Frailty is a health problem characterized by a state of increased vulnerability and decreased reserve capacity (1). As age increases, the prevalence of frailty rises dramatically (2). Frail older adults are the predominant consumers of healthcare across all healthcare delivery and social care settings (3). Frail individuals experience a diminished quality of life (4) and increased risks of disability, hospitalization, institutionalization, and morbidity and mortality (2, 5). Given the economic and individual burdens, frailty is a high priority and a better understanding of frailty is needed to advance the science and ultimately mitigate its effects.

The issue of quantifying frailty remains unresolved (6). Depending on the population studied and research method used, the measures of frailty may encompass different domains (e.g., physical, psychological, or social) with each domain including a number of components (e.g., mobility, nutrition) quantified by a variety of indicators (e.g., gait speed, weight loss). Although frailty has recently been conceptualized as a multi-domain syndrome that includes physical, psychological, or social domains (7-9), research has focused primarily on the physical domain of frailty. The identification of the components of frailty within psychological and social domains remains elusive.

Therefore, the purposes of this literature review are to: (1) describe commonly used frailty components and corresponding indicators within the physical, psychological and social frailty domains; (2) critique existing measures of frailty; and (3) identify knowledge gaps and provide recommendations for future research.

Search strategy and selection criteria

A comprehensive search of literature published between January 1, 1990 and March 31st, 2016 was performed. The electronic databases of PubMed, CINAHL, and the Web of Science were searched using the following subject headings in combination and in isolation: frail elderly, frailty and older adult, along with the words of definition, concept or measure in the abstract. Reference lists of the selected articles were also reviewed to identify relevant citations. Studies were included that: 1) contained original measures of frailty, in other words, providing a new method or definition to qualify frailty rather than citing someone else’s definition/measure; 2) adults aged 65 years and older; and 3) were written in English. Studies with animal subjects were excluded. If an author published several studies and used the same measure/definition of frailty, only the original one was included and the subsequent studies were excluded. Literature reviews, letters to the editor, commentaries, book chapters, case studies, master’s theses and doctoral dissertations were also excluded.
COMPONENTS AND INDICATORS OF FRAILTY MEASURES: A LITERATURE REVIEW

Results

A total of 1725 published studies were initially identified. Based on the title and the abstract, 1385 studies were eliminated because they did not focus on frailty measures, included non-human subjects, and because they did not include empirical data. Twenty-two published studies were excluded because of duplicate titles. Of the remaining 318 published studies, 49 studies met the criterion of providing an original measure of frailty and, therefore, comprised the sample for this literature review (Figure 1). Each included study described one unique measure of frailty, resulting in a total of 49 different measures of frailty in the 49 published studies.

Figure 1

Search strategy for studies included in literature review

Characteristics of selected frailty measures

Of the 49 frailty measures, 19 (39%) contained the two domains of physical and psychological frailty (10-28); 16 (33%) focused only on the physical domain (2, 29-43); and 14 (28%) included all three domains (physical, psychological and social) (44-57). The types of frailty measures varied considerably among the 49 studies: 22 were a combination of self-reported and performance based (45%) (2, 11, 12, 15-22, 24, 25, 28, 29, 31, 33, 34, 37, 43, 45, 49, 53, 56, 57), 4 were objective performance-based (8%) (30, 36, 39, 40), 17 were participant self-report (40%) (10, 13, 14, 23, 26, 32, 38, 42, 44-49, 51, 52, 54), and 5 were clinician/researcher judgment (10%) (27, 35, 41, 56, 57). Over 90% of the scores for frailty measures (46/49) were either categorical (e.g. robust, pre-frail or frail) or continuous indexes with equal weight for each frailty indicators (e.g. summative score or mean score). Three frailty measures scores (16, 17, 31) were assigned relative weights to indicate the importance of each frailty components. The frailty components and commonly used corresponding indicators in each physical, psychological and social domain were shown as below. Details on the components and corresponding indicator in each measure were displayed in online Appendix 1 to 4.

Frailty components in each domain

Physical domain

Deficits in mobility and balance. Mobility and balance were the most frequently reported (32/49, 65%) components of physical frailty (2, 11-16, 20-27, 31, 36, 37, 39, 40, 43-46, 49-53, 56, 57). Indicators to assess deficits in mobility and balance included self-report measures and measures of objective physical performance. In the self-report questions, participants were asked if they had difficulties or needed assistance in walking or balance (13, 14, 23, 26, 37, 44, 46). A slowest 20% or quartile in the setting population, adjusting for gender and standing height, was used as a cut-off to determine the deficit in mobility (e.g. > 7 seconds for a man with a height < 173 cm and > 6 seconds for a men with a height >173 cm, for time to walk 15 ft. (2)). Another objective indicator to quantify mobility and balance was the Time Up and Go Test (TUG), which tests the time a person takes to raise from a chair, walk a certain distance, turn around, walk back to the chair and sit down (e.g. > 15 s for a walk 10 ft.). The Tandem Position Test, which assesses the time to maintain the progressively more challenging positions (side-by-side position, semi tandem position, and tandem position), was used in five studies (43, 50) (unable to maintain full tandem position for 10 seconds). Other tests or scales for assessment of mobility and balance included Romberg test (30), Elderly Mobility Scale (20), Tinetti Balance and Gait Test (21, 40) and Short Physical Performance Battery (SPPB) (16).

Poor nutrition. Poor nutrition was reported as a component of physical frailty in 32 studies (65%) (2, 11-13, 15-18, 20-22, 24-26, 28, 31-34, 37, 43, 44, 49-55, 57). Indicators of poor nutrition included self-report unintended weight loss (2, 11-13, 15, 24-28, 32-34, 37, 44, 49, 51, 53-55, 57), self-report poor appetite (13, 14, 26, 55) and abnormal Body Mass Index (BMI) (<18.5 or >30 kg/m2) (12, 17, 20, 28, 31, 33, 50, 58). Other indicators of poor nutrition included Mini Nutritional Assessment scores (<23.5) (18), calf circumference (<31cm) (21), mid-arm circumference (<27cm) (18), waist circumference (men>102cm /women >88cm) (12), waist-hip ratio (men>0.90 /women>0.85) (17). A serum albumin level

With equal weight for each frailty indicators (e.g. summative score or mean score). Three frailty measures scores (16, 17, 31) were assigned relative weights to indicate the importance of each frailty components. The frailty components and commonly used corresponding indicators in each physical, psychological and social domain were shown as below. Details on the components and corresponding indicator in each measure were displayed in online Appendix 1 to 4.
was used as an indicator of nutrition although a cutoff point varied across studies (12, 16, 18, 22, 27, 43).

Muscle weakness. In 16/43 (31%) of the studies, muscle weakness was reported as a component of frailty (2, 11, 12, 15, 24-27, 31, 34, 36, 37, 39, 43, 45, 51). The indicators of muscle weakness included self-reported lack of strength or weakness in the arms or legs (11, 26, 37, 45, 51), objective grip strength assessed by dynamometer (2, 12, 15, 24, 25, 27, 31, 39, 43) (lowest 20% stratified by gender and BMI in a setting population), and the Chair Stand Test to assess lower extremity strength (12, 27, 31, 34, 36) (e.g., inability to rise from chair 5 times without using arms).

Difficulties in physical performance. Three studies (29, 30, 43) used physical performance as a component of frailty. The physical performance were evaluated as nine standardized tasks, including the ability to: put on and take off a jacket; pick up a penny from the floor; lift a five-pound book overhead to a shelf; climb one flight of stairs; turn 360 degrees; and climb four flights of stairs; walk 50-ft as quickly as possible; and Progressive Romberg test(29, 30, 43). The score for each task ranges between 0 and 4. The score was classified into 4 categories: “32-36”=not frail, “25-32”=mild frailty, “17-25”=moderate frailty and below 17=function dependence.

Decreased endurance. Endurance as a component of physical frailty was noted in 16 of the 49 (33%) studies. All of the corresponding indicators across these studies used self-reported exhaustion, fatigue or low energy (2, 11, 13, 14, 24, 25, 27, 32, 34, 37, 43, 49, 51, 53, 55, 57).

Low physical activity. Eleven of the 49 studies used physical inactivity as a component of physical frailty (2, 11, 12, 21, 24, 25, 28, 31-33, 51). All of the indicators of physical activity were self-reported (e.g., self-reported moderate activity less than 4 hours/week (21)). None of the included studies used an objective indicator of physical activity (e.g., pedometer, accelerometer).

Impaired sensory function. Declines in sensory function (vision and hearing) were reported in 13studies (13, 14, 17, 21, 26, 28, 39, 44, 46, 49, 51, 53, 56). All, but one of the 43 studies (39), used self-reported declines in vision or hearing. Only Klein et al.(39) quantified deficits in vision using the objective Distance Visual Acuity Test, which defines a deficit as best-corrected visual acuity of 20/40 or poorer in the better eye.

Disability. Approximately half of the selected studies (22/49) included disability as a component of frailty in the physical domain (13, 16-19, 21-23, 29, 38, 42, 43, 45-48, 52-56) and even 11 of them published in the last 5 years. Disability was usually quantified as difficulties in performing activities of daily living (ADL) or instrumental activities of daily living (IADL).

Comorbidity. Comorbidity was included as a components of frailty in 15studies (10, 13, 17-22, 37, 44, 47, 49, 53, 54, 56). Measures of comorbidity included the Charlson Comorbidity Index (18, 22), the presence of a series of chronic conditions (e.g. hypertension, cardiac diseases, bronchitis/emphysema, diabetes, stroke)(10, 13, 17-20, 47, 53), self-report of five or more illnesses (37), and self-report of three or more different types of medication for different chronic diseases(20, 21, 44, 49, 53, 54, 56).

Other physical frailty components. Other components of frailty in the physical domain included advanced age (20, 21, 31, 42), gender (20, 21) (male), abnormal biomarkers/ laboratory values (e.g. calcium, creatinine, Interleukin-6) (19, 25), self-perceived declines in general health status (31, 42, 44, 45, 47, 54, 55), and symptoms/signs (e.g. incontinence, sleepless, impaired lung function, pain, anemia ) (13-15, 17, 19, 22, 23, 28, 29, 39, 43, 46, 52, 54). Four studies also treated hospitalization and falls as the physical components of frailty (22, 45, 49, 55).

Psychological domain

Cognitive impairment. Cognitive impairment was a component of frailty in more than half (59%, 29/49) of the 49 identified studies. Cognitive frailty was mainly characterized by deficits in global cognitive function and was measured using cognitive screening instruments such as the Mini Mental State Examination (MMSE) (10, 11, 15, 16, 18, 24, 28, 46), the Clock-Drawing Test (54), Mini-Cog measures (22) or a series of cognitive tests (measuring language, executive function, spatial ability, and verbal and nonverbal memory) (25). Additionally, fifteen of the 43 studies quantified cognitive frailty using self-report of memory problems (13, 14, 17, 19, 23, 26, 44, 45, 47, 49, 51-53, 56, 57). Only three studies (12, 27, 50) included indicators to reflect specific aspects of cognitive function, such as, neuro-motor processing, verbal fluency, and executive function.

Emotional disorders. Over one third of the selected studies (17/49) used emotional disorders as a component of frailty(10, 13, 17, 19, 21, 24, 28, 44, 45, 47, 48, 50-54, 56). Emotional disorders were mainly quantified by the presence of depressive symptoms and anxiety (10, 13, 17, 19, 24, 28, 44, 45, 47, 48, 50-52, 54), but also included coping/mastery (28, 48, 51), pessimism (21), motivation(52), psychiatric complain (56), positive and negative psychological well-being (53) and anger(45) as indicators of frailty in the psychological domain.

Social/environmental domain

Fifteen of the 49 studies (21%) included frailty components of the social domain in their assessment of frailty (20, 44-56). Components in the social domain included living alone(49-51, 53), loneliness(44, 47, 48, 56), social support/ resource as needed(46, 48, 49, 51-54), social network/ relation and social activities (20, 45, 47, 48, 55-57). Two studies included the environmental domain, which was assessed in terms of housing and neighborhood conditions (48, 53). Indicators for these social/environmental frailty components used self-report responses.
COMPONENTS AND INDICATORS OF FRAILTY MEASURES: A LITERATURE REVIEW

Discussion

In this literature review, 49 studies published between 1997 and 2015 were examined. The most commonly used components of frailty and the corresponding indicators across existing measures were identified within the physical, psychological and social domains. Across all three domains, the most common components of frailty were: mobility and balance (65%), nutrition (65%), and cognitive function (59%). The cutoff values of frailty indicators varied across studies. The gender difference was considered in frailty measures. The cutoff values (e.g., cutoffs of mobility, muscle strength or physical activity) to determine frailty were adjusted by gender (2, 11, 12, 39). Although no study used different cutoff values of frailty indicators for different age ranges, four studies included advanced age as an indicator of frailty (20, 21, 31, 42). No studies considered the race/ethnic impact on the standards to determine frailty. Consistent with previous work (7, 59), this review found a lack of consensus regarding components used to characterize frailty.

This review highlights considerable gaps in frailty measures within the current literature. One problem associated with frailty measures is the use of un-weighted scores. All but three (16, 17, 31) of the 49 measures used un-weighted scores. For example, “mobility” and “loneliness” are equally weighted in the Tilburg Frailty Indicator (51), giving these two components equal importance for predicting frailty-related adverse outcomes. However, because declines in mobility may lead to loneliness, mobility should perhaps be assigned greater weight than loneliness. In fact, one study (24) reported the difference in importance of each frailty component for predicting adverse outcomes. Rothman et al. found mobility was the strongest predictor for disability, long-term nursing home stay, and mortality, compared to other frailty components (24). Additionally, applying weighted components can improve the predictive power of a frailty measure (17, 60, 61). Kamaruzzaman et al. (17) reported the weighted Frailty Index (FI) was a better independent predictor of 2.5-year mortality, hospitalization, and institutionalization than the traditional un-weighted Frailty Index. However, a limitation of weighted frailty components is that they rely on statistical methods that are not easy to calculate and use in clinical practice to screen frail older adults. Moreover, weights for each component are dependent on the study population and may not be generalizable to other populations. Given the varying importance of frailty components, the difficulty of generalization and the present state of research findings, more studies are needed so that we can obtain the information on the generalizability of weights and the potential for weights to vary across populations and settings. With this information, we may be able to develop decision aids that make it easy to compute scores in clinical settings.

Second, findings from this literature review indicate that frailty components in the physical domain are in need of further clarification. The overlap of concepts, such as disability and comorbidity, confound the measure of frailty. This literature review found that approximately 45% of identified studies treated disability as a component of frailty and nearly 31% considered comorbidity as a physical frailty component. Although the terms of frailty, disability and comorbidity are sometimes used interchangeably, these concepts are distinct. In fact, disability is a consequence of both frailty and comorbidity and comorbidity is an antecedent of frailty (2). Frailty measures combined with disability may increase measurement bias when assessing the vulnerability of this population. This is because disability itself is an important predictor for adverse outcomes, such as hospitalization and mortality (62-64). More importantly, treating disability and comorbidity as frailty components may confound the interventions designed to prevent or mitigate frailty.

Another important finding in this review is that over half of the identified studies considered cognitive function as an important component of frailty. Indeed, there is a growing literature in neuroscience documenting correlates of cognitive function in aging (e.g. using both structural and functional MRI) that could provide insight into understanding the link between physical and cognitive frailty components (65). In this review, cognitive impairment in the psychological domain of frailty was mainly determined by declines in global cognitive function. Only three studies used specific aspects of cognitive function (12, 27, 50). For example, Freiheit et al. (50) used executive function, tested by the Trail-Making Test Part B (TMTB), as a frailty indicator, and found that TMTB was a better predictor of ADLs than the global cognitive measure (i.e. MMSE). Given the different trajectories of decline for specific aspects of cognitive function (66), it may be more precise and sensitive to use the specific aspects of cognitive function to identify frailty rather than to use global cognitive function. Further research is needed to determine the value of specific aspects of cognitive function versus global cognitive function.

Whether frailty measures should be multi-domain and, if so, how many domains should be included is a controversial issue. Findings from this review indicated that 70% (34/49) of frailty measures including physical and psychological components, indicating that these two domains are perhaps less controversial. However, only 29% of frailty measures (14/49) contained components associated with all three domains (physical, psychological and social). In fact, an ongoing debate is whether social factors are components of frailty or predictors of frailty (67). Markle-Reid and Browne (9) argued that frailty must be a multi-domain concept because the presence of frailty may result from conditions occurring within society, environment and the biological and physiological conditions within individuals. Similarly, Gobbens et al. (67) stated that multi-domain frailty reflects a holistic view of humanity. In contrast, Woo et al. (68) claimed that social factors (e.g. socioeconomic factors, lifestyle, and social support) are the...
COMPONENTS AND INDICATORS OF FRAILTY MEASURES: A LITERATURE REVIEW

The added value of psychological and social components for predicting frailty-related adverse outcomes remains unclear. Gobbens et al. (69) found adding psychological and social frailty components improved the ability of their frailty model to predict QOL in community-dwelling older adults. In contrast, Ament et al. (70) reported that cognitive, psychological, and social frailty components failed to significantly account for additional variance in QOL and ADL/IADL after controlling for physical frailty components. A possible reason for this inconsistency may be that cognitive frailty and QOL in Ament et al.’ study measured by a single question of which internal consistency reliability cannot be evaluated. Given that the added predictive power of psychological and social frailty has not yet been established, future studies are needed to validate the additional variance in frailty-related adverse outcomes explained by the psychological and social frailty compared to physical frailty.

There are two limitations of this literature review. One is the exclusion of the grey literature (e.g. dissertations, theses, and unpublished data), which may have omitted some frailty measures that are currently in development. We chose to focus this review on papers that have passed peer-review. Another is that only studies written in English were included and those frailty measures in other language may have been omitted. However, a noted strength of this literature review, to the best of our knowledge, is that this is the first of its kind to describe the components of frailty in each physical, psychological and social domain along with its corresponding indicators.

Conclusion and Recommendations

This literature review provides a comprehensive overview of the components of frailty within three domains: physical, psychological and social. Although there is no consensus on frailty measures, this review describes the most commonly used frailty components and the corresponding indicators in contemporary publications. These findings can be used to guide the development of a theoretical framework of frailty in future studies. Clinicians can use these frailty components and their corresponding indicators to comprehensively identify frail older adults from physical, psychological and social perspectives to provide holistic care to meet the multidimensional healthcare needs of this vulnerable population.

This literature review also raises concerns about current frailty measures. In particular, concern is raised regarding the use of weighted scores in determining the level of frailty, which clearly important for the predictive value of a frailty measure. However, there is limited knowledge on which frailty components are needed to use weighted indices and how those indices vary across populations and settings. More research is needed in this area so that we may be able to develop a measure of frailty that is most predictive for a given population. In addition, as the theoretical framework of frailty evolving, it has been agreed with that frailty is not a sole physical syndrome. It is important to know which psychological and social indicators work best for identifying the trajectory of frailty and for predicting adverse health-related outcomes. To be more important, we need to know whether these indicators work for ethic and culturally diverse populations. The answers remain indefinite, especially for components/indicators in social domain. We call for more studies conducted across diverse populations and setting to clarify the components and indicators of frailty in psychological and social domain. These studies will advance our understanding on frailty and may shed light on the development of intervention to mitigate its effect.

Conflict of interest: ???????
Ethical standards: ???????

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