JAMDA 16 (2015) 536.e1–536.e7

JAMDA

journal homepage: www.jamda.com

Original Study

Toward a Comprehensive Model of Frailty: An Emerging Concept From the Hong Kong Centenarian Study

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Keywords:
Centenarians
aging
frailty
psychosocial
multidisciplinary

A B S T R A C T

Objectives: A better understanding of the essential components of frailty is important for future developments of management strategies. We aimed to assess the incremental validity of a Comprehensive Model of Frailty (CMF) over Frailty Index (FI) in predicting self-rated health and functional dependency amongst near-centenarians and centenarians.
Design: Cross-sectional, community-based study.
Setting: Two community-based social and clinical networks.
Participants: One hundred twenty-four community-dwelling Chinese near-centenarians and centenarians.
Measurements: Frailty was first assessed using a 32-item FI (FI-32). Then, a new CMF was constructed by adding 12 items in the psychological, social/family, environmental, and economic domains to the FI-32. Hierarchical multiple regressions explored whether the new CMF provided significant additional predictive power for self-rated health and instrumental activities of daily living (IADL) dependency.
Results: Mean age was 97.7 (standard deviation 2.3) years, with a range from 95 to 108, and 74.2% were female. Overall, 16% of our participants were nonfrail, 59% were prefrail, and 25% were frail. Frailty according to FI-32 significantly predicted self-rated health and IADL dependency beyond the effect of age and gender. Inclusion of the new CMF into the regression models provided significant additional predictive power beyond FI-32 on self-rated health, but not IADL dependency.
Conclusions: A CMF should ideally be a multidimensional and multidisciplinary construct including physical, cognitive, functional, psychosocial/family, environmental, and economic factors.

With aging, frailty increases the risk of adverse health outcomes when an individual's diminished strength, endurance, and physiological reserve results in the person's inability to withstand environmental stressors.[1] The consequences of frailty are perhaps the major obstacle to healthy and disability-free life years in old age, while consuming a significant proportion of societal resources.

Clarity on the operational definition and components of frailty is important for clinical care, research, and policy planning. From the many attempts to systematically review the growing numbers of frailty assessment tools,[2–4] 2 of the most commonly used validated approaches are (1) the Frailty Phenotype[5]; and (2) the Deficit Accumulation model (Frailty Index, FI).[6] The Frailty Phenotype is based on 5 clinical criteria indicating the physical manifestation of physiological aging, including excessive weight loss, exhaustion, slow gait speed, weak handgrip, and sedentary behavior.[5] The FI originally composed of over 70 items indicating cumulative physical and cognitive comorbidities.[6] More recently, shorter lists of 30–40 variables have been validated, such as the 36-item scale in Song et al[7] or the 39-item scale by Gu et al,[8] without loss of predictive power.

The essential components that constitute frailty and how these components interact to exacerbate functional disability, comorbidity, and perceived health status are unresolved. Increasingly, researchers and practitioners are also proposing that frailty should shift its focus from organ- or disease-based approaches toward one that is based upon the well-being of the whole person.[9–11] Table 1 summarizes the various commonly used frailty assessment tools and their range of core components in the different domains, including physical,

The authors declare no conflicts of interest.
This study was supported by the Seed Funding Program for Basic Research, the matching fund from Department of Social Work and Social Administration at the University of Hong Kong (Project No. 104001032), and AXA funded red packets to the participants upon the completion of the interview.
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http://dx.doi.org/10.1016/j.jamda.2015.03.005
1525-8610/

Table 1
Comparing the Components of the Some Commonly Used Frailty Assessment Tools

Frailty Assessment Scales	Physical Factors (eg, Weight Loss, Fatigue, Slowness, Weakness, Low Activity, Comorbidity)	Functional Factors (eg, Difficulty with Mobility or Self-caring, ADL and IADL Dependency)	Cognitive Factors (eg, Memory Decline, Dementia)	Psychological Factors (eg, Depression, Anxiety, Distress)	Social/Family Factors (eg, Living Alone, Social Activities, Spouse/ Children Confidants)	Environmental Factors (eg, Barriers to Activities and Societal engagement)	Economic Factors (eg, Subjective Economic Status)
CHS-FSS[5]	Yes						
SOF[52]	Yes	Yes					
FRAIL-IANA[53]	Yes	Yes					
SHARE-FI[54]	Yes	Yes					
VES-13[55]	Yes	Yes					
CSHA-CFS[6]	Yes	Yes	Yes				
CSHA-FI[56]	Yes	Yes	Yes	Yes			
GFST[57]	Yes	Yes	Yes		Yes		
GU[8]	Yes	Yes	Yes	Yes			
TFI[30]	Yes	Yes	Yes	Yes	Yes		
EFS[58]	Yes	Yes	Yes	Yes	Yes		
CFAI[19]	Yes	Yes		Yes	Yes	Yes	
GFI[59]	Yes	Yes	Yes	Yes	Yes		
CMF (HKCS)	Yes	Yes	Yes	Yes	Yes	Yes	Yes

ADL, activities of daily living; CHS-FSS, Cardiovascular Health Study—Frailty Screening Scale[5]; SOF, Study of Osteoporotic Fractures,[52] FRAIL-IANA, FRAIL Questionnaire by the International Academy of Nutrition and Aging[53]; SHARE-FI, Frailty Instrument of the Survey of Health, Ageing and Retirement in Europe[54]; VES-13, Vulnerable Elder Survey-13[55]; CSHA-CFS, Canadian Study of Health and Aging - Clinical Frailty Scale[6]; CSHA-FI, Canadian Study of Health and Aging-FI[56]; GFST, Gérontopôle Frailty Screening Tool[57]; GU, Gu et al. 2009[8]; TFI, Tilburg Frailty Indicator[30]; EFS, Edmonton Frail Scale[58]; CFAI, Comprehensive Frailty Assessment Instrument[19]; GFI, Groningen Frailty Indicator[59]; CMF (HKCS), Comprehensive Model of Frailty (Hong Kong Centenarian Study).

functional, cognitive, psychological, social/family, environmental, and economic. This list is not exhaustive, and there may be other frailty assessment tools that have not been mentioned here but include some or all of the aforementioned domains.

Centenarians are generally regarded as the sickest and frailest in the society, yet few centenarian studies have explored the concept, components, and consequences of frailty.[12–15] Duarte et al[12] noted that "those reaching 100 years old are often classified as being noticeably frail; nonetheless, this population has not been included in the majority of contemporary studies on frailty, and to our knowledge, no research has specifically examined the prevalence and the variables associated with frailty among individuals aged 100+". Our study aimed to examine whether physical, cognitive, functional, psychological, social/family, environmental as well as economic factors converge to form the essential components of frailty, and to assess the incremental validity of a Comprehensive Model of Frailty (CMF) over FI in predicting self-rated health and functional dependency.

Methods

Sampling and Procedures

The Hong Kong Centenarian Study recruited 153 Chinese near-centenarians and centenarians who were born in 1905–1915. Quota sampling method was used according to the proportion of elders aged 85+ of the 18 Geographical Constituency Areas to recruit a geographically representative sample. Eligible elders were recruited based on 2 community social and clinical networks. First, through the Hong Kong Council of Social Service, 628 letters of invitation were sent to day care centers, district elderly community centers, neighborhood elderly centers, social centers for the elderly, home support teams throughout the territory, and the University of the Third Age centers. Two hundred near-and centenarians were reached. Among them, 56 elders participated in the study (participation rate 28%). Second, based on the database of the Elderly Health Clinics of the Department of Health, 210 letters of invitation were sent to eligible elders directly, and 97 of them participated in this study (participation rate 46%). The current study reports on the findings from a subset of 124 participants who were living in the community and not institutionalized. The rest of the 29 participants were institutionalized at the time of the data collection. The original intention of Hong Kong Centenarian Study was to evaluate the health and well-being of community-dwelling near- and centenarians. These 29 participants were initially community-dwelling at the first contact based on the existing databases compiled by the 2 community social and clinical networks but were then institutionalized at the time of sample recruitment and data collection. Considering their special circumstances compared with the 124 community-dwellers, we only included the latter subset in the current analysis. Participants signed written informed consent prior their in-home or center-based face-to-face interviews. At least 1 family member and/or registered social worker were present and witnessed at the consent procedure and the assessment. Because many elders were less familiar with structured interviews and physical examinations, the presence of the family member and/or the social worker was helpful to build a friendly and reassuring environment for the assessment. The assessment protocol was constructed based on 2 validated instruments: the 2008 versions of the Chinese Longitudinal Healthy Longevity Survey and the Elderly Health Center Questionnaire.[16,17] This study was approved by the Human Research Ethics Committee for Non-Clinical Faculties of the University of Hong Kong in January 2011 (Reference Number: EA200111) and by the Ethics Committee of the Department of Health (Reference Number: L/M 48/2011 in DHHQ/5030/5/5) in May 2011.

Thirty-Two-Item Frailty Index

Searle et al[18] suggested that a frailty index should contain 30–40 deficits in multiple systems, which have health-related consequences and exacerbate with age. Thus, based on Song et al,[7] we created a new FI using 32 items [32-item FI (FI-32] (Table 2) that represented deficits in a range of systems including chronic diseases, fatigue, mobility restrictions, sensory loss, difficulties in activities of daily living, memory problems, and negative emotions.[7] Following the approach suggested by Searle et al[18] and Song et al,[7] therefore, a score of 1 was assigned to indicate the presence of deficit for an item, whereas 0 was assigned to indicate the absence of deficit. FI-32 was calculated by summing up the scores for the 32 items and divided by the total number of valid responses. Thus, if a person has deficits in 8 items and have valid responses for all 32 items, their FI-32 will be 0.25 (8/32). The Cronbach alpha was 0.67, which suggested sufficient reliability.

CMF

We then constructed a new CMF. Based on the items available in the Hong Kong Centenarian Study assessment package, as well as the model of De Witte et al,[19] we added 12 new items that evaluated deficits in the psychological, social/family, environmental, and economic domains to the 32-itemed FI-32 to create the CMF (with 44 items). De Witte et al[19] (2013) had demonstrated the incremental validity of psychological, social/family, and environmental domains to a comprehensive frailty assessment. Financial security, which is measured in the economic domain, is often perceived as an important resource for successful aging especially by Hong Kong Chinese elders.[20–22] This domain was, therefore, included on top of De Witte et al's[19] domains to comprehensively capture Hong Kong Chinese elders' systemic vulnerabilities to stressors. All the 12 new items carried the same weight. Similar to FI-32, a score of 1 was assigned to a response that indicates a deficit, and a score of 0 was assigned to a response that indicated otherwise (Table 3). The Cronbach alpha was 0.70, indicating sufficient reliability.

Psychological Component of the CMF

Psychological well-being, according to Bradburn,[23] encompasses both positive and negative emotional experiences. Thus, for the psychological component, 2 aspects were evaluated.

Positive psychological well-being

This was whether the participant scored the highest possible score (ie, 5 = always/very much can/very much like) on 4 positive well-being items ("is able to look on the bright sides of things," "prefers to keep things clean and tidy," "is able to make decisions for oneself," and "feels as happy as when younger"; $\alpha = 0.53$).

Negative psychological well-being

This was whether the participant scored the lowest possible score (ie, 1 = never) on 3 negative well-being items ("often feels anxious and fearful," "often feels lonely," and "feels that the older one gets the less useful one becomes"; $\alpha = 0.67$).

Deficits were indicated by not scoring the highest possible score on the positive well-being items (ie, deficits in positive psychological well-being) and by scoring other than the lowest possible score on the negative well-being items (ie, presence of negative psychological well-being symptoms).

Social and Family Component of the CMF

In the light of the significance of living with family, frequent social activities, and familial emotional support for physical health and psychological adjustment,[22,24–26] for the social/family component, 3 aspects were evaluated: (1) whether the participant lived alone or with family members; (2) whether the participant had weekly or more frequent social activities; and (3) whether they had spouse or children to confide with when they need emotional support. Deficits were indicated by living alone and having social activities at a

Table 2
Thirty-Two Items Included the FI (FI-32)

FI with 32 Items
Physical well-being
Suffering from hypertension
Suffering from diabetes
Suffering from or have had cancer in the previous 5 years
Suffering from migraine or headaches
Suffering from glaucoma
Hearing problem
Speech problem
Weight loss (≥3 kg in 6 months)
Feeling tired all the time
Need assistance with bathing
Need assistance with toileting
Need assistance with continence
Has limited kind or amount of activity
Has no regular exercises
Dexterity problem
Suffering from arthritis or rheumatism
Suffering from chronic bronchitis, emphysema, asthma, or pneumonia
Suffering from heart diseases
Suffering from stomach or intestinal ulcers
Suffering from cataracts
Suffering from the effects of stroke
Vision problem
Suffering from bodily pains
Taking 5 or more medications
Functional well-being
Need assistance with dressing
Need assistance with indoor transfer
Need assistance with eating
Difficulty lifting light loads (5 kg)
Mobility problem
Psychocognitive well-being
Suffering from psychiatric disorders (eg, depression)
Suffering from dementia
Feeling hopeless

Table 3
CMF: 12 Additional Factors on Top of FI-32

CMF = FI-32 Plus
Psychological factors
(A) Positive psychological well-being
Able to look on the bright sides of things
Prefers to keep things clean and tidy
Able to make decisions for oneself
Feels as happy as when younger
(B) Negative psychological well-being
Often feels anxious and fearful
Often feels lonely
Feels that the older one gets the less useful one becomes
Social/family factors
Living alone or with their family members
Frequency of attending social activities
Having a spouse or a child to confide with when they need emotional support
Environmental factors
Barriers to social activities
Economic factors
Perceived self-rated economic status

frequency less than weekly and having no spouse or children to confide with.

Environmental Component of the CMF

Participants' challenges with respect to residing in their urban environment were conceptualized based on the idea of "age-friendly cities."[27] For this component, we asked participants to indicate the extent to which their social activities were interfered by factors such as mobility problems, lack of toileting facilities, lack of company, delayed access to activity information, difficulties with transportation, noisiness, activity arrangement unfitting the time, too costly, unattractive activity, and lack of appropriate activity (ie, barriers to social activities). Participants answered on a 5-point scale running from 1 (strongly disagree) to 5 (strongly agree). The 3 most common factors were mobility problem [mean ± standard deviation (SD) = 3.6 ± 1.5], lack of company (2.6 ± 1.5), and lack of suitable activity options (2.2 ± 0.1). A deficit was indicated by answering 4 (agree) or 5 (strongly agree) on any of these factors.

Economic Component of the CMF

For the economic component, we assessed the participants' perceived socioeconomic status by asking them to compare their socioeconomic standing of their households with most of the other households in Hong Kong. A deficit was indicated by the perception of one's household being "worse-off" or "mediocre" compared with an average local household.

Outcome Measures

Self-rated health

We assessed the participants' perception of their overall health by the question "how do you rate your current health?" using a 5-point scale, with 1 = very bad, to 5 = very good.

Instrumental activities of daily living dependency

Participants assessed their difficulties with 6 instrumental activities of daily living (IADL) tasks including shopping, preparing meals, washing clothes, using public transport, telephoning, and handling finances ($\alpha = 0.86$).[28] We assigned a score of 1 if the participant requires assistance on a particular task; and 0 if the participant can perform independently. We totaled the number of IADL tasks which required assistance to derive the overall IADL dependency score.

Statistical Modeling

To estimate the strength of associations between frailty indicators and outcomes, we calculated the partial correlations between FI-32 and CMF with self-rated health and IADL dependency, controlling for age and gender. Then, we proceeded to conduct hierarchical multiple regressions to examine whether our CMF provided significant additional variance explained to self-rated health and IADL dependency, controlling for the effects of FI-32 and baseline demographics. For model I, age and gender were added to the first block of the regression models to control for their effects on the outcome variables. In model II, we added FI-32. In model III, we inserted CMF into the model with FI-32. The percentage of missing values in the FI-32 was very low (<4%) except for 2 variables: "having spouse/children confidant" (7.3%) and "perceived socioeconomic status" (5.6%).

Results

Baseline Demographics

Of the 124 participants, 74.2% were female. The mean age was 97.7 (SD 2.3) years, with a range from 95 to 108.77 (62.1%) were living with their family members, and 47 (37.9%) were living alone in the community. Mean Charlson Comorbidity Index was 6.53 (SD 1.33); 40.4% were cognitively impaired with Mini-Mental State Examination (MMSE) score of lower than 24 (Table 4).

Distribution of Frailty States

The mean (SD) of FI-32 was 0.19 (0.13). Using the cut-off thresholds for frailty states according to the FI,[6] 16% of our participants were nonfrail (FI ≤ 0.08), 59% were prefrail (0.08 < FI < 0.25), and 25% were frail (FI ≥ 0.25). There was no significant difference in the gender distribution for the 3e frailty states [female = 0.20 (±0.14) vs male = 0.16 (±0.10), $t(122) = -1.53$, $P = .129$]. FI-32 was comparable for nonagenarians (aged 95–99 years) and centenarians (aged 100 or more) [FI-32 for nonagenarians = 0.19 (±0.13) vs centenarians = 0.17 (±0.17); $t(122) = 0.718$, $P = .474$].

The mean (SD, range) of CMF was 0.27 (0.13, 0.02–0.75). The 25th, 50th, and 75th percentiles of CMF were 0.18, 0.25, and 0.34. Unlike FI-32, female participants were found to be significantly frailer than male participants for CMF [female = 0.28 (±0.14) vs male = 0.23 (±0.11), $t(122) = -2.01$, $P = .046$]. Again, nonagenarians and centenarians had comparable CMF [$t(122) = 0.837$, $P = .404$].

Partial Correlations and Regression Models

Using self-rated health as outcome

Controlling for the effects of age and gender, the partial correlations of self-rated health with FI-32 and CMF were −.45 and −.51 (*P*s < .000), respectively. In other words, both FI-32 and CMF were significantly associated with self-rated health. However, the

Table 4
Baseline Characteristics of the Participants

Characteristic	Full Range	Value
Age, mean (SD) years	95–108	97.7 (2.3)
Female gender, n (%)		92 (74.2)
Charlson age-adjusted comorbidity index, mean (SD)	0–39	6.5 (1.3)
MMSE score, mean (SD)*	0–30	24.7 (4.3)
MMSE score <24, n (%)*	-	46 (40.4)
Deficits in positive psychological well-being		
Not able to look on the bright sides of things, n (%)		38 (31.9)
Not prefer to keep things clean and tidy, n (%)		44 (37.0)
Not able to make decisions for oneself, n (%)		33 (28.2)
Not feel as happy as when younger, n (%)		49 (41.9)
Presence of negative psychological symptoms	-	
Often feels anxious and fearful, n (%)		52 (44.1)
Often feels lonely, n (%)		52 (43.7)
Feels that the older one gets the less useful one becomes, n (%)		84 (70.6)
Living alone, n (%)	-	47 (37.9)
No regular (weekly) social activities, n (%)	-	57 (46.7)
No spouse/child as confidant, n (%)		35 (30.4)
Presence of barriers to social activities, n (%)	-	106 (87.6)
Poor or mediocre socioeconomic status, n (%)	-	78 (62.9)
Instrumental ADL dependency, M (SD)†	0–6	1.81 (2.05)
Self-rated health, mean (SD)‡	1–5	3.20 (0.95)

ADL, activities of daily living.

*MMSE scores were only available from 114 participants who have provided valid answers on one-half of the MMSE items. Higher score meant better cognitive capability.

†Higher score meant greater IADL dependency.

‡Higher score meant better self-rated health.

difference in these 2 partial correlations was marginally significant, $Z = 1.90$, $P = .057$. That is, the association of self-rated health with CMF was marginally stronger than that with FI-32. Table 5 summarizes the results of hierarchical regressions conducted with self-rated health as the outcome (criterion variable). Self-rated health was not predicted by age or gender in Model I. In model II, FI-32 significantly predicted self-rated health beyond the effect of age and gender. Higher FI-32 was associated with poorer self-rated heath. In model III, the inclusion of CMF in the regression model provided significant incremental predictive power on self-rated health. The regression coefficient of CMF was significant, indicating a substantial negative relationship between CMF and self-rated health, after adjusting for the effects of FI-32. The regression coefficient of FI-32 remained significant even after the inclusion of CMF into model III. To summarize, results from the comparison of partial correlations and the hierarchical multiple regression support the incremental predictability of CMF over FI-32 on self-rated health.

Using IADL dependency as outcome

Controlling for the effects of age and gender, the partial correlations of IADL dependency with FI-32 and CMF were .52 and .48 (Ps $< .000$), respectively. Once again, both FI-32 and CMF were significantly related to IADL dependency. Nevertheless, the difference in these 2 partial correlations was nonsignificant, $Z = 1.28$, $P = .20$. That is, the extent to which IADL dependency was associated with FI-32 was not significantly different from that with CMF. Table 5 also summarizes the results of hierarchical regressions conducted with IADL dependency as the outcome (criterion variable). Despite the relatively narrow age range of our participants, model I found that age was a significant predictor of IADL dependency, with higher age predicting more dependency in IADL. In model II, FI-32 and age were significant predictors of IADL dependency. Both higher FI-32 and age were associated with greater IADL dependency. Model III was not significant in the regression model; the regression coefficient of FI-32 and age remained highly significant in model III, whereas that of CMF was nonsignificant. In other words, the addition of CMF did not add any significant increment in variance explained on IADL dependency after controlling for the effects from FI-32. This finding was in line with the results from the comparison of partial correlations with IADL dependency.

Discussion

Frailty Predicts IADL Disability and Self-Rated Health

Our study found that IADL disability and self-rated health status were significantly predicted by frailty as measured by our FI-32 and CMF. This finding is in line with previous studies examining the correlation between frailty and functional dependency and self-rated health.[29–33] One systematic review of 28 studies showed that frailty predicted IADL disability in community-dwelling elderly people.[34] In particular, slow gait speed and low physical activity were the most powerful predictors followed by weight loss, lower extremity function, balance, muscle strength.[34] Lucicesare et al[31] found that self-rated health and frailty were moderately correlated and both predicted mortality.

Table 5
Regression Models

Variables	Standardized Regression Coefficients					
	Using IADL Dependency as Outcome			Using Self-Rated Health as Outcome		
	Model I	Model II	Model III	Model I	Model II	Model III
Gender*	−0.17	−0.09	−0.09	0.06	0.02	−0.01
Age	0.23‡	0.25‡	0.25‡	0.13	0.06	0.05
Frailty (FI-32)		0.54‡	0.42†		−0.45‡	0.03
Comprehensive Model of frailty			0.13			−0.54‡
R^2	0.07	0.36	0.36	0.02	0.22	0.28
Adjusted R^2	0.06	0.35	0.34	0.00	0.20	0.26
SE of estimate	1.98	1.65	1.66	0.94	0.85	0.82
F change	4.86‡	53.99‡	0.49	1.25	29.95‡	9.54‡

SE, standard error.
†$P < 01$; ‡$P < .001$.
*A score of 1 was assigned to male, and 0 to female.

CMF

Our study demonstrated that, among Chinese community-dwelling centenarians, the inclusion of psychological, social/family, environmental, and economic factors provided significant additional predictive power on self-rated health, but not IADL dependency, even after adjusting for frailty status and baseline demographics. Despite the strong association between self-rated health and CMF, we propose that the 2 constructs were conceptually distinct and should not replace each other. Self-rated health is a subjective judgment, which is often substantially influenced by frames of reference (eg, same-aged peers, the past self).[35] Although it is a robust predictor of mortality and morbidity,[36] its association with "objective" indicators of health, such as physical functions and diseases, wanes as the subject ages.[35] Subjective well-being also depends on a favorable cognitive evaluation of life as well as affective balance between positive and negative emotional experiences, as well as personalities.[37,38] Physical frailty and some of the newly added components of CMF (such as psychological well-being and social activities) could be considered as components of self-rated health.[39–41] However, some of the vulnerabilities included in CMF, such as perceived socioeconomic status and barriers to social activities are correlates of self-rated health, rather than components that are sampled by people when they are to make a coherent judgment of their health.[42,43] As the field moves toward adopting a multidimensional understanding of health- and well-being-related constructs, it is imperative that theories distinguish between core components of the construct from its correlates, in order to safeguard their construct validities.[44]

Our findings, therefore, support the concept that a comprehensive model of frailty should be a multidimensional and multidisciplinary construct including physical, cognitive, functional, psychological, social/family, environmental, and economic factors, all contributing and interacting together. This resonates with the recent call from the field to expand the concept of frailty from vulnerabilities of the physical health system to vulnerabilities of multiple systems that affects the totality of well-being.[9–11,19] Markle-Reid and Browne[45] advocate that frailty should be a multidimensional concept that considers (1) the complex interplay of physical, psychological, social and environmental factors; (2) an individual's context and incorporate subjective perceptions; and (3) the contribution of both the individual and environmental factors. Their proposition also aligns with other recent studies that frailty appears to be a dynamic process and frailty-specific multidimensional components should be used to measure the level of frailty as part of a stepwise and risk-stratified geriatric assessment of vulnerability in primary care in order to make individualized intervention decision and to improve the quality of life of a frail elder.[46–49]

Comprehensive Approach to Preventing and Treating Frailty

The future of treatment strategies against frailty could in fact be conducted using multifactorial and multicomponent interventions that target the different modifiable components of frailty. From the results of our study, we propose that such an intervention could

target the physical, cognitive, functional, psychological, social/family, environmental, and economic components of frailty. The concept of well-being is more than simply the absence of disability or chronic disease. Thus, strategies to improve a frail person's psychological state, or to improve of their living or financial environment, may in turn strengthen other interventions aimed at improving their physical (eg, exercise and nutrition) or cognitive health (eg, cognitive stimulation).[50] We hypothesize that this comprehensive approach to preventing and treating frailty, which can be individually tailored to each person, could be effective in reversing the frailty state.[51]

Community-Dwelling Centenarians May Hold the Key to Successful Aging

Community-dwelling centenarians are interesting to frailty research because they provide a unique insight into the levels of frailty in extreme old age, and how "successful aging" may mean different things between the oldest-olds and the young-olds. Our study challenges the intuitive view that centenarians are all frail because of their extreme old age. In fact, many centenarians lived in the community and were robust, but they are commonly neglected. Studying frailty among community-dwelling centenarians may enable us to tease apart the concept of old age and frailty, and explore what prevents some very old people from frailty, while some much younger people are frail. This may in turn help us to design viable interventions that can be applied at the earliest opportunity to prevent the decline in frailty states, whatever the age of the participants.

Limitations of Our Study

Our study utilized cross-sectional data, hence, causal inferences were not tested. Another weakness of this study was the low participation rate. It remains possible that those centenarians who replied to the request of the social workers or family members to participate in our study were relatively more physically and mentally sound. It is also possible that elders of a higher level of physical frailty or lower cognitive capacity were under-represented in our sample because their family members were reluctant to consent the interview, which would be conducted by the research team whom they were not familiar. Among our participants, 40.4% had a MMSE score below 24, and 7.9% had a MMSE score of 18 or less. In other words, a significant proportion of our sample exhibited symptoms of mild cognitive impairment. Missing values were very rare in our study. Nonetheless, because comprehensive frailty assessments tended to tap into the lived experience of elders,[19] future studies may benefit from developing assessment tools that are less sensitive to the effects of cognitive impairment. This may be achieved by the use of binary yes/no responses and visual analogues, or simpler expressions in items. The results of our study need to be validated in larger samples of centenarian from different living settings, different countries, and compared with other age groups. Comparing characteristics of centenarians with those of their younger counterparts may inform researchers the developmental trajectory of the different core components of CMF. Moreover, the findings of our study should be cross-examined against other definitions of frailty (eg, frailty phenotype) and gender distribution. However, because of the limited number of male centenarians in our study, our data are yet to be valid for testing the gendered patterns of centenarian frailty.

Conclusions

Our results support the concept that a comprehensive model of frailty should ideally be a multidimensional and multidisciplinary construct including physical, cognitive, functional, psychological, social/family, environmental, and economic factors. We propose that future studies that examine the role of frailty in outcome prediction can consider using the CMF, which may enhance the robustness and completeness of statistical evaluation.

Acknowledgments

The authors would like to thank Mr Kenneth Liang, Institute of Human Performance and Prof Paul Yip and Dr. Ernest Chui, The Department of Social Work and Social Administration at University of Hong Kong. Our heart-felt appreciation also goes to Dr. Morris Tai, Dr. Jason So, Queen Mary Hospital, Dr. Winnie Mok and Dr. Felix Chan, TWGHs Fung Yiu King Hospital, Dr. Chan Wai-man, Dr. Linda Hui, Dr. Sammy Ng, Ms. Shelley Chan, Elderly Health Service, the Department of Health and Ms. Grace Chan M Y and Ms. Winter Chan, Hong Kong Council of Social Service. The authors also thank Mr. Wan W-K (phlebotomist), Ms. Karen Cheung C-P, Ms. Irene Lau, Ms. Rosanna Liu and Ms. Luk F-L (registered nurses) for supporting this study. The project would not have been possible without the keen involvement of our participants and their family members.

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