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# Short functional geriatric evaluation: Confirmatory factor analysis to assess the multidimensionality of frailty in community-dwelling older adults

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ABSTRACT

This paper explores the ageing population in Italy, where older adults account for more than 14 million individuals (in January 2023) and constitute 24.1 % of the total population. Frailty, a condition encompassing biological, psychological, social, and economic challenges, is recognised as a significant public health issue. The study introduces the Short Functional Geriatric Evaluation (SFGE) as a large-scale screening tool for frailty in community-dwelling older individuals. A Confirmatory Factor Analysis (CFA) was conducted on the SFGE. The CFA scrutinises the construct validity of SFGE using a sample population from the "Long Live the Elderly!" program in Italy. Initial results indicate an acceptable fit, prompting the incorporation of Modification Indices to enhance model performance. The refined CFA demonstrates that the SFGE model effectively captures the multidimensional nature of frailty. The text underscores the timeliness of identifying frailty, emphasising the need for simple, fast, and predictive tools to screen large populations efficiently.



## Introduction

According to the latest Eurostat data, the overall population of Europe is progressively ageing. In 2022, more than one-fifth (21.1 %) of the European Union (EU) population was aged 65 or older and, compared to 2021, the percentage of people over 65 increased in all member states. Over the past decade (2012-2022), an increase of 3.1 % was observed for the EU.[1] As in Europe, Italy also witnesses an average rise in the median age. The population over 65 years old accounts for 14.177.000 individuals (in January 2023) and constitutes 24.1 % of the total population. There is an increase in octogenarians, rising to 4.530.000 and accounting for 7.7 % of the total population in Italy[2] and a significant increase in Europe.[1] In 2100, the proportion of people over 80 in the EU population will be 9.2 times higher than in 2022, rising from 6.1 to 15.3 %.[3]

The older population runs into biological, psychological, social, and economic problems identified in the frailty condition. Considering the rise in number, biopsychosocial frailty has become a public health problem.[4] Frailty was defined by Gobbens et al. as "*a dynamic state affecting an individual who experiences losses in one or more domains of human functioning (physical, psychological, social) that are caused by the influence of a range of variables and which increases the risk of adverse outcomes*".[5] The World Health Organisation also states that a holistic and comprehensive approach to frailty is needed.[6]

Frailty has been associated with a higher risk of mortality, disability,[7] institutionalisation,[8] and healthcare expenditures.[9] It is a dynamic condition that tends to progress[10] if not prevented at an early stage. As timing is essential, it is crucial to identify a scale that can be used for population screening. This tool could also help to allocate economic resources more efficiently to frail and pre-frail older people.[11]

Simple, fast, easy-to-use, and predictive tools should be used to assess frailty in large populations due to its growing impact on public health. Many scales have been developed and validated in recent years to stratify the older population and plan appropriate health promotion and prevention activities.[12] Some tools assess frailty as a clinical syndrome, such as Fried's criteria,[10] while others are based on a multidimensional concept, such as the Tilburg Frailty Index, in which 20 % of the items relate to social frailty.[13] The Short Functional Geriatric Evaluation (SFGE) is short and easy to administer questionnaire implemented to evaluate multidimensional frailty in

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community-dwelling older adults. It has been shown to have good sensitivity and specificity[14] and predictive validity for mortality, hospitalisation, and institutionalisation.[15] It comprises 50 % of items investigating social aspects, which is relevant because studies have shown the importance of social determinants of health in frailty among older people.[16–18] For example, Huang et al. show how social frailty, including economic difficulties, living alone, and reduced sociability, was associated with reduced intrinsic capacity,[19] indicating the person's physiological and psychological resources. Social isolation and loneliness are also characteristics that have been associated with the development of frailty.[16] Although there is no general agreement on measuring social frailty, its prevalence is high [20]; therefore, its accurate identification is crucial for public health.

In our recent study, we conducted an Exploratory Factor Analysis (EFA) on the SFGE to assess latent factors in the questionnaire and to study the construct validity, which is a critical psychometric property of the tool. Three constructs (psychophysical frailty, the need for social and economic support, and the lack of social relationships) have proved to explore and assess biopsychosocial frailty accurately.[21]

This paper aims to conduct a Confirmatory Factor Analysis (CFA) on the multidimensional questionnaire SFGE as the final step in the study of its construct validity. The aim is to verify if all tool items are performing well as a screening method for frailty in community-dwelling older people and to stratify frailty into four levels: robust, pre-frail, frail, and very frail.

## Materials and methods

### *Study design and sample*

This study is the second part of the SFGE Factor Analysis. Therefore, it is based on the same sample population used in the previous research.[21] The sample comprised 8800 people over 65 who are from different regions and cities in Italy (Brindisi, Catania, Civitavecchia, Ferentino, Genoa, Naples, Novara, Rome, and Sassari) who live in community, alone or with other people (familiars, caregivers). They all participate in the program "Long Live the Elderly!" (LLE) of the Community of Sant'Egidio, in Rome. The program was instituted in 2004 primarily to mitigate the adverse health effects of heat waves on older people living in Rome. Subsequently, the LLE program has been extended to other cities in Italy, and its principal aim is meeting social unmet needs.

LLE is an innovative service to contrast social isolation, through the creation of networks to reach large cohorts of older adults' population. The main goal is prevention, by counteracting the negative effects of critical events such as flu epidemics, falls and loss of a partner.

Nonhealth operators, as volunteers or social workers, previously trained, administer the SFGE questionnaire to assess the stage of frailty. If the evaluated person needs help, e.g., purchasing medications or food, a social support network will be activated.

### *The questionnaire*

The SFGE is a short version of the Functional Geriatric Evaluation (FGE).[22] The FGE is a questionnaire derived from the Geriatric Functional Rating Scale[23] and, in Italy, it is validated by Palombi et al.[22] The SFGE is straightforward to use, quick and simple questionnaire, composed of 13 items. It is a multidimensional tool as it assesses every aspect of frailty, from biological to socioeconomic domains.[24] It is possible to stratify the community-dwelling older people into four levels, based on the score: robust (score $\leq$ 0), prefrail (1–2), frail (3–9), and very frail ($\geq$10).

### *Statistical analysis*

The statistical analysis conducted is based on the results of the Explorating Factor Analysis (EFA)[21] [Table 1]. Two items (Q7, Q8) were merged into one, as Q8 requires a response only if Q7 is positive, reducing the number of items from 13 to 12. The EFA identified three latent factors: "need for social and economic support" (Q3, Q4, Q7), "psychophysical frailty" (Q6, Q8-Q12), and "lack of social relationships" (Q1, Q2, Q5).

In this study, we performed a Confirmatory Factor Analysis (CFA). The error metrics considered in assessing the fit of the model were: Root Mean Square Error of Approximation (RMSEA) $<$0.05; Comparative Fit Index (CFI) $>$0.90[25] and the related Tucker-Lewis Index (TLI) $>$0.90, Standardized Root Mean Square residual$<$ 0.08 (SRMR).[26] We assumed acceptable loadings$\geq$ 0.3, as in the previous article on the EFA.[21]

Lavaan package of R studio version 4.3.1 was used for data processing, with p-values $<$ 0.05 considered statistically significant.

## Results

The sample used in this study was the same as the one from the EFA of the SFGE published in 2023 by Liotta et al.[21] It comprised 67.2 % females (mean age 84.3, SD $\pm$ 4.7) and 32.8 % males (mean age 84.5, SD $\pm$ 5.5) aged over 65 from various Italian cities. Most people were from Rome (n = 4331, 49.1 %), Naples (n = 1874, 21.3 %), and Novara (n = 1218, 13.8 %). The SFGE is a questionnaire composed of 13 items that assess multidimensional frailty in community-dwelling older people, and it comprises the psychophysical and socioeconomic domains.[24] The sum of the individual scores is used to stratify older adults into 4 classes: robust (score $\leq$ 0), prefrail (1–2), frail (3–9), and very frail ($\geq$10). According to the SFGE score, 37.7 % of our sample were robust (n = 3319), 24.0 % prefrail (n = 2108), 29.3 % frail (n = 2577), and 9.0 % very frail (n = 796) individuals. Therefore, a lower score indicates a better health status.

To evaluate the performance of the CFA applied to SFGE, thus how well the model fits the data, we used the Chi-squared test, Comparative Fit Index (CFI), the Tucker-Lewis Index (TLI), the Root Mean Square Error of Approximation (RMSEA) and the Standardized Root Mean Square Residual (SRMR). The p-value for the chi-square test is reported as 0.000, which is highly significant suggesting that the model fit may not be ideal. However, it's important to note that chi-square tests can be sensitive to sample size, and in large samples (such as 8800 in this case), even small deviations from perfect fit can lead to a significant chi-square. In such cases, it's often recommended to consider other fit indices and practical significance as well, such as CFI, TLI, RMSEA, SRMR.

**Table 1**
Results of the EFA. Latent factors and corresponding items with the highest loading.

| Latent factor | Items of the SFGE |
|---|---|
| Psychophysical frailty | Q6: Are you receiving formal care services? |
| | Q8: Energy and motivation |
| | Q9: Able to use the shower or bath independently |
| | Q10: Leaves the house |
| | Q11: Bedridden |
| | Q12: Confused |
| Need for social and economic support | Q3: Cohabitants |
| | Q4: In case of need, is there someone you can count on? |
| | Q7: Is your monthly income enough to get to the end of the month? |
| Lack of social relationships | Q1: Age |
| | Q2: Education |
| | Q5: Are you involved in social activities or group? |

The first results reported a CFI (0.848) and TLI (0.803) lower than 0.9, indicating an acceptable but not excellent fit because the value is not greater than 0.90. The value of RMSEA was 0.069 and expressed a good fit above the threshold value of 0.05.[25] The SRMR was 0.051, also below the threshold value of 0.08.[26] These results show an overall acceptable fit of the model, which could be improved. In the CFA model [Fig. 1], Q4, Q7, Q2 and Q5 load less than 0.3 on their factors. In addition, the items Q6, Q3, and Q1 load more than 0.3, 0.35, 0.70, and 0.40, respectively. The items Q8, Q9, Q10, Q11, and Q12 load with negative values, indicating an inverse relationship with the latent construct.

Considering the results obtained from the CFI, TLI, RMSEA, and SRMR, previously described, we approached the model by considering the addition of Modification Indices (MI) and Standardized Expected Parameter Change for Model Modification[27] [Table 2] to improve the goodness of fit, identifying significant correlated residual error terms. The MI estimates the reduction in chi-square that would result if a particular fixed parameter were free to be evaluated in the model, as well as the expected change in the value of the specific parameter, given its inclusion in the model.[28] The R Lavaan package suggested adding correlations among items. Therefore, we tested a second model illustrated in Fig. 2. According to the conceptual meaning of some items and what they investigate, we considered the first two suggestions of correlations, namely between Q4-Q7 and Q8-Q12.

Thus, we performed the CFA again with the addition of Modification Indices, and the new error metrics of the model appeared as follows: CFI=0.913, RMSEA=0.053, TLI 0.883, SRMR 0.041, indicating a good fit of the SFGE tool CFA [Table 3, Fig. 2].

**Table 2**
Modification Indices.

| Lhs | op | rhs | MI | EPC |
|---|---|---|---|---|
| Q8_N | ~~ | Q12_N | 61.455.439 | 0.0202178 |
| Q4_N | ~~ | Q7_N | 30.968.973 | 0.1136334 |
| Q7_N | ~~ | Q2_N | 26.396.499 | 0.0853071 |
| Q2_N | ~~ | Q5_N | 16.704.027 | 0.0247160 |

## Discussion

In this study, data from a survey of a representative sample of older adults was used to validate a short version of the Functional Geriatric Scale, which was introduced initially by Grauer.[23] An EFA was performed to analyse the factor structure of the tool and compare it with the models reported by other authors.[21] It is crucial in public health to validate a questionnaire that can also be a valid screening tool for frailty in large populations of community-dwelling older people. The aim is to act proactively before the occurrence of outcomes such as disability and subsequent institutionalisation. This can be done by following personalised strategies based on risk stratification.

We assessed the model fit of the CFA based on several indexes, including CFI, TLI, RMSEA and SMRM. The threshold values for these indexes were derived from the relevant literature. The CFA was developed for the three-factor model obtained via EFA of the Italian older adult population sample. The CFA demonstrates that the three-dimensional model is well-fitted. All indexes used in the CFA reached

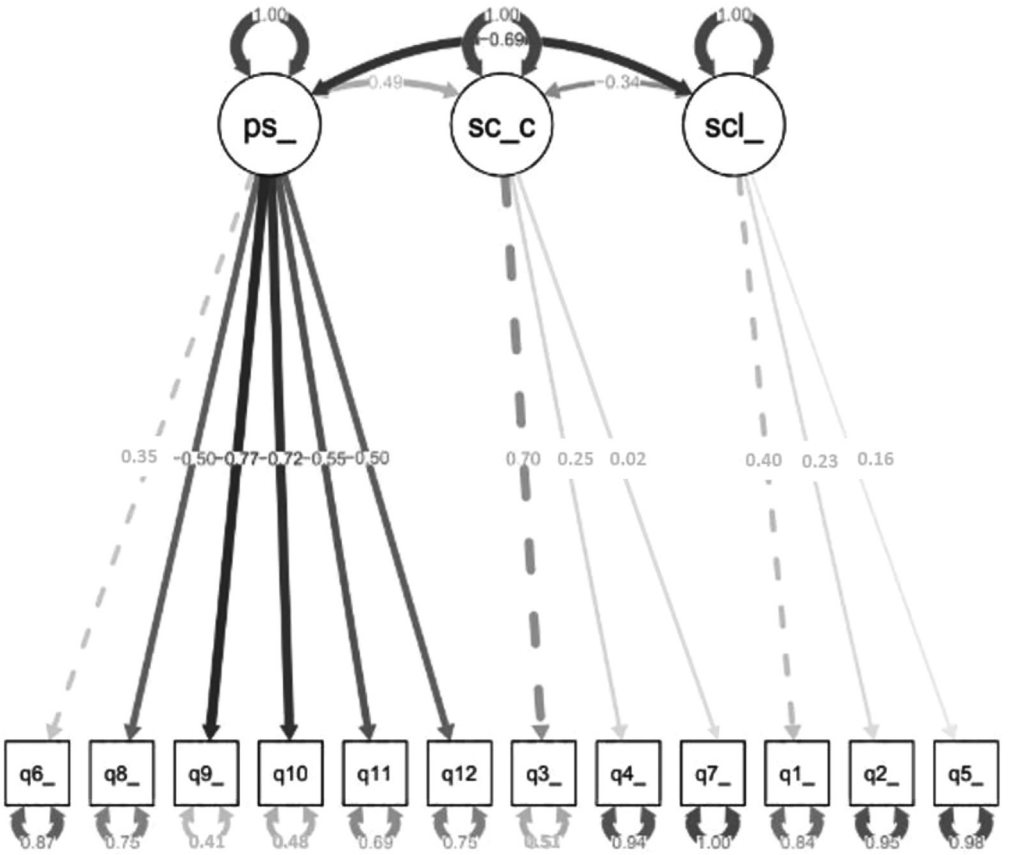


**Fig. 1.** CFA model of the SFGE. The dashed lines indicate that the raw factor loading has been set to 1. Labels: ps_: psychophysical frailty. sc_c: need for social and economic support. scl: lack of social relationships.

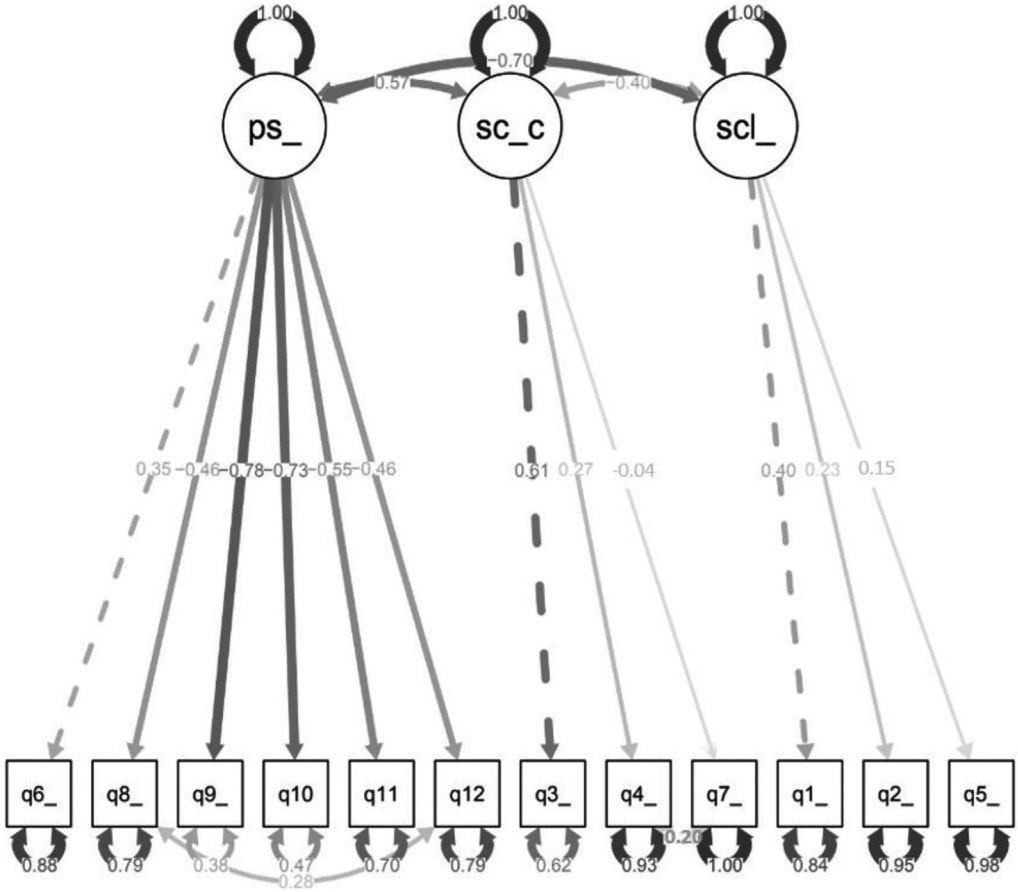


**Fig. 2.** The CFA model of the SFGE with modification indices was added. The dashed lines indicate that the raw factor loading has been set to 1. Labels: ps_: psychophysical frailty. sc_c: need for social and economic support. scl_: lack of social relationships.

at least an acceptable level. The parametric error results of the CFA among the older adults' group are acceptable (CFI=0.913, TLI=0.883, RMSEA=0.053, SRMR=0.041). The CFI with a value greater than 0.90 reflected an excellent fit to the data.[25] In addition, RMSEA was recommended to be lower than 0.06 and SRMR lower than 0.08.[26] Based on the EFA, three dimensions were proposed: psychophysical frailty (Factor 1), the need for social and economic support (Factor 2), and the lack of social relationships (Factor 3). Q4, Q7, Q2 and Q5, belonging, respectively, the first two to factor 2 and the second two to factor 3, were retained in the present scale, despite the loading of the items being lower than 0.3, to stay consistent with prior studies and provide a better diagnostic criterion. Considering the results obtained from the first CFA, we applied Modification Indices (MI) and Standardized Expected Parameter Change (EPC) for Model Modification to improve the goodness of fit. Therefore, we chose the questions with higher MI and EPC correlation, Q4-Q7 and Q8-Q12. The correlation is due to the theoretical framework. Q4 is related to the availability of aid if needed, while Q7 investigates economic status. A higher economic availability is likely to correspond to the presence of a formal caregiver. Q8 is related to the modification in energy and motivation (normal or hypo/hyperactive), and Q12 contributes to investigating the functional health state. Therefore, conceptually, the questions are related. This procedure to modify an initial model represents a blend of exploratory and confirmatory approaches. It is common practice when models that are grounded in solid theory achieve less than adequate goodness-of-fit.[28] While critics perceive the modification indices (MI) either as a form of data snooping or a veering away from the theory-driven paradigm,[29] there are practical advantages to the modification approach.[30] Firstly, Confirmatory Factor Analysis (CFA) is restrictive because hypotheses that allow the specification of a simple factor pattern aligning with accurate data are seldom available. Secondly, the criteria for accepting CFA models, such as the percentage of variance accounted for, are more stringent than the acceptance standards for Exploratory Factor Analysis (EFA) models.[31] Achieving such a high standard may only sometimes be feasible in practical applications. This approach addresses concerns related to potential overfitting to the original dataset and supports the validity of our factor model. Therefore, the model assumed for the SFGE based on the previously published EFA is suitable, indicating that SFGE has construct validity.

**Table 3**
SFGE Confirmatory Factor Analysis error metrics after application of Modification Indices.

| | Good Fitting Range | Results |
|---|---|---|
| CFI | > 0.9 | 0.913 |
| TLI | > 0.9 | 0.883 |
| RMSEA | < 0.05 | 0.053 |
| SRMR | < 0.08 | 0.041 |

### *Limitations*

This study has some limitations that need to be considered. Firstly, screening research makes it impossible to evaluate all screen-negative cases to identify misses and calculate true sensitivity. In addition, no screening tool can have perfect CFA correlation values for some questions. Regarding the potential impact of inter-observer

reliability, the majority of our questionnaire items are objective, while only approximately 30 % are subjective. Considering that this could have a minor effect on our results, we plan to assess inter-observer reliability in future work to address this concern. Providers should continue to perform developmental surveillance and use large-scale validated screening tools.

## Conclusions

SFGE is a valuable tool as it performs a multidimensional evaluation of frailty,[5] based not only on health parameters but also on functional, psychological, and social characteristics (age, level of education, cohabitation, social isolation, and economic situation). Moreover, the instrument is tailored for large numbers. It is easy, brief, and acceptable. In addition, the data collection for the SFGE scale in this study was completed by several LLE non-healthcare operators as data collectors. Therefore, when SFGE is used to measure the frailty assessment of the community's older adults, the data collection consistency between data collectors is already proven. All these characteristics underline SFGE's capability as a significant large scale screening tool that can be used as a public health instrument for the early assessment of frailty. Widespread implementation of universal screening can reduce the delay in frailty identification, increasing the time available for early intervention.

## Ethical statement

The research was approved by the Independent Ethical Committee of the University of Rome Tor Vergata (R.S. 60/17) and people signed a written informed consent before taking part in the study. This survey was performed in accordance with the Declaration of Helsinki.

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Nothing to declare.

## Data availability statement

The datasets analyzed in the study are available from the corresponding author on request.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## CRediT authorship contribution statement

**Clara Donnoli:** Writing – original draft, Software, Methodology. **Giulia Picardo:** Writing – original draft, Methodology. **Valeria Formosa:** Writing – original draft, Data curation. **Grazia Lorusso:** Writing – original draft. **Leonardo Emberti Gialloreti:** Supervision, Methodology, Formal analysis. **Stefano Orlando:** Software, Methodology. **Giuseppe Liotta:** Writing – review & editing, Validation, Supervision, Conceptualization.

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