Title: Investigating the Prevalence of Malnutrition, Frailty and Physical Disability and the Association between them amongst older Care Home Residents.

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Abstract:

Background: Malnutrition, frailty and physical disability are inter-related, more prevalent in the older population and increase the risk of adverse health outcomes. Thus, screening is essential, especially in the understudied care home setting where the population is vulnerable and at higher risk of malnutrition. Furthermore, prevalence may vary depending upon screening tools used. The aims of this study were to: 1) investigate the prevalence of 1) malnutrition risk using Mini Nutritional Assessment – Short Form (MNA-SF) and Malnutrition Universal Screening Tool (MUST), 2) frailty

using the Edmonton Frailty Scale (EFS), 3) physical disability using the Barthel Index (BI) and (4) examine the association between variables and coexistence of states.

Methods: Screening for malnutrition (MNA-SF and MUST) and frailty (EFS) was performed as part of a comprehensive geriatric assessment (CGA) in 527 residents from 17 care homes in Lincoln, UK. Mean age of the group was 85.6+/- 7.6 years and body mass index, BMI 23.0+/-5.1 kg/m^2.

Results: A high prevalence of malnutrition risk was detected: 41.4% by MNA-SF and 25.5% by MUST (high risk/malnourished). Furthermore, there was a clear discordance between MNA-SF and MUST scoring of malnutrition; for example, the percentage of those identified as being at low risk was 18.8% using the MNA-SF and 57.0% using the MUST. In addition, there was a high prevalence of severe frailty by EFS (69.6%) and functional impairment by BI (62.0%). There was good association between some variables ($P<0.001$) and 33.4% of residents had coexistence of all three states of malnutrition, frailty and physical disability.

Conclusions: Malnutrition risk, frailty and physical disability are highly prevalent in care home residents and interrelated. However, prevalence varies depending on the screening tool used. More research should be conducted in the care home setting to improve daily clinical practice as screening may impact upon subsequent treatment and care modalities and clinical outcomes.

(303 words)

Keywords: Malnutrition, Frailty, Sarcopenia, Physical Function, Cachexia

Introduction:

Frailty is a syndrome experienced by many older people. It is characterised by a decline in physiological systems, impaired homeostatic capability and reserve (1-3)

which reduces the ability to withstand stress and increases vulnerability to adverse health outcomes such as disability, falls, and mortality (1-3). Frailty has a complex aetiology; it may be due to a combination of ageing, “anorexia of ageing”, presence of malnutrition, physical factors (inactivity), disease, polypharmacy and psychosocial factors (depression) (1-3). The phenotype of physical frailty (PF) includes weight loss, fatigue, slow gait speed, weak grip strength or reduced physical activity, while psychosocial factors of frailty include cognitive, functional, and social aspects (1-3).

With respects to nutrition, the “anorexia of ageing”, has been suggested to be a geriatric syndrome and to play a principal role through a progressive reduction in appetite and/or food intake (1,4-6). This may lead to the development of a negative energy balance, weight loss and malnutrition which has been linked to negative clinical outcomes (1, 4-6). In particular, this may exacerbate muscle loss, diminish exercise capacity and strength, leading to the development and progression of sarcopenia, which is a major aetiological factor in the development of multifaceted frailty (1, 2, 4-7). Frailty in turn increases the risk of disability (1,2,8,9), which further worsens the state of anorexia and malnutrition (4,10). Superimposed upon this state, cognitive impairment may lead to further functional decline and reduced resilience, making it a risk factor for physical frailty (11-13).

The ability to accurately screen for malnutrition, frailty and physical function/disability using simple tools in settings such as care homes is of great importance as this population group is highly vulnerable, has higher than expected prevalence of malnutrition, frailty and disability and is currently under-studied/researched (14). In the United Kingdom (UK) the Malnutrition Universal Screening Tool (MUST) is recommended as a screening tool (15) whilst in other parts of the world the Mini Nutritional Assessment (MNA) and MNA Short Form (MNA-SF) have been

recommended and are endorsed by ESPEN (16). There is some debate as to which tool is most accurate for settings with frail older people. Previous reports suggest a possible discordance between MUST and MNA scoring patterns; MUST may potentially under-report malnutrition risk (17-19). The Edmonton Frailty Scale (EFS) is a simple, valid and reliable multidimensional screening tool, consisting nine domains including physical, cognitive and psychsocial aspects of frailty, which assesses the severity of frailty (20). However, there is little literature available on EFS's effectiveness, particularly when used with older people residing in care homes. The Barthel Index (BI) is a measure of Activities of Daily Living (ADLs), physical function and disability (21). Previous studies have shown that nutritional status is associated with functional status by BI score in institutionalised older people (22,23).

Therefore, the aims of this study were to assess the prevalence of risk of malnutrition (by MNA-SF and MUST), frailty (by EFS) and disability (by BI) in a large group of care home residents across a number of care homes and to examine their possible relationships and coexistence of states.

2. Methods

2.1 Participants and study design

This observational study was undertaken on 620 older participants residing in 17 care homes in Lincoln, United Kingdom (UK), between May 2015 and March 2018, and was part of an ongoing care home service evaluation (Bromhead Medical Charity funded care home service). This study was part of a joint National Health Service (NHS) service evaluation. The Chief Investigator of this study was Dr Adrian Slee. The study was carried out in accordance with the code of ethics of the World Medical Association (Declaration of Helsinki) and was cleared through Coventry and Warwickshire NHS

research ethics committee (REC reference number: 15/WM/0240, IRAS project ID: 153246). Participants had varying degrees of frailty, were treated with many medications, and were diagnosed with a range of comorbidities, such as diabetes, cancer, cardiovascular disease, chronic heart failure, chronic kidney disease, chronic obstructive pulmonary disease, arthritis, and dementia. The participants underwent full Comprehensive Geriatric Assessment (CGA) undertaken by a multidisciplinary team of healthcare professionals (Medical Consultants, Nurses, Occupational Therapist and Physiotherapist) lead by Dr Gill Garden. Of the 620, 93 participants with incomplete datasets or errors were excluded (n=527) and only those with complete MNA-SF, EFS, and BI scores were included. 33 participants had estimated MNA-SF and MUST scores because weight and/or height for BMI were unable to be measured accurately because of severe disability.

2.2 Anthropometric measurements

Body weight (kg) and height (m) were measured as part of CGA using weighing scales and stadiometers. When height could not be measured appropriately, it was estimated using ulnar length using the British Association of Parenteral and Enteral Nutrition (BAPEN) conversion tables within the MUST tool documentation (24). Body mass index (BMI in kg/m^2) was calculated from the weight and height, by dividing the weight (in kilograms) by the height (in meters squared).

2.3 Assessment of nutrition status by MNA-SF and MUST

Nutritional risk status was assessed using the validated MNA-SF and MUST screening tools according to suggested published guidelines (24, 25). The final MNA-SF score is out of 14 and can be converted into categories of nutritional risk; 12-14 normal

nutritional status, 8-11 at risk of malnutrition and 0-7 malnourished. The final MUST score is out of 6 and categorises; 0 low/normal risk, 1 medium risk, and ≥2 high risk of malnutrition.

2.4 Assessment of frailty by EFS

The EFS consists of 9 domains; cognition, general health status, functional independence, social support, medication use, nutrition, mood, continence, and functional performance (20). The final EFS score is out of 17 and can be converted into categories of frailty status; 0-5 not frail, 6-7 vulnerable, 8-9 mild frailty, 10-11 moderate frailty, and 12-17 severe frailty.

2.5 Assessment of physical function by BI

The BI reports the functional ability of an older person to undergo the following 10 activities; grooming, toilet use, feeding, bowel movement, bladder continence, transfer, mobility, dressing, stairs, and bathing (21). The final BI score is out of 20, in which the lower the score, the higher the physical disability. For the purpose of this study, the participants were divided into three categories; 0-10 severe functional impairment, 11-15 moderate functional impairment, and 16-20 mild/no functional impairment. The cut-off points were adapted from a paper by Supervia et al (26).

2.6 Statistical analysis

Continuous variables were presented as mean ± standard deviation (SD) or median and range (minimum-maximum). Histograms were used to evaluate normality of distribution of continuous variables. Data obtained was entered on Microsoft Excel, and analysed using IBM SPSS statistics, version 25. Number of residents and

percentage were calculated to measure prevalence. Pearson and Spearman correlation tests were used to investigate associations between variables. A p-value of < 0.05 was considered to be statistically significant.

3.0 Results

3.1 Participants characteristics

Data was analysed for 527 older people from 17 different care homes in Lincoln. The characteristics of the sample can be seen in Table 1. MNA-SF, EFS and BI was completed in 527 residents, BMI was completed in 494 residents and MUST in 505.

Table 1: Participants characteristics and variables.

Parameter	**Mean ± SD or Median [range]**
Age (years)	85.6 ± 7.6
BMI (kg/m^2)	23.0 ± 5.1
MNA-SF	9 [0-14] (At Risk)
MUST	0 [0-6] (Low Risk)
EFS	12.4 ± 2.4

Normally distributed datasets are written as mean ± standard deviation while non-normally distributed datasets are written as median [range].

3.2 Assessment of malnutrition risk

The percentage of those at high risk of malnutrition/malnourished was 41.4% using the MNA-SF and 25.5% using the MUST, while the percentage of those at medium risk/at risk was 39.8% by MNA-SF and by 17.5% by MUST. Those at low risk of malnutrition/normal nutritional status was 18.8% using the MNA-SF and 57.0% using

the MUST. These results clearly show discordance between the screening tools. The prevalence of malnutrition and discordance between the MNA-SF and MUST is depicted in Figure 1.

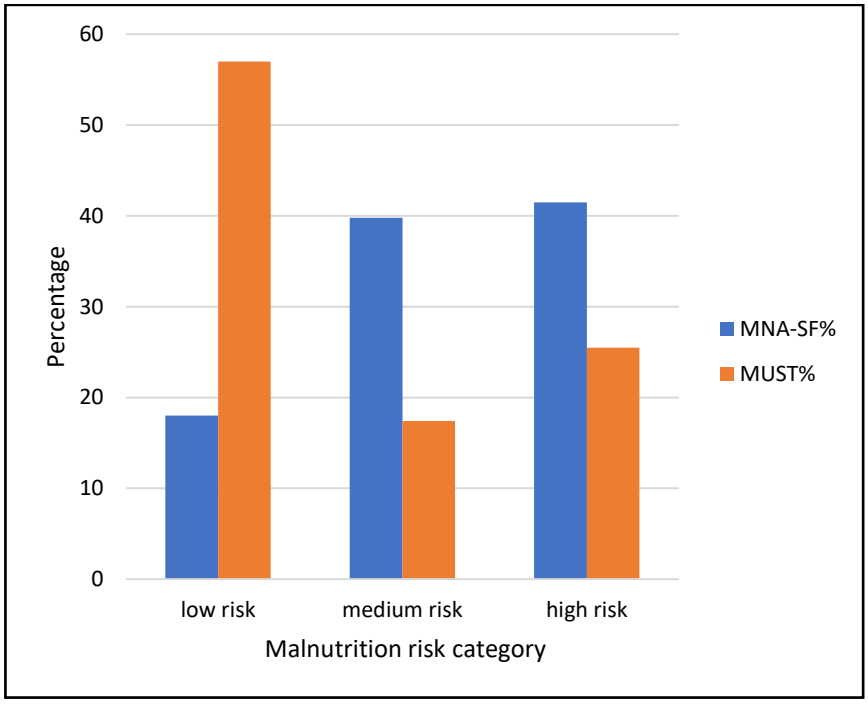

Figure 1: Malnutrition prevalence (%) by MNA-SF and MUST. Low risk/normal; medium risk/at risk; high risk/malnourished.

3.3 Assessment of frailty

The prevalence of frailty according to the EFS categorisation can be seen in Table 2.

Table 2: Frailty prevalence by EFS.

Frailty status	**% (n)**
Not frail (0-5)	0 (0)
Vulnerable (6-7)	3.6 (19)
Mild frailty (8-9)	9.7 (51)
Moderate frailty (10-11)	17.1 (90)

Severe frailty (12-17)	69.6 (367)

Data recorded as percent (number) of participants.

The percentage of severe frailty was 69.6%. Note that of those who were severely frail, 54.5% were identified at high risk of malnutrition by the MNA, while 31.8% were at high risk by the MUST.

3.4 Assessment of physical function

The prevalence of functional impairment/disability can be seen in Table 3.

Table 3: Disability prevalence by BI (0-20 scale).

Functional status by BI	**% (n)**
Mild/no functional impairment (16-20)	17.5 (92)
Moderate functional impairment (11-15)	20.5 (108)
Severe functional impairment (0-10)	62.0 (327)

Data recorded as percent (number) of participants.

3.5 Coexistence of states of malnutrition, frailty and disability

The co-prevalence of different states was analysed and can be viewed in Venn diagram format in Figure 2 below.

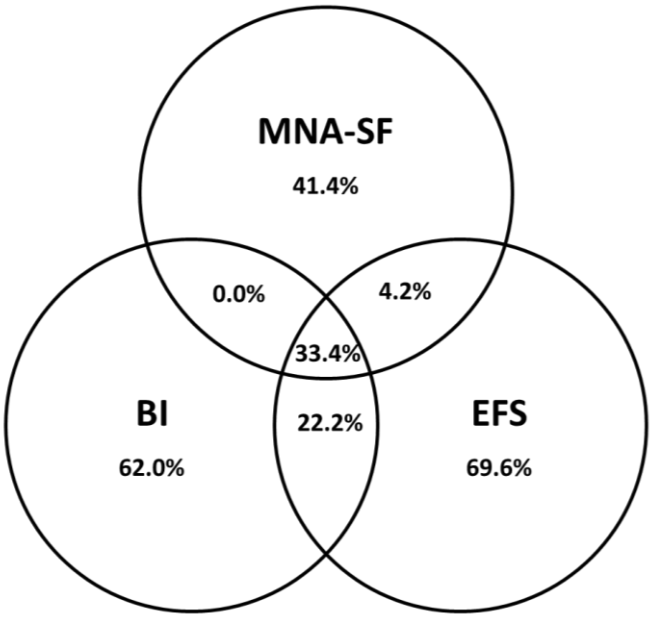

Figure 2. Venn diagram depicting the co-prevalence of different states of malnutrition risk (by MNA-SF), frailty (by EFS) and physical disability (by BI).

3.6 Associations between malnutrition, frailty and disability.

The correlations between the different measured variables (MNA-SF, MUST, BI, and EFS) can be seen in Table 4.

Table 4: Correlations between variables.

Variable	**r-value,**	**p-value**
EFS vs BI	-0.67	<0.001
MNA-SF vs BI	0.55	<0.001
MNA-SF vs EFS	-0.60	<0.001
MNA-SF vs BMI	0.56	<0.001
MUST vs BI	-0.34	<0.001
MUST vs EFS	0.40	<0.001
MUST vs BMI	-0.55	<0.001

Discussion

As far as it is known this is the first study to compare the combined use of the MNA-SF, MUST, EFS and BI combined in a large care home population, with significant study power to detect meaningful differences. With regards to malnutrition risk, it was found that 41.4% and 25.5% of the participants were at high risk of malnutrition/malnourished, 39.8% and 17.4% were at medium risk, and 18.8% and 57.0% were at low risk/normal based on the MNA-SF and MUST screening tools, respectively (Figure 1). Evidently, the prevalence of possible malnutrition (from screening tool scores) in care homes is high, which is consistent with other studies conducted in the same setting (27-31). One recent systematic review evaluated the potential cause of malnutrition in older people and another specifically in care homes and found that it is most likely multifactorial and associated with frailty, depression, dysphagia, chewing problems, poor oral intake, pharmacological use (such as the use of statins, antiparkinson's medication, muscle relaxants, antihypertensives, diuretics, heart failure medications, antiarrhythmics, and antipsychotics), dementia, and eating dependence (32, 33). This poor nutritional status predisposes older people to adverse outcomes, such as increased risk of infections and chronic disease, reduced effective disease treatment, reduced quality of life, and increased mortality (34-36). Therefore, accurate nutritional screening, assessment and intervention would be potentially beneficial in minimising and preventing adverse outcomes. The clear discordance between the MNA-SF and MUST scoring patterns (Figure 1) demonstrated in this study is a similar finding to previous studies (17-19). A study by Poulia et al, examined 6 screening tools in 248 hospitalised older people and found that the risk of malnutrition ranged from 47.2% to 97.6% depending on the tool being used (37).

Likewise, a study by Diekmann et al, evaluated the prevalence of malnutrition in care homes using three screening tools; MNA, MUST, and NRS, and found significant differences in prevalence of risk (38). This discrepancy requires further study; lack of consensus on an effective universal malnutrition screening tool limits comparability of available research and influences intervention trials. Furthermore, the mismatch between the MNA-SF and the MUST has important clinical implications since underreporting/misreporting of malnourished frail older people may adversely impact on nutritional intervention.

With regards to frailty, 69.6% of the participants were deemed to be severely frail, 17.1% moderately frail, and 14.3% mildly frail/vulnerable using the EFS (Table 2). Therefore, the prevalence of frailty in care homes is high. This high prevalence was reported in other studies using the EFS. A study of 382 hospitalised older people in Poland assessed the prevalence and severity of frailty using the EFS and found that the prevalence of frailty was 41.1% and concluded that the EFS is a reliable tool for the assessment of frailty in this population (39). Another study using the EFS in 54 older people residing in care homes reported the prevalence of frailty to be 74.1%, with 27.5% having severe frailty (40). Whilst the high prevalence of frailty amongst care home residents is predictable, there is sparse literature on the efficacy of the EFS in screening for frailty in this setting. Similar results were found predictably for physical function/disability using the BI with 62% of residents having a BI score of 0-10, indicating severe disability/poor physical function. Coexistence of the three states of malnutrition, frailty and disability were thus also found to be concerningly high (33.4%), as depicted in the Venn diagram format in Figure 2.

Correlation testing showed that the EFS was negatively associated with the MNA-SF and positively associated with the MUST, meaning that as frailty becomes more severe, malnutrition risk increases, and vice versa. In fact, amongst those who were severely frail, almost half were identified at high risk of malnutrition using the MNA-SF, whilst only 31.8% were identified at high risk using the MUST. The association between malnutrition risk and frailty has been reported by other researchers. For example, a study by Bollwein et al, evaluated the association between MNA scores and physical frailty in 206 community-dwelling older people and found that 90% of those at risk of malnutrition had frailty or pre-frailty and frail older people scored significantly lower on the MNA than other participants (41). A study of 1200 community-dwelling Lebanese older people reported that the number of malnourished older people increased with rising level of frailty (42). Moreover, a study of 366 hospitalised older people, evaluated the performance of the EFS and found it to be significantly associated with cognition, functional status, medication use, mood, and nutrition, and that the MNA score, used to assess nutritional status, was the most associated with the EFS (43). Interestingly, a study by Dent et al, investigated the ability of the MNA-SF to identify frailty, and found that the MNA-SF is a good tool to predict not just malnutrition, but also frailty in hospitalised older people (44). A further study by Valentini et al also showed similar results (45). This may be due to the fact that the MNA-SF items and the frailty phenotype overlap in content; for example, neuropsychological criteria, weight loss, and markers of muscle mass (e.g. calf circumference). In addition to frailty, poor physical function/disability is another obvious overlapping state and the coexistence/prevalence with a low MNA score and high EFS is depicted in Figure 2. Table 4 also indicates that there is a positive association between the MNA-SF and BI in our study ($r=0.55$, $P<0.001$). Cereda et al,

previously showed similar relationships between nutritional status (by MNA and Geriatric Nutritional Risk Index) and BI scores in two different studies (22,23). Furthermore, other studies by Stange et al, performed in 286 older people residing in 6 different care homes in Germany (46), and a study by Serrano-Urrea and Gracia-Meseguer, performed in 895 older people residing in 34 care homes in Spain, found a close relationship between between the MNA and BI (47). Similarly, Villafaňe et al also found a similar positive association in older hospital patients using the MNA (48).

To conclude, more research is needed to examine the association between nutritional status, physical function and frailty. The EFS is a holistic screening tool for frailty which examines psychosocial factors in addition to the physical factors of frailty (19). Research should examine fully the association between the EFS and multiple malnutrition screening methods (such as measuring fat free mass (FFM), BMI, MNA, MUST) and measures of physical function as it may have significant clinical implications.

There are some limitations to the current study. This was an observational screening study which relied on a single screening and assessment period and hence it was not possible to detect changes or trajectory over a follow-up period. In addition, it may be somewhat difficult to accurately estimate basic measurements such as weight and height in the older care home population, which can lead to measurement inaccuracies (e.g. BMI and weight loss % score). Medication use, cognitive function and the presence of comorbidities are major confounders that affect both frailty and mortality (35). Body composition (e.g. FFM) and blood measurements to evaluate malnutrition and inflammatory markers (e.g. albumin and C-reactive protein), could have been

used however these tests would have been intrusive, time-consuming and expensive in the care home setting. Nevertheless, the importance of this large study is that it was conducted in a whole health care system in a specific geographical area, which helps to remove potential bias and variability, and allows generalisability of the conclusions.

Conclusion

This study provided important information on malnutrition risk, frailty and disability amongst a large population of older people residing in multiple care homes in a single county in the UK. It was found that malnutrition risk prevalence is high, with clear discordance between MNA-SF and MUST scoring patterns. Prevalence of frailty was also found to be high using the EFS as a screening tool. Malnutrition, frailty and disability are interrelated, and older people who are severely frail with poor function tend to be more malnourished. More research should be focused on the use of the EFS and its validation in care homes. Older people residing in care homes are a vulnerable population but there is a paucity in research in this setting. Therefore, more funds and resources should be invested in care home research in order to establish the best screening tools and to improve clinical practice.

Authors contributions: AS, GG and TA played key roles in the design of the study. AS, GG, DR, LS, LW and GW undertook the measurements and data collection. GG lead the multidisciplinary team. EF and AS analysed the data and wrote the main manuscript. All authors played a role in the review of the final manuscript.

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Conflicts of interest: None

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Figure Legends

Figure 1: Malnutrition prevalence (%) by MNA-SF and MUST. Low risk/normal; medium risk/at risk; high risk/malnourished.

Figure 2. Venn diagram depicting the co-prevalence of different states of malnutrition risk (by MNA-SF), frailty (by EFS) and physical disability (by BI).

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