001; Mitnitski et al., 2001; Carriere et al., 2005; Rothman et al., 2008; Studenski et al., 2004; Chin A Paw et al., 1999; Puts et al., 2005; Winograd et al., 1991; Ravaglia et al., 2008) and seventeen instruments (85%) include items on mobility (Fried et al., 2001; Mitnitski et al., 2001; Carlson et al., 1998; Carriere et al., 2005; Schuurmans et al., 2004; Rothman et al., 2008; Studenski et al., 2004; Kiely et al., 2009; Winograd et al., 1991; Scarcella et al., 2005; Jones et al., 2004; Ravaglia et al., 2008; Gealey, 1997; Gloth et al., 1995; Guilley et al., 2008; Saliba et al., 2001; Brody, 1997). Strength is represented in eight instruments (40%) (Fried et al., 2001; Mitnitski et al., 2001; Carriere et al., 2005; Studenski et al., 2004; Kiely et al., 2009; Matthews et al., 2004; Saliba et al., 2001; Syddall et al., 2003), energy level in six instruments (30%) (Fried et al., 2001; Mitnitski et al., 2001; Studenski et al., 2004; Kiely et al., 2009; Scarcella et al., 2005; Guilley et al., 2008), cognition in eight instruments (40%) (Mitnitski et al., 2001; Schuurmans et al., 2004; Rothman et al., 2008; Puts et al., 2005; Matthews et al., 2004; Scarcella et al., 2005; Jones et al., 2004; Guilley et al., 2008) mood in seven instruments (35%) (Mitnitski et al., 2001; Schuurmans et al., 2004; Studenski et al., 2004; Puts et al., 2005; Winograd et al., 1991; Jones et al., 2004; Ravaglia et al., 2008) and social relations/social support in six instruments (30%) (Mitnitski et al., 2001; Schuurmans et al., 2004; Studenski et al., 2004; Winograd et al., 1991; Scarcella et al., 2005; Jones et al., 2004). The physical domain is represented in all instruments, the psychological domain in 55% of the instruments (Mitnitski et al., 2001; Schuurmans et al., 2004; Rothman et al., 2008; Studenski et al., 2004; Puts et al., 2005; Winograd et al., 1991; Matthews et al., 2004; Scarcella et al., 2005; Jones et al., 2004; Ravaglia et al., 2008; Guilley et al., 2008) and the social domain in 30% of the instruments (Mitnitski et al., 2001; Schuurmans et al., 2004; Studenski et al., 2004; Winograd et al., 1991; Scarcella et al., 2005; Jones et al., 2004). Only five instruments include items on all three frailty domains. These instruments are: the Frailty Index (FI) (Mitnitski et al., 2001), the Groningen Frailty Indicator (GFI) (Schuurmans et al., 2004), the Clinical Global Impression of Change in Physical Frailty (CGIC-PF) (Studenski et al., 2004), the Geriatric Functional Evaluation (GFE) (Scarcella et al., 2005) and the Frailty Index-Comprehensive Geriatric Assessment (FI-CGA) (Jones et al., 2004).

When we consider the type of instrument, Table 2 shows that ten instruments (50%) use a dichotomous scoring system categorizing into frail and not frail (Carlson et al., 1998; Schuurmans et al., 2004; Studenski et al., 2004; Chin A Paw et al., 1999; Puts et al., 2005; Winograd et al., 1991; Matthews et al., 2004; Gealey, 1997; Guilley et al., 2008; Saliba et al., 2001; Brody, 1997). Five instruments (25%) classify on three levels (Fried et al., 2001; Rothman et al., 2008; Kiely et al., 2009; Scarcella et al., 2005; Jones et al., 2004), mostly robust, pre-frail and frail. The remaining five instruments do not use a cut-off point to classify frailty (Mitnitski et al., 2001; Carriere et al., 2005; Ravaglia et al., 2008; Gloth et al., 1995; Syddall et al., 2003). The scoring range of these instruments is diverse. The FI (Mitnitski et al., 2001) and the instrument defined by Carriere (Carriere et al., 2005) use a continuous scoring system with range from 0.00 to 1.00. The instrument by Syddal (Syddall et al., 2003) scores grip strength on a continuous scale. The Frail Elderly Functional Assessment Questionnaire (Scarcella et al., 2005) ranges on an ordinal scale from 0 to 55 and the instrument defined by Ravaglia (Ravaglia et al., 2008) from 0 to 9. It can be noted that in the original study (Jones et al., 2004), the FI-CGA classifies frailty on three levels. In a comparative study between the FI-CGA and the FI, however, another scoring system is used for the FI-CGA and a classification on seven levels is made (Jones et al., 2005). Eleven instruments (55%) (Carlson et al., 1998; Schuurmans et al., 2004; Chin A Paw et al., 1999; Winograd et al., 1991; Matthews et al., 2004; Scarcella et al., 2005; Gealey, 1997; Gloth et al., 1995; Guilley et al., 2008; Saliba et al., 2001; Brody, 1997) are based on self-report, one instrument consists of a performance test (Syddall et al., 2003) and 7 instruments (35%) combine self-report with performance tests (Fried et al., 2001; Mitnitski et al., 2001; Carriere et al., 2005; Rothman et al., 2008; Kiely et al., 2009; Puts et al., 2005; Ravaglia et al., 2008). Finally, two instruments (Studenski et al., 2004; Jones et al., 2004) use the information from a geriatric assessment by a geriatrician.

Table 2
Frailty instruments assessed on frailty factors and scoring system.

Instrument/study	Description	Nutritional status	Physical activity	Mobility	Strength	Energy	Cognition	Mood	Social relations/social support	Type of scale
Frailty Phenotype/Fried et al. (2001), Cigolle et al. (2009), Kiely et al. (2009), and Rockwood et al. (2007)	Presence of 3 out of 5 frailty factors (slow gait, low physical activity, weight loss, exhaustion and weakness)	+	+	+	+	+	–	–	–	Range: 0–5 type: ordinal, 3 levels (robust, pre-frail, frail). Combination of performance tests and self-report
Frailty Index, accumulation of deficits/Mitnitski et al. (2001), Cigolle et al. (2009), Rockwood et al. (2007), and Rockwood (2006)	Number of health deficits (symptoms, signs, disabilities, laboratory, radiographic) out of a list of at least 40 possible deficits.	+	+	+	+	+	+	+	+	Range: 0–1 type: continual, no cut-off points. Combination of (performance) tests and self-report
Modified Functional Independence Measure (FIM)/Carlson et al. (1998)	Questionnaire on functional (in) dependence in seven functional dimensions: feeding, hygiene, bathing, toileting, dressing, communication, mobility	+	–	+	–	–	–	–	–	Range: 7–49 type: dichotomous (frail–not frail). Self-report
Instrument 'Carriere'/Carriere et al. (2005)	Predictive score for risk of dependency based on: mobility, balance, nutrition, muscle strength, physical inactivity, perceived health, educational level, age, time since baseline evaluation	+	+	+	+	–	–	–	–	Range: 25–165, translated into predictive score of 0–1. Type: continual, no cut-off point. Combination of performance tests and self-report
Instrument 'Gealey'/Gealey (1997)	ADL/IADL scale (eating, bathing, toileting, dressing, transfers, walking, ability to use a phone, shopping, food preparation, housekeeping, laundry, mode transportation, ability or lack thereof to self-medicate)	–	–	+	–	–	–	–	–	Range: ADL: 0–10, IADL: 0–14, combination of ADL/IADL: 0–24. Type: dichotomous (frail–not frail). Self report
Groningen Frailty Indicator (GFI)/Schuurmans et al. (2004)	15-Item questionnaire on 8 frailty factors: mobility, physical fitness, vision, hearing, nourishment, morbidity, cognition, psychosocial	+	–	+	–	–	+	+	+	Range: 0–15 type: dichotomous (frail–not frail). Self-report
Frail Elderly Functional Assessment Questionnaire/Gloth et al. (1995, 1999)	19-Item questionnaire on: mobility, toileting, meals, eating, washing dishes, dressing, bathing, mechanical skills, handling finances, communication by telephone, medication administration	–	–	+	–	–	–	–	–	Range: 0–55 type: ordinal, no cut-off points. Self report
Instrument 'Guilley'/Guilley et al. (2008)	Self reported deficiencies in five health dimensions: sensory capacities, mobility capacities, physical pains, memory problems, energy	–	–	+	–	+	+	–	–	Range: 0–3 for each dimension. Type: dichotomous (frail–not frail). Self report

Instrument 'Rothman'/Rothman et al. (2008)	Modification of the Frailty Phenotype, including cognition	+	+	+	–	–	+	–	–	Range: 1–5 type: ordinal (robust, pre-frail, frail). Combination of performance tests and self-report
Clinical Global Impression of Change in Physical Frailty (CGIC-PF)/Studenski et al. (2004)	Clinical judgment on 13 items in multiple dimensions: mobility, strength, social status, ADL, emotional status, perceived health, neuromotor, stamina, nutrition, balance, medical complexity, healthcare utilization, appearance	+	+	+	+	+	–	+	+	Range: – type: dichotomous (frail, not frail). Judgment during geriatric assessment
The Vulnerable Elders Survey (VES)/Saliba et al. (2001) and McGee (2008)	Self report 13-item questionnaire on physical functioning	–	–	+	+	–	–	–	–	Range: 0–10 type: dichotomous (frail, not frail). Self report
Study of Osteoporotic Fractures (SOF) instrument/Kiely et al. (2009)	Presence of 2 or more out of 3 frailty factors: weight loss, inability to rise from a chair five times, reduces energy level	+	–	+	+	+	–	–	–	Range: 0–3 type: robust, 3 levels (robust, pre-frail, frail). Combination of performance tests and self-report
Instrument 'Chin A Paw'/Chin A Paw et al. (1999)	Presence of two frailty factors: inactivity and weight loss	+	+	–	–	–	–	–	–	Range: 0–2 type: dichotomous (not frail, frail). Self-report
Instrument 'Puts'/Puts et al. (2005)	Presence of three or more out of 9 frailty factors: body weight, peak expiratory flow, cognition, vision, hearing problems, incontinence, sense of mastery, depressive symptoms, physical activity	+	+	–	–	–	+	+	–	Range: 0–9 type: dichotomous (frail, not frail). Combination of performance tests and self-report
Instrument 'Ravaglia'/Ravaglia et al. (2008)	Presence or absence of 9 frailty factors: age $\geq$80, male gender, low physical activity, comorbidity, sensory deficits, calf circumference, IADL dependence, gait, performance test score, pessimism about one's health	–	+	+	–	–	–	+	–	Range: 0–9 type: ordinal, no cut-off points. Combination of performance tests and self-report
Instrument 'Winograd'/Winograd et al. (1991)	Presence of any one of the 15 criteria: CVA, chronic AND disabling illness, confusion, dependence in ADL, depression, falls, impaired mobility, incontinence, malnutrition, polypharmacy, pressure sore, prolonged bed rest, restraints, sensory impairment, socioeconomic/family problems	+	+	+	–	–	–	+	+	Range: 0–15 type: dichotomous (frail, not frail). Self-report
Grip strength as a single marker/Syddall et al. (2003)	Grip strength measure	–	–	–	+	–	–	–	–	Range: – type: continual. Performance test

Table 2 (*Continued*)

Instrument/study	Description	Nutritional status	Physical activity	Mobility	Strength	Energy	Cognition	Mood	Social relations/social support	Type of scale
1994 Frailty Measure Strawbridge/Cigolle et al. (2009) and Matthews et al. (2004)	16-Item index on 4 dimensions: physical functioning, nutrition, cognition, sensory system	+	–	–	+	–	+	–	–	Range: 0–16 type: dichotomous (not frail, frail). Self report
Self-report Screening Instrument/Brody (1997)	16-Item questionnaire on health status and health service utilization	–	–	+	–	–	–	–	–	Range: 0–100% type: dichotomous (not frail, frail). Self-report
Geriatric Functional Evaluation (GFE)/Scarcella et al. (2005)	Multidimensional questionnaire on seven dimensions: physical condition, mental health, functional status, community support, housing, social relationships, financial situation.	+	–	+	–	+	+	–	+	Range: −118 to +91 type ordinal, 3 levels (not self-sufficient, partially self-sufficient, self-sufficient). Self-report
Frailty Index-Comprehensive Geriatric Assessment (FI-CGA)/Jones et al. (2004, 2005)	Rating of 10 frailty dimensions based on clinical judgment and comorbidity: cognition, mood and motivation, communication, mobility, balance, bowel function, bladder function, IADL and ADL, nutrition and social resources	+	–	+	–	–	+	+	+	Range: 0–20+ co morbidity count of active diagnoses/range: 0–1. Type: ordinal, 3 levels (mild, moderate and severe frailty)(Gloth et al., 1995)/type: ordinal, 7 levels. Judgment based on geriatric assessment

3.3. Clinimetric properties

The clinimetric properties of the frailty instruments were studied by using an assessment scale for clinimetric properties (Terwee et al., 2007). Both raters agreed on 88% of the ratings and the remaining 12% disagreement was dissolved by consensus. From Table 3, it is obvious that most frailty instruments have not been extensively studied on clinimetric properties. Construct validity is mostly studied. Studies on construct validity show that a positive score on a frailty index is predictive of adverse health outcome, for example disability, institutionalization or mortality. Some studies also pay attention to interpretability. In most studies, however, no minimal important change (MIC) value is presented or the instrument gives information on less than four subgroups. With the exception of the instrument defined by Carriere (Carriere et al., 2005), which scores positively on interpretability. With regard to floor- and ceiling effects, some studies do present information, but in most cases the design or method is doubtful (0 score) or more than 15% of the respondents achieved the highest or lowest score, which implies a negative score. The Frail Elderly Functional Assessment Questionnaire (FEFA) (Gloth et al., 1995, 1999) has been tested on reliability and responsiveness in addition to construct validity. This instrument also gives a good impression of floor- and ceiling effects. The Clinical Global Impression of Change in Physical Frailty (CGIC-PF) (Studenski et al., 2004) scores positively on both reliability and content validity (Table 3). In none of the studies information was found on agreement and internal consistency.

We also found four studies that made a comparison between frailty instruments (Cigolle et al., 2009; Rockwood et al., 2007; Kiely et al., 2009; Jones et al., 2005). Cigolle et al. (2009) compared three frailty instruments with each other: Frailty Index, Frailty Phenotype and the 1994 Frailty Measure. It was concluded that all instruments identify older people at risk of adverse health outcome, but they capture different sub-populations. Kiely et al. (2009) compared the Frailty Phenotype with the Study of Osteoporotic Fractures instrument (SOF). The results show that both instruments are predictive of key geriatric outcomes and appear to be good measures of frailty. A comparative study (Jones et al., 2005) of the FI-CGA with the FI showed a high correlation ($r = 0.76$) between both indexes. The last study of Rockwood et al. (2007) compares two frailty indexes (Frailty Phenotype and Frailty Index) with each other. This study concludes that the two indexes correlate moderately well with each other ($r = 0.65$) and show considerable convergence.

4. Discussion

This review presents an overview of existing frailty instruments. Based on the results of this study we can conclude that many frailty instruments have been developed in recent years. We identified twenty instruments in current literature. To the author's knowledge this is the first time a systematic overview of all frailty instruments is given. This overview is a first step towards more transparency in frailty research and clinical practice. We assessed all the frailty instruments on eight factors in three dimensions. A better understanding of the content of the numerous frailty instruments can help researchers as well as clinicians to make a better funded choice in using a specific instrument in a specific situation for specific sub-populations of frail elderly. On top of that, comparing the different frailty measures can contribute to the current debates on frailty and can provide a better understanding of the way in which different researchers and clinicians deal with frailty. This will make it easier to compare studies and draw generally accepted and comparable conclusions.

The aim of our study was to find an instrument that can be used as an evaluative outcome measure in both clinical practice

Table 3
Assessment on clinimetric properties.

Instrument/study	Reliability	Agreement	Construct validity	Responsiveness	Interpretability	Content validity	Internal consistency	Floor- and ceiling effects
Frailty Phenotype/Fried et al. (2001), Cigolle et al. (2009), Kiely et al. (2009), and Rockwood et al. (2007)	0	0	+	0	?	0	0	–
Frailty Index, accumulation of deficits/Mitnitski et al. (2001), Cigolle et al. (2009), Rockwood et al. (2007), and Rockwood (2006)	0	0	+	0	?	0	0	?
Modified Functional Independence Measure (FIM)/Carlson et al. (1998)	0	0	+	0	?	0	0	?
Instrument 'Carriere'/Carriere et al. (2005)	0	0	+	0	+	0	0	0
Instrument 'Gealey'/Gealey (1997)	0	0	?	0	?	0	0	?
Groningen Frailty Indicator (GFI)/Schuurmans et al. (2004)	0	0	+	0	0	0	0	0
Frail Elderly Functional Assessment Questionnaire/Gloth et al. (1995, 1999)	+	0	+	+	0	0	0	+
Instrument 'Guilley'/Guilley et al. (2008)	0	0	+	0	?	0	0	–
Instrument Rothman/Rothman et al. (2008)	0	0	+	0	0	0	0	0
Clinical Global Impression of Change in Physical Frailty (CGIC-PF)/Studenski et al. (2004)	+	0	0	0	0	+	0	0
The Vulnerable Elders Survey (VES)/Saliba et al. (2001) and McGee (2008)	0	0	+	0	0	0	0	–
Study of Osteoporotic Fractures (SOF) instrument/Kiely et al. (2009)	0	0	+	0	0	0	0	0
Instrument 'Chin A Paw'/Chin A Paw et al. (1999)	0	0	+	0	0	0	0	0
Instrument 'Puts'/Puts et al. (2005)	0	0	+	0	0	0	0	0
Instrument 'Ravaglia'/Ravaglia et al. (2008)	0	0	+	0	0	0	0	0
Instrument 'Winograd'/Winograd et al. (1991)	0	0	+	0	0	0	0	0
Grip strength as a single marker/Syddall et al. (2003)	0	0	+	0	0	0	0	0
1994 Frailty Measure Strawbridge/Cigolle et al. (2009) and Matthews et al. (2004)	0	0	–	0	?	0	0	0
Self-report Screening Instrument/Brody (1997)	0	0	+	0	0	0	0	0
Geriatric Functional Evaluation (GFE)/Scarcella et al. (2005)	0	0	+	0	?	0	0	–
Frailty Index-Comprehensive Geriatric Assessment (FI-CGA)/Jones et al. (2004, 2005)	0	0	+	0	?	0	0	+

+, instrument fulfills the mentioned criterion; –, instrument does not fulfill the mentioned criterion; ?, doubtful design or method; 0, no information found (Terwee et al., 2007).

and clinical effect studies on frailty. Numerous ways to measure frailty have been described in literature. We identified self report questionnaires or interviews, performance tests and combinations of both. At this point it remains unclear what type of instrument is preferred for frail elderly. Each instrument has its' advantages and disadvantages. Dependent on the setting, the aim of the measurement, the qualities of the person who administers the instrument and available time, a choice can be made for a particular instrument. In a clinical setting, for example, a performance test might be easily applicable and also more relevant than a self report questionnaire because such a test also informs the clinician about actual functioning. A researcher on the other hand might find a self-report questionnaire more feasible to administer. The instruments also differ substantially in the way they operationalize the frailty factors. For example, some authors use grip strength (Fried et al., 2001) as an indicator of muscle strength, while others use peak expiratory flow (Puts et al., 2005) or ability to rise from a chair without using the arms (Kiely et al., 2009). Some instruments use a physical performance test (for example gait speed) to measure mobility (Carriere et al., 2005) and others include only self reported mobility problems (Saliba et al., 2001). Because of the differences in frailty instruments it is hard to compare the measured outcome of these instruments with each other. The dimensions and factors on which the frailty instruments were assessed in this study were based on previous studies by Karunananthan et al. (2009) and Gobbens et al. (2009). These factors reflect current thinking on the concept of frailty. Analyzing the frailty instruments on these factors showed that most instruments do not include all predefined factors and even not all three dimensions. A substantial part of the instruments only consider physical aspects of frailty. Five instruments pay attention to all three domains (i.e. physical, psychological and social domain) and only one instrument includes items on all frailty factors. Factors that were addressed in most of the instruments were nutritional status and mobility. Social relations/social support, on the other hand, was only considered in a few instruments. Also, almost half of the total number of instruments does not contain one or more items on psychological factors. This finding is remarkable because of the well established relationship between frailty and these factors (Markle-Reid and Browne, 2003). The studied frailty instruments also contained factors that we did not include in our predefined criteria, mostly co-morbidity. We did not include co-morbidity in our analysis because we searched for an instrument that would be able to evaluate interventions. Therefore, we focused on the factors from which we know that they are changeable by interventions. A lot of co-morbidities are not or minimally changeable by any sort of intervention and are mostly stable over time, for instance Cerebral Vascular Incident or Osteoporosis. This makes it less appropriate to include items on co-morbidity in an evaluative outcome measure. However we acknowledge that the presence of co-morbidities influences the level of frailty after an intervention and, therefore, has to be taken into account. Moreover, some interventions have an influence on co-morbidity too. Lifestyle interventions can, for example, influence hypertension (Chodzko-Zajko et al., 2009). Therefore co-morbidity can be included in a frailty instrument, but the value of items on co-morbidity in an evaluative outcome measure on frailty is, as opposed to using these instruments for screening purposes, still questionable and has to be studied.

Most instruments identified in this study use a dichotomous scoring system. A person is classified as either frail or not frail. In order to be used as an outcome measure that captures the dynamic nature of frailty, a continuous scoring system or an ordinal scoring system on multiple levels would be preferred (Mitnitski et al., 2001). The Frailty Index and the instrument defined by Carriere et al. (2005) use a continuous scoring system and seem therefore to be able to discriminate and measure change after an intervention. Both instruments have not specified a cut-off point for frailty, but this is not necessary for an evaluative outcome measure in clinical trials. In future research, it will be important to learn about clinically relevant changes.

The assessment of the clinimetric properties of the frailty instruments was based on a previously described assessment scale for clinimetric properties of health status questionnaires (Terwee et al., 2007). Even though this scale is not considered a gold standard, we preferred to use a recent standardized assessment scale for clinimetric properties that reflects current and generally accepted principles of clinimetric research. We strictly applied the described criteria to the frailty instruments. Some of these criteria were, however, not very suitable for frailty instruments. To score positively on the criterion content validity, for example, a clear description of the measurement aim, the target population and the concepts that are being measured must be given. Also the target population must be involved in item selection. In most of the studied articles no information was found on this latter item. A positive score for content validity could therefore not be assigned, even though most studies did give a clear description of the measurement aim and the concept being measured. Also, the used assessment scale does not contain an item on generalizability while a measurement instrument is not naturally generalizable. However, we believe it is important to conduct research on measurement properties in different samples and settings to study whether they perform equally outside the dataset they were created in. Studying the overall results of the assessment on clinimetric properties (Table 3) we can conclude that frailty instruments are mainly developed as risk assessment tools, not as outcome measures and, as a consequence, have been validated as such. For most instruments only information on construct validity was found. Besides a positive score on content validity, The Frail Elderly Functional Assessment Questionnaire (FEFA) (Gloth et al., 1995, 1999) scored positively on reliability, responsiveness, floor- and ceiling effects and construct validity. The Clinical Global Impression of Change in Physical Frailty (CGIC-PF) (Studenski et al., 2004) also had a positive score on reliability and content validity, the instrument defined by Carriere et al. (2005) on interpretability and the Frailty Index-Comprehensive Geriatric Assessment (FI-CGA) (Jones et al., 2004, 2005) on floor- and ceiling effects. These instruments that have been additionally studied on clinimetric properties however, do not fulfill the criteria set in this study considering multidimensionality. On top of that, particularly the study on the CGIC-PF, was done in a very small sample ($n = 10$). Altogether, according to the criteria set in this study these instruments are not appropriate as evaluative outcome measures.

Because there is no consensus on how to define frailty, a standard search strategy on this subject is difficult to determine. In this review we chose to focus on the population which was explicitly defined as frail by the authors. We also focused on outcome measures and not on screening or predictive instruments. Therefore, we missed studies on frail elderly in which the population was not defined as such or instruments that exclusively defined their instrument as a screening instrument. For this reason a number of more or less well known frailty screening instruments were not included in this systematic review, for example the Edmunton Frail Scale (Rolfson, 2006). Also, the recently developed and validated Tilburg Frailty Indicator (TFI) (Gobbens et al., 2009; Metzelthin et al., 2010) was not included as a possible outcome measure in this systematic review. However, we do not expect that this is a lack of this study because screening instruments are generally not appropriate to evaluate outcomes.

Based on the results of this study we can conclude that among the selected instruments only one instrument, the Frailty Index (FI) (Mitnitski et al., 2001), covers all the frailty factors. The FI also uses a continuous scoring system. Besides items on present functioning the Frailty index also includes many more or less stable

deficits and diseases (co-morbidity) which are not changeable by any sort of intervention, for example the presence or absence or a hearing problem. Future studies should be conducted to study in which extent co-morbidity has to be part of a frailty index or should be considered as a distinct entity that influences the impressionability of frailty by interventions. A great advantage of the Frailty Index on the other hand is that it is not a fixed index. As long as the index contains at least 40 items that fulfill certain criteria (Mitnitski et al., 2001), item choice is free. This means that the number of unchangeable items can be minimized in relation to the number of changeable items, dependent of the aim for which the instrument is used. As a consequence, the Frailty Index does need clinical translation to be used in research or clinical practice (Rockwood et al., 2007). An essential discussion point is the question whether it is possible to measure frailty with one outcome measure. The measure has to reflect the changeability of frailty over time and the interaction between the factors in the physical, psychological, and social domain as part of the complex dynamic system. The challenge is to define an adequate set of factors, and to validate the weight the factors have on frailty individually and in interaction. Therefore we suggest that a fixed index with outcome variables relevant to the intervention aim could be appropriate. In recent cohort studies, the Frailty Index has been used and significant effects over time were found as a result of physical exercise (Hubbard et al., 2009a; Peterson et al., 2009). However, further examination of the clinimetric properties of the Frailty Index revealed that, methodologically, only studies on construct validity were carried out. This means that, before applying the Frailty Index as an evaluative measure in effect studies as a primary outcome measure, more studies are needed to gain insight in the clinimetric properties of this index.

Another four instruments, the GFI, the CGIC-PF, the FI-CGA and the GFE do not cover all the frailty factors, but do cover all frailty domains. The GFI and the CGIC-PF use a dichotomous scoring system and the GFE uses an ordinal scale on three levels. Both systems are not preferred as an outcome measure in clinical trials on frailty because these systems do not capture the dynamic nature of frailty. Moreover, the CGIC-PF and the FI-CGA are based on clinical judgment by a geriatrician. For this reason these instruments might be not very easily applicable in clinical trials or clinical practice.

In conclusion, this review gives an exhaustive overview of available frailty instruments. All instruments that intend to measure frailty were included and were assessed on a predefined set of factors of frailty and clinimetric criteria. At this point, the Frailty Index seems to be the most suitable instrument to be used as an evaluative outcome measure in frailty research but the clinimetric properties of this and other indexes need to be explored far more extensively. We also emphasize the need for more consistency and transparency in frailty research to make comparison between studies possible.

Conflict of interest statement

None declared.

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