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Frailty assessment in geriatric trauma patients: comparing the predictive value of the full and a condensed version of the Fried frailty phenotype

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Abstract

Background Frailty is associated with multiple negative outcomes in geriatric trauma patients. Simultaneously, frailty assessment including physical measurements for weakness (grip strength) and slowness (gait speed) poses challenges in this vulnerable patient group. We aimed to compare the full 5-component Fried Frailty Phenotype (fFP) and a condensed model (cFP) without physical measurements, with regard to predicting hospital length of stay (LOS) and discharge disposition (DD).

Methods Prospective cohort study in patients aged 70 years and older at a level I trauma center undergoing frailty assessment by 5-component fFP (fatigue, low activity level, weight loss, weakness, and slowness). For the cFP, only fatigue, low activity level and weight loss were included. Co-primary outcomes were LOS and DD.

Results In 233 of 366 patients, information on all 5 frailty components was available (mean age 81.0 years [SD 6.7], 57.8% women) and included in our comparative analysis. Frailty prevalence was 25.1% and 3.1% by fFP and cFP, respectively. LOS did not differ significantly between frail and non-frail patients, neither using the fFP ($p = .245$) nor the cFP ($p = .97$). By the fFP, frail patients were 94% less likely to be discharged home independently (OR 0.06; 95% CI 0.007-0.50, $p = .0097$), while using cFP, none of the frail patients were discharged home independently.

Conclusion The fFP appears superior in identifying frail trauma patients and predicting their discharge destination compared with the condensed version. LOS in this vulnerable patient group did not differ by either frailty phenotype even if compared with those identified as non-frail.

Keywords Adverse outcomes, Comparative analysis, Frailty assessment, Geriatric trauma, Older adults

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Introduction

With the growing number of older adults, an increase in geriatric trauma patients, who benefit from orthogeriatric care, can also be expected [1, 2]. Many of these patients sustain fragility fractures from low-energy injuries, such as falls from standing height in 45% of cases [3, 4] and frequently experience adverse outcomes, including prolonged length of hospital stay (LOS) and adverse discharge disposition (DD; i.e., discharge to a nursing care facility) [5]. Often, this can be attributed to frailty, the age-associated decline in functional capacities linked to increased vulnerability in the face of multiple stressors, which negatively influences recovery [6]. Notably, frailty prevalence in geriatric trauma patients ranges widely from 13 to 94%, depending on timing of assessment and frailty instrument used [7]. While evidence indicates that frail patients require more health care resources than robust (i.e., non-frail) patients [8, 9], timely identification of frailty appears important from an individual and socioeconomic perspective, also in geriatric trauma patients.

Over the last two decades, multiple approaches to assess frailty have been proposed [10]. Among various definitions, the physical Frailty Phenotype (FP), introduced by Fried et al. [11]. is widely used and well validated [12]. The FP consists of five clinical criteria: fatigue, low activity level, weight loss, low grip strength and slow gait speed. While the association of the FP with multiple negative outcomes in acute care and community-dwelling older adults has been widely established, its five items have often been modified between reporting studies [13]. In general, patients with ≥3 of the five criteria are considered frail, those with 1–2 criteria are pre-frail (vulnerable) and those who fulfill none are considered robust (non-frail) [11].

While frailty assessed by the FP is considered a multifactorial and syndromic based concept [14], among its components, gait speed has been found to be more informative with regards to clinical outcomes than other criteria, e.g., fatigue and weight loss [15]. Simultaneously, assessing gait speed and grip strength by test-based measurements requires manual cooperation and ambulation of the patient. Thus, the requirement of the two test-based components potentially limits the clinical implementation of the FP, including geriatric trauma patients, who are often not ambulatory [16] or present with injuries to their dominant hand or arm [17]. In contrast, the substitution of those items, e.g., by a questionnaire may not cover the aspect of physical function to the same extent [12, 18]. Of note, earlier studies established the applicability of a condensed version of the FP with only three items (unintentional weight loss, fatigue, weakness) in community-dwelling older women [19, 20]. Consequently, the investigation of a condensed model of the FP, utilizing only verbally collected items appears of interest also for geriatric trauma patients. To our knowledge, no prior study has investigated the performance of the FP with and without test-based measurements in geriatric trauma patients so far.

Our aim was to investigate frailty assessment by the FP in geriatric trauma patients and to compare the predictive value of the full Fried FP (fFP) versus a condensed FP (cFP) model covering only three items (fatigue, unintentional weight loss and low activity) with regard to their association if any with hospital LOS and DD.

Materials and methods

Study design and measures

This prospective cohort study used data from the Zurich-POPS (Peri-Operative care project for older PatientS) [21] database of consecutive orthogeriatric patients aged 70 and older at a Swiss level 1 trauma center admitted to inpatient care between May and December 2018. In the absence of a generally recognized age-related definition for orthogeriatric patients [22], at our center all patients aged 70 years and older admitted to the department of traumatology are assigned to the orthogeriatric service. As described in detail in an earlier study from our group, the POPS database includes patients with a broad range of injuries with single and multiple fractures; including limb, thoracic, vertebral and pelvic fractures, plus craniocerebral injuries [23]. All patients received a standardized comprehensive geriatric assessment (CGA) by trained members of the orthogeriatric care team within 4 days of admission and were seen by a senior geriatrician, regardless of their planned course of treatment (conservative treatment or operative procedure). We excluded patients without admission (outpatients), re-admitted patients, and those with critical health status, severe dementia, severe delirium, aphasia, or severe dysarthria, not speaking German, patients in isolation or intensive care or who died in the hospital.

To investigate the feasibility of frailty assessment, we included all eligible patients into our analysis. For the investigation of the predictive abilities of the FP regarding LOS and DD, we only included patients with complete data on all five components of the FP, including test-based measurements of gait speed and grip strength into a sub-group analysis (Fig. 1).

Data collection

The Zurich-POPS CGA included the assessment of mobility, grip strength, cognition, frailty, malnutrition, depression, multimorbidity, and polypharmacy. Frailty was operationalized by a standardized Frailty Phenotype variant as described below. Mobility was assessed by the Short Physical Performance Battery (SPPB) [24]. The Mini-Mental State Examination (MMSE) [25] and a clock-drawing test [26] were used for cognitive screening.

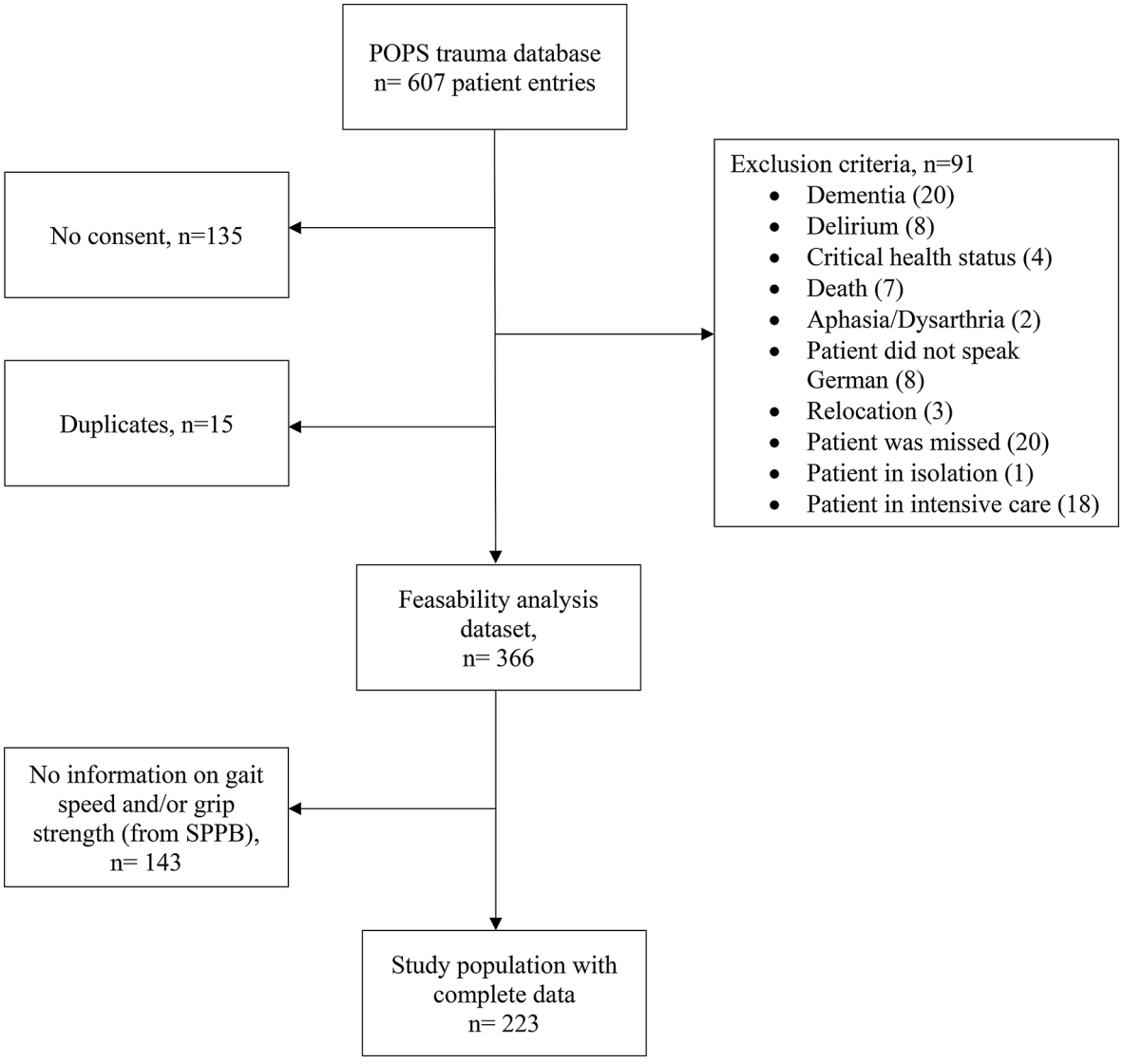

Fig. 1 Study flow diagram

Nutrition was assessed by the Mini Nutritional Assessment [27]. Multimorbidity and polypharmacy were assessed by a self-report questionnaire [28] and chart review. Information on LOS and DD, as well as patients' demographic and clinical characteristics (living situation prior to hospitalization, weight, height, medication, type of fracture) was retrieved from the primary clinical information system.

Frailty assessment

Frailty was captured according to operational definition of the Swiss Frailty Network and Repository [29]. Unintentional weight loss was defined as ≥5% reduction of body weight in the past three months. Fatigue was defined by a score of ≥2 on the four-item Geriatric Depression Scale (GDS-4) [30]. Slowness was defined as gait speed of ≤0.8 m/s. Weakness was defined by low grip strength (lowest 20%), measured at the dominant hand using a Martin Virgorimeter [31, 32]. A low activity level was considered present if a patient left home less than once a week during the last two weeks. Frailty status was recorded by two models, using either the full FP (fFP) or a condensed three item version (cFP), excluding gait speed and grip strength. For the cFP, patients were considered frail if ≥2 of the 3 criteria were met.

Statistical analysis

All analyses were performed using datasets with complete outcome data (either LOS in hospital or DD), independent variables (frailty status defined using the fFP and cFP), and covariates. Descriptive statistics are presented as frequencies and percentages for categorical variables and means±SD or medians (interquartile ranges) for continuous variables depending on the normality of data

distributions. Bivariate association between two categorical variables was examined using the Chi-square test and Fisher's exact test. Bivariate association between a categorical variable and a continuous variable were examined using either the two-sample t-test or ANOVA if the continuous variable was normally distributed; otherwise, nonparametric Wilcoxon rank sum tests or the Kruskal-Wallis tests were used. To examine bivariate associations between two continuous variables correlation analysis using the Pearson's correlation coefficient or the Spearman's Rho was performed.

Two separate multivariable logistic regression models with the outcome of DD after hospitalization (home independently vs. other settings, including transfer to another hospital, discharge home with help, nursing home admission or transfer to rehabilitation) were matched with the independent variable of frailty status based on either the fFP (robust vs. pre-frail vs. frail) or the cFP (robust vs. pre-frail vs. frail).

Two separate multivariable linear regression models with the outcome of LOS in hospital (days) were matched with the independent variable of frailty status based on either the fFP (robust vs. pre-frail vs. frail) or the cFP (robust vs. pre-frail vs. frail).

Analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC) with significance level set at 5%.

Results

Out of 607 entries in our database, we excluded 241 patients for meeting any of the exclusion criteria ($n=91$), missing informed consent ($n=135$), or duplicate data entries ($n=15$). Overall, 366 patients were included in the primary analysis investigating the feasibility of frailty assessment. Subsequently, we excluded 143 patients without SPPB information (i.e., no information on gait speed and/or grip strength), resulting in a sub-sample of 223 patients (mean age 81.0 years [SD 6.7], 57.8% women) eligible for the comparative analysis of fFP and cPF (Fig. 1). Stratified by the type of injury, our sample included 45 (20%) fractures of the upper extremities, 35 (15%) fractures of the lower extremities, 38 (17%) fractures of the spine or pelvis, 13 (6%) thoracic fractures, 98 (44%) craniocerebral injuries, and 61 (27%) other injuries. In all, 170 (76.2%) patients presented with a single injury, 43 (19.3%) with the combination of two injuries, 7 (3.1%) with three, and 3 (1.4%) with the combination of four injuries.

Feasibility of frailty assessment

Stratified by the five frailty criteria, data on all three questionnaire-based items were available for 340 (93%) patients, while grip strength data were available for 324 (88.5%) patients, gait speed data were available for 243 (66.4%) patients, and data for both were available for 239 (65.3%) individuals. Data for all five components of the fFP were available for 238 (65%) patients, and data for all 3 criteria of the cFI were available for 340 (93%) patients. (Fig. 2a and Fig. 2b, and Supplementary Table S1).

Patient characteristics by frailty status

In our final sample for the comparison of both FP models, according to the fFP, 32 (14.4%) patients were robust (non-frail), 135 (60.5%) were pre-frail and 56 (25.1%) were frail. According the cFP, 122 (54.7%) were robust, 94 (4.2%) were pre-frail and 7 (3.1%) were frail. Overall, 172 (77.1%) patients lived at home independently before hospitalization (robust; 32, 100% vs. frail; 30, 53.4%, $p=.38$). The mean LOS in the hospital was 10.3 days [SD 8.4] with no significant differences between robust and frail individuals. Stratified by frailty status, robust patients had significantly fewer comorbidities than did frail individuals (2.0 [SD 2.4] vs. 8.0 [SD 4.2], $p<.001$), while frail patients took nearly twice as many medications as did their robust counterparts (3.8 [SD 2.3] vs. 7.5 [SD 3.8], $p<.001$). Regarding overall SPPB scores, robust individuals scored on average 8.3 points higher than frail individuals (9.8 [SD 2.2] vs. 1.5 [SD 2.4], $p<.001$). Furthermore, robust individuals on average scored 5 points higher than frail patients on the MMSE (27.1 [SD 2.2] vs. 22.2 [SD 3.7], $p<.001$). Patient characteristics are summarized in Table 1.

Bivariate association of selected variables with length of stay

Stratified by the fFP, robust, pre-frail and frail patients spent a median of 6 (IQR 3.0, 10.0), 9 (IQR 5.0, 15.5), and 8 (IQR 3.0, 15.0) days in the hospital, respectively. The bivariate association model for LOS showed no significant difference between frailty categories ($p=.245$). Stratified by the cFP, robust, pre-frail and frail patients spent a median of 8 (IQR 4.0, 13.0), 8 (IQR 4.0, 15.0), and 9 (IQR 4.0, 19.0) days in the hospital respectively, and the bivariate association model for LOS showed no significant difference between frailty categories ($p=.97$). Furthermore, our results for the bivariate association of age, sex, BMI, MMSE, SPPB, comorbidity, polypharmacy, and housing situation prior to admission with LOS indicated no statistically significant association (Table 2).

Bivariate association of selected variables with discharge disposition

The bivariate association of frailty with DD revealed that robust patients were more likely to be discharged home independently by the fFP, while pre-frail and frail patients were more likely to be discharged with help at home or into nursing homes (robust 84% ($n=16$) vs. pre-frail 44.9% ($n=48$) and frail 14.6% ($n=7$), $p<.001$) (Table 3).

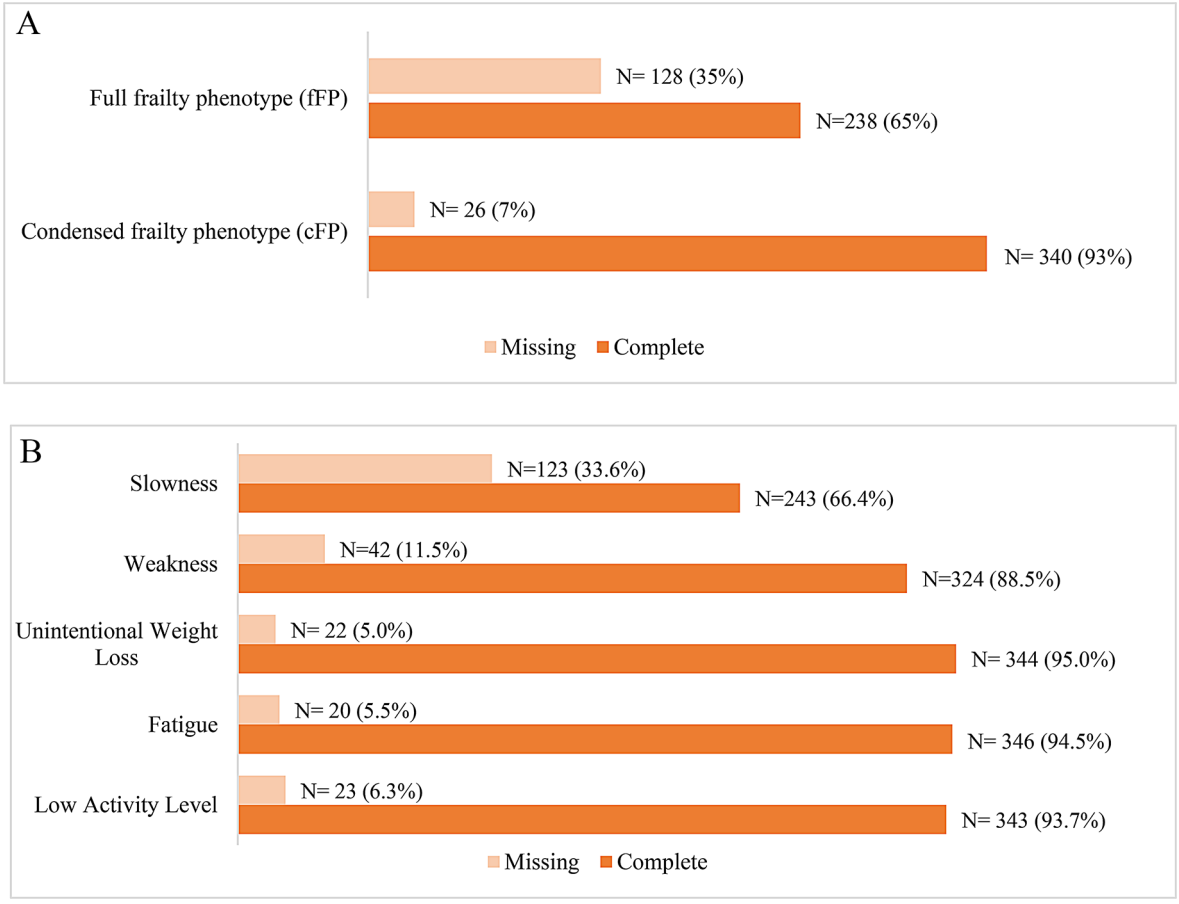

Fig. 2 **a**, **b** Data completeness of the full Frailty Phenotype (fFP) and the condensed Frailty Phenotype (cFP)

Similarly, according to the cFP, robust patients were more likely to be discharged home independently, while pre-frail and frail patients were more likely to be discharged with help at home or into nursing homes (robust 56.5% ($n=52$) vs. pre-frail 25.0% ($n=19$) vs. frail; 0% ($n=0$), $p<.001$). Furthermore, patients discharged home independently were statistically significantly younger (78.6 y [SD 6.0] vs. 82.1 y [SD 6.7], $p<.001$), had better cognitive function (MMSE scores 26.6 [SD 2.4] vs. 23.8 [SD 2.8], $p<.001$), and had higher mean SPPB scores (4.8 [SD 4.3] vs. 1.61 [SD 3.0], $p<.001$) than patients discharged home with help or into nursing homes.

Notably, patients who were discharged home independently were more likely to have intact cognitive function (MMSE score > 24 points) (78.9% [$n=56$] vs. 47% [$n=48$], $p<.001$), more often had < 2 comorbidities (33.8% [$n=24$] vs. 3.9% [$n=04$], $p<.0001$), more often took < 5 medications (47.9% [$n=34$] vs. 21.4% [$n=22$], $p=.0002$) and were more likely to have lived at home independently before hospitalization (97.2% [$n=69$] vs. (65% [$n=69$], $p<.001$) (Table 3).

Associations of frailty with length of stay and discharge disposition

In our linear regression model for LOS for the fFP (pre-frail and frail compared to robust as a reference), no statistically significant difference in LOS was detected (pre-frail; ß=2.51, SE 2.63, $p=.32$ vs. frail ß=1.75, SE 3.05, $p=.57$). Likewise, for the cFP (pre-frail and frail compared to robust as a reference), no statistically significant difference in the LOS was identified (pre-frail; ß=1.00, SE 1.82 $p=.58$ vs. frail; ß=2.63, SE 4.80, $p=.58$) (Table 4).

Our logistic regression model for DD by fFP category indicated statistically significant lower odds of being discharged home independently for frail vs. robust patients (OR 0.06, 95% CI 0.007-0.5, $p=.0097$), while the odds of being discharged home independently were not significantly lower for pre-frail patients than for robust patients (OR 0.27, 95% CI 0.04–1.70, $p=.1628$.).

Our logistic regression model for the cFP showed statistically significant lower odds of being discharged home independently for pre-frail patients than for robust patients (OR 0.23, 95% CI 0.08–0.65, $p=.0053$), but there was no statistically significant difference in odds between robust and frail patients in regard to being discharged

Table 1 Patient demographic characteristics, overall and by frailty status (full Frailty Phenotype)

	Overall (n = 223)	Frailty Status (fFP)*			*p-value*
		Robust (n = 32, 14.4%)	Pre-frail (n = 135, 60.5%)	Frail (n = 56, 25.1%)	
Age (years) mean, ± SD	81.0 ± 6.7	78.1 ± 6.3	80.7 ± 6.8	83.5 ± 6.1	< .001
Women, N (%)	129 (57.8)	15 (46.9)	83 (61.5)	31 (55.4)	0.293
BMI (kg/m^2) mean, ± SD	24.5 ± 4.5	24.3 ± 3.0	26.6 ± 5.0	24.3 ± 4.1	0.967
Number of comorbidities mean, ± SD	5.9 ± 4.2	2.0 ± 2.4	6.0 ± 4.0	8.0 ± 4.2	< .001
Number of medications mean, ± SD	6.05 ± 3.5	3.8 ± 2.3	6.0 ± 3.5	7.5 ± 3.8	< .001
MMSE total mean, ± SD	25.0 ± 3.5	27.1 ± 2.2	25.8 ± 3.0	22.2 ± 3.7	< .001
SPPB mean, ± SD	3.4 ± 4.0	9.8 ± 2.2	2.8 ± 3.6	1.5 ± 2.4	< .001
Lived at home independently, N (%) **	172 (77.1)	32 (100)	110 (81.5)	30 (53.4)	0.385

MMSE, mini mental state examination; LOS, length of stay; SPPB, short physical performance battery

* Full Frailty Phenotype (fFP): Patients who fulfill three or more of the five criteria are considered frail, those with one or two criteria are pre-frail (vulnerable) and those who fulfill none of the criteria are considered robust. Breakdown by cFP not shown

** Living situation prior to hospitalization

Table 2 Bivariate association of frailty with length of stay

	N	Mean (SD)	LOS (days) Median (IQR)	*p-value*
Full Frailty Phenotype (fFP)				0.245
Robust (0)	20	8.55 ± 8.66	6.0 (3.0,10.0)	
Pre-frail (1–2)	84	10.96 ± 8.40	9.0 (5.0,15.5)	
Frail (≥ 3)	43	9.77 ± 8.32	8.0 (3.0,15.0)	
Condensed Frailty Phenotype (cFP)				0.972
Robust (0)	82	9.94 ± 7.95	8.0 (4.0,13.0)	
Pre-frail (1–2)	58	10.67 ± 8.99	8.0 (4.0,15.0)	
Frail (3)	7	11.14 ± 9.46	9.0 (4.0, 19.0)	
Living situation prior to admission				0.215
At home independently	172	9.67 ± 8.02	8.0 (4.0,12.0)	
At home with help, nursing home, or geriatric ward	51	12.0 ± 9.25	9.0 (4.0,20.0)	

home independently (OR < 0.001, 95% CI [< 0.001 - >1000, $p = .9832$]) (Table 5).

Discussion

The present study in geriatric patients at a level I trauma center demonstrated the availability of complete information on all five FP components in about two-thirds (65%) of individuals. At the same time, complete data for the measurement-based components of grip strength and gait speed were available for 88.5%, and 66.4%, respectively. Overall, frailty was not associated with LOS, according to either the full or condensed FP model. However, frail patients had significantly lower odds of being discharged home independently by the fFP. Due to low numbers, we were unable to draw conclusions on DD by the cFP.

Our observed proportion of complete data for the fFP appears to be in line with previous studies investigating the feasibility of the FP in acute care. For example, Bieniek et al. reported on the availability of all five frailty criteria with conclusive results for two thirds of geriatric inpatients [33]. Additionally, Ibrahim et al. reported on available grip strength measurement in 95%, and gait speed measurement in only 30% of geriatric patients [16]. In contrast, gait speed data were available for two-thirds of the patients in our sample.

Although the mean LOS in our study differed by 1.3 days between robust and frail patients according to the fFP, we were not able to demonstrate a significant association of frailty with LOS, for either the fFP or the cFP. This finding is in line with a previous study by Thompson et al. assessing frailty with the Clinical Frailty Scale in geriatric trauma patients [34] but in contrast to earlier studies, e.g., by Kistler et al. indicating that frail patients had a 1.7-fold longer stay in the hospital than robust individuals [35]. Similarly, a study by Green et al. investigating a four item FP indicated that frail patients had a 1.5-fold longer stay in the hospital [36]. This variance might be explained by differences in the investigated patient population and differences in the organization of health care in-between countries, not been accounted for.

Regarding the association of frailty with DD, our results confirm those of prior studies indicating lower odds of being discharged home independently in frail patients. A prior study by our group showed that being frail upon admission to geriatric trauma care was associated with a 3-fold increased risk for permanent institutionalization [37]. Another study by Robinson et al. showed that 59% of frail patients were institutionalized following visceral surgery [38]. While in the present study only six patients were identified as being frail according to the cFP and none of the frail patients were discharged home independently, we were not able to demonstrate whether robust patients were significantly more often discharged home

Table 3 Bivariate association of frailty with discharge disposition

	Discharge disposition		
	At home independently (*N* = 71)	**Other (At home with help, nursing home etc.) (*N* = 103)**	***p*-value**
Full Frailty Phenotype (fFP)			$p < .001$
Robust (0)	16 (84%)	3 (15%)	
Pre-frail (1–2)	48 (44.9%)	59 (55.1%)	
Frail (≥ 3)	7 (14.6%)	41 (85.4%)	
Condensed Frailty Phenotype (cFP)			$p < .001$
Robust (0)	52 (56.5%)	40 (43.5%)	
Pre-frail (1–2)	19 (25%)	57 (75%)	
Frail (3)	0 (0)	6 (100)	
Housing situation prior to admission			$p < .001$
At home independently	69 (97.2%)	67 (65%)	
At home with help, nursing home, other and unknown	2 (2.8%)	36 (35%)	

Table 4 Linear regression model for frailty status and length of stay (in days)

Frailty	**Beta coefficient (SE)**	***p*-value**
Full Frailty Phenotype (fFP)		
Robust (0)	1.0 (Ref.)	
Pre-frail (1–2)	2.51 (2.63)	0.325
Frail (≥ 3)	1.75 (3.05)	0.567
Condensed Frailty Phenotype (cFP)		
Robust (0)	1.0 (Ref.)	
Pre-frail (1–2)	1.00 (1.82)	0.582
Frail (3)	2.63 (4.80)	0.585

* Models included covariate adjustment for age, sex, BMI, living status (alone or with spouse/family), impaired cognition (MMSE < 24), multimorbidity (> 2 chronic diseases), polypharmacy (> 5 drugs) and transfer to geriatric ward

Table 5 Logistic regression model for the odds of being discharged home independently by frailty status

Frailty Phenotype	**Odds Ratio (95% CI)**	***p*-value**
Full Frailty Phenotype (fFP)		
Robust (0)	1.0 (Ref.)	
Pre-frail (1–2)	0.27 (0.04,1.70)	0.163
Frail (≥ 3)	0.06 (0.01,0.50)	0.010
Condensed Frailty Phenotype (cFP)		
Robust (0)	1.0 (Ref.)	
Pre-frail (1–2)	0.23 (0.08,0.65)	0.005
Frail (3)	< 0.001 (< 0.001, > 1000)	0.983

* Models included covariate adjustment for age, sex, BMI, living status (alone or with spouse/family), impaired cognition (MMSE < 24), multimorbidity (> 2 chronic diseases), polypharmacy (> 5 drugs) and transfer to geriatric ward

independently compared to frail patients according to this condensed frailty instrument.

Our study has several strengths. First, we utilized a real-world dataset enrolling older patients at a level I trauma center, who underwent a standardized CGA within the first four days of admission. In addition, to our knowledge, no prior study has investigated the comparative performance of a full Frailty Phenotype model with a condensed three item version regarding LOS and DD in this population so far.

At the same time, some limitations need consideration. First, assessing frailty within 4 days after admission may be subjective to the acute state of illness, and we did not consider potential changes in the patients' health status prior to hospitalization. Next, missing informed consent and the limited study period were relevant factors regarding recruitment. Although we included more than 50% of the potential candidates for our feasibility analysis ($n = 366$ of $n = 607$ candidates), a larger number of patients were missing information on gait speed and grip strength. Thus, further limiting the size of our final sub-sample investigating the predictive value for LOS and DD. Therefore, generalizability appears limited. Additionally, the psychometrical properties of the cFP were not further studied. Moreover, we lack information on why certain frailty components were not assessable.

While all five criteria of the original FP are scored equally to the total sum of the original operationalization, they may not automatically carry identical significance for clinical practice [15]. Further, we did only investigate frailty according to the phenotypic concept and therefore cannot provide information about a comparison with frailty defined as a state of accumulated health deficits, e.g., by the Trauma-Specific Frailty Index (TSFI) [39]. Finally, we did not account for potential selection bias, injury severity index (ISS), and the operative procedures performed. Thus, the findings of our study should be integrated and further investigated in a larger scale study, including additional data on comorbidities, ISS, that have been highlighted as important to include.

In summary, the FP approach appeared fairly feasible within our sample of geriatric trauma patients when comparing both FP models, although we identified a discrepancy in feasibility between questionnaire-based and test-based items. While the fFP indicated an association with DD, the cFP did not, and neither instrument showed an association with LOS. Therefore, our study does not support the utilization of a condensed FP model for the prediction of LOS or DD in geriatric trauma patients. Notably, assessing grip strength and gait speed might also provide valuable information for the geriatric trauma care team as clinical markers of sarcopenia, the age-associated loss of muscle mass and function [40, 41], in regard to the (secondary) prevention of subsequent functional decline [16]. In conclusion, future studies on the topic should include a larger sample size and more detailed information on the specific patient characteristics, including extensive data on comorbidities and injury mechanisms, and also subsequent surgical treatment in order to further investigate the predictive ability of frailty instruments via head-to-head comparisons in this patient population.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12877-024-05594-x.

Supplementary Material 1

Author contributions

J.B. drafted the first manuscript and interpreted the data. M.G. had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. M.G., J.B., W.L. and H.A.B.-F. analyzed and interpreted the data and contributed to the drafting of the manuscript. G.F. and C.H. provided critical revision of the manuscript. M.G., W.L. and H.A.B.-F. designed the study concept, acquired the data and critically revised the manuscript.

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Data availability

The data that support the findings of this study are available from the corresponding author, [M.G.], upon reasonable request.

Declarations

Ethical approval and consent to participate

Our study was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of the Canton of Zurich, Switzerland (BASEC 2021 – 00900). Written informed consent was obtained from all patients.

Clinical trial number

Not applicable.

Competing interests

HBF has received speaker fees from Vifor, Johnson and Johnson, Deotsch-Graeter, SwissRe, and Pierre-Fabre. All other authors declare no conflict of interest in regard to this work.

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