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Article

Derivation of a Frailty Index from the interRAI-HC to Assess Frailty among Older Adults Receiving Home Care and Assistance (the "fraXity" Study)

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ABSTRACT

Background: Today, the value of screening for frailty among older adults is undisputed; to this endeavor, care at-home professionals are the "frailty whistleblowers" of choice. Yet, they need quick at-hand tools for routine use. To this aim, this study proposes a frailty index (FI) directly derived from the interRAI-HC MDS. The FI is used to assess frailty in a panel of home service recipients to document the rate of frailty among types of users.

Methods: "fraXity" relies on a case-control design comparing community dwelling older adults receiving home care or assistance to peers who do not receive formal home services. The participants (N = 231) received the interRAI-HC at home from trained nurses. MDS data were used to derive a FI by following published guidelines. Regression modeling was used to assess group differences in the outcomes of interest.

Results: The FI was normally distributed, with a mean of 0.19 (SD 0.10), and a value of 0.46 at the 99th percentile. The effect of age was significant (B = 0.003, 95% CI = (0.001–0.005)). As compared to the control group (FI = 0.14 ± 0.07, m ± SD), the FI was higher among individuals who received assistance (B = 0.04, 95% CI = (0.02–0.07)) and care (B = 0.11, 95% CI = (0.08–0.14)). These differences were adjusted for age.

Conclusions: The results replicate demonstrations of MDS-based FI derivations and support the usefulness of a FI to distinguish different types of home service recipients. The study is a proof of concept supporting the need of a comprehensive assessment of health needs for all individuals who apply for homes services, including those admitted only for assistance. Further work is needed to evaluate the cost-benefit ratio of implementing the proposed methodology in homecare practice.

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KEYWORDS: frailty index; screening; home care; resident assessment instrument

ABBREVIATIONS

CFS, Clinical Frailty Scale
CGA, Comprehensive Geriatric Assessment
FI, frailty index
FI-CGA, frailty index derived from a comprehensive geriatric assessment
FI-MDS, frailty index derived from a minimum data set
HES-SO, University of Applied Sciences and Arts of Western Switzerland
imad, Geneva Institution for Home Care and Assistance
MDS, minimum dataset
RAI, Resident Assessment Instrument
RAI-HC, Resident Assessment Instrument–Home Care

INTRODUCTION

Today, the value of early screening of frailty among older adults is undisputed [1–4]. Frailty is consensually defined as a "multidimensional syndrome characterized by decreased reserve and diminished resistance to stressors" ([5], p. 65) that "represents a state of extreme vulnerability where minimal stress may cause functional impairment" ([5], p. 66). Provided the dynamic nature of frailty and its potential reversibility [6] as a predisability state [7], screening for frailty is crucial to identifying individuals at risk of functional decline and adverse health outcomes [8]. Yet, beyond these agreed-upon matters, different conceptual models of frailty coexist [9] along with a large panel of measurement instruments [10–12]. Today three main conceptions of frailty emerge in the literature: (1) frailty as a phenotype characterized by loss of physical health resources [13]; (2) frailty as an accumulation of deficits [14,15] which mimics the properties of aging and reflects a loss of physiological reserve; and (3) frailty as a multidimensional construct [16,17] which reflects a loss biopsychosocial resources. As recently highlighted, the diversity of these conceptions is a source of semantic dissonances and of misleading interpretations [18]. The most frail individual by one definition might also be the one living in the community with some moderate functional health difficulties eventually caused by muscle wasting. In the present study, we adopted the cumulative deficit model of frailty [14,15] because it aims to grasp internal/intrinsic reserves beyond physical resources, while leaving out from its empirical definition external/extrinsic determinants of health such as social, economic and environmental resources. According to this model, frailty is operationalized by a frailty index (FI), computed as the sum of deficits reported for a given set of systemic and functional variables and then divided by the maximum number of deficits expected in the set. Virtually any set of health variables can be used to compute a FI, as long as the computation complies with the standard procedure for

creating the index (i.e., at least 30 variables associated with health status and reflecting a variety of physiological systems, for which a documented age-related increase in deficit prevalence exists, yet without floor or ceiling effects) [19]. The FI shows good construct [20,21] and criterion validity [22,23]. By construction, the FI ranges between 0 and 1. To facilitate the interpretation of the score, cut points can be used to distinguish fitness from frailty. In clinical samples, a cut-off value of FI > 0.25 has been used [24–26] to identify frail individuals. A cut point of FI > 0.21 is preferred for studies conducted in community-based population [27–32]. A FI can be computed from routinely collected health data, whether from CGAs [26,33,34], primary care electronic health records [35] or minimum datasets [MDS] gathered with Resident Assessment Instruments (RAI) [36,37] designed for acute care [38–40], home care [29,41–44] and nursing homes [45]. The rationale underlying deriving the FI from clinical datasets is to provide a measure of frailty that demonstrates substantial agreement across studies [25,46] and high predictive validity of undesirable health outcomes [47,48]. Interestingly enough, FI values can be used to trigger a specific frailty warning whenever a given threshold is exceeded [35]. This information may serve for the presumptive identification of frailty by the use of a test which can be rapidly applied, in other words, it may serve for screening [49]. Actually, the FI demonstrates a good reliability for screening purposes [23]. If the screening is positive, a second step involves confirming frailty. An in-depth and careful secondary analysis of clinical profiles delineated in health records or MDS serves this diagnostic purpose. Given that a FI computation algorithm is potentially implementable into any electronic data collecting system, the approach appears compelling notably for RAI users who can apply it for screening, for confirming a diagnosis and for developing care plans that includes management of frailty [50]. The method virtually turns RAI assessors into “frailty whistleblowers”—i.e., qualified professionals who can point out (screen for) a risk of a health threatening condition (frailty) and who initiate regulatory processes to reduce this risk (design adapted care plans based on comprehensive assessments).

In Switzerland, but even more so in certain cantons such as Geneva, the authorities strongly defend “aging-in-place” and “care-at-home” policies [51]. As a result, home service professionals stand at a cardinal place for frailty screening in community-based populations who apply for assistance or care at home, which is indeed a substantial portion of the aged population. In Switzerland, the use of the RAI-HC has been recommended since the mid-2000s for routinely assessing the health needs of people seeking care at-home. Further a recent study proposed a convincing FI derivation algorithm based on a retrospective analysis of MDS data collected among 3700 home care recipients [44]. The algorithm differs from other available MDS-FI notably because it does not include additional specific medical diagnoses [38–40], but includes polymedication

[29,42]. Altogether, deriving a FI from routinely collected RAI-HC MDS data appears to be a reasonably suitable method for frailty screening among home care recipients. Yet, the Swiss RAI-HC [52] is currently being replaced by the interRAI-HCSuisse [53] and the algorithm for deriving the IF needs to be adapted the specificities of the new instrument. Further, comprehensive health assessments are currently restricted to those who apply for care at-home, but a potential extension of these assessments to those who apply for assistance deserves to be addressed. By definition, individuals requesting assistance face reduced functional abilities and according to a genuine assumption, they are eventually "frail enough" to benefit from specific health management plans. Unfortunately, in the absence of clinical data, this assumption still needs to be empirically addressed. To this aim, a reasonable work-around is the use of a dedicated research protocol based on interRAI-HC assessments performed under conditions that thoroughly mimic those used in routine practice. Such a protocol would serve as a proof of concept for the early identification of frail people by means of MDS-derived FI that concerns all types of home service users.

In this paper, we report the results of the first wave of the "fraXity" study [54] which was specifically designed to bring about responses to these issues. Specifically, we report an updated algorithm for a FI-MDS computation adapted to the interRAI-HC. We also report differences in frailty estimates for three samples of older adults living at home: individuals who do not utilize formal home services, individuals receiving formal home assistance, and individuals receiving formal homecare. The rationale for this comparison is to provide frailty estimates for different strata of the elderly population, which differ in terms of contact with home service providers (i.e., the potential screeners) but also in terms of their risk of disability (i.e., the potential relevance of screening). By applying the same protocol to different groups of the older population, it make it possible to assess group differences in health needs and frailty rates. The resulting empirical evidence is critical to discuss the relevance of identifying frail people as soon as they reach for home services. It is also useful to question the clinical relevance of introducing a CGA at admission for home assistance, notably to design health management plans that meet the needs of a larger range of the older population.

MATERIALS AND METHODS

Study Design and Setting

The "fraXity" [54] study relies on a case-control longitudinal design with three measurement occasions (baseline, follow-up 1, and follow-up 2), each separated by a six-month interval. The study takes place in the canton of Geneva, Switzerland, an urban area of 501,748 residents; among them, 82,642 (16%) are aged 65 or older [55], and more than 20,000 receive home care or assistance [56].

Participants

Participants were recruited from the community. Efforts were made to disseminate the calls throughout all municipalities of the canton of Geneva, in all socioeconomic types of neighborhoods and environments (e.g., urban vs rural) and through both public and private home service providers. The study was open to all men and women aged 65 or older living in private homes in the canton of Geneva, Switzerland. Additional eligibility criteria were the ability to hold a meaningful and coherent conversation in French, show appropriate orientation in time and space, and not be under a trusteeship. One of the four nurses of the research team assessed eligibility at first phone contact by means of a dedicated questionnaire and a clinical qualitative appraisal of fluency in French, coherence of speech, and orientation in time and space. Upon confirmation of the participant's eligibility and verbal agreement to participate, the nurses set the appointment for the baseline assessment. At first visit, the nurses ensured that each participant gave written informed consent for participation prior to data collection.

The overall sampling relied on a non-probabilistic convenience method; volunteers meeting the eligibility criteria were enrolled on a first-come, first-served basis. Subsequently, the participants were divided into three samples (control, case 1, and case 2) based on the weekly amount of formal home service and/or care they were receiving when entering the study. Assigning the participants to different groups allowed samples of home service beneficiaries with different profiles to be constituted according to an adverse health outcome risk stratification approach [57]. In the "control" group (lower risk), participants did not receive formal homecare or assistance. In the "assistance" group (medium risk, case 1), participants did not receive formal care but benefited at least once a week from formal home assistance motivated by health difficulties. Such formal assistance included help with the household chores, shopping, meal preparation, transportation, or administration as well as the use of meal delivery services. In the "care" group (higher risk, case 2), the participants received formal homecare at least once a week, in addition to formal assistance. This care included any homecare service provided by a nurse, a nurse assistant, or another health professional and was recognized as care by the Swiss health insurance system. The types of home care and home assistance received by each participant were documented twice (at first contact and at baseline) in order to reduce information bias and potentially inappropriate group assignation.

Data Sources and Measurement

Four nurses (two men, two women) were in charge of data collection. Prior to the fieldwork, these nurses received training on use of the measurement instruments so to foster the quality of data collection. This training focused on appropriate knowledge of what each instrument actually measures, on appropriate use of homogenous instructions in standardized questionnaires, and on avoiding missing values. As a rule, the nurse in charge of the first contact and of administering the eligibility questionnaire also ran the subsequent assessments. The nurses were in charge of an equal number of interviews.

The core data source of the "fraXity" study is the MDS of the interRAI-HC, Canadian French edition, v.9.1 [58]; the interRAI-HCSuisse [53] was not available when the study started. The interRAI-HC demonstrates a good inter-rater reliability [37,59] and a good content validity, at least with respect to items common to the interRAI Acute Care [60]. Questionnaires covering demographics and patient-reported health outcomes completed the interRAI-HC assessments. Standardized instruments were used to measure health-related quality of life [61], global cognitive status [62], nutritional status [63], and comorbidities [64]. At the end of each interview, the nurses filled out a 30-point checklist assessing the multidimensional complexity of the case/situation [65]. Data were collected using paper-and-pencil forms formatted using the EvaSys Survey Automation Suite (Stat'Elite, Lausanne, Switzerland) for automatic document processing. Once filled out, the forms were scanned, and every disputed answer detected by the system was manually corrected before data storage on an institutional server. The data were cleaned and recoded using routines written with SPSS.

Primary Outcome Variable: The Frailty Index (FI) Derived from the interRAI-HC

In this paper, the primary outcome measure is a frailty index (FI) derived from interRAI-HC MDS. The FI's computation relies on the "accumulation of deficits" model of frailty [14,15] and complies with the recommendations for FI computation [19]. The computation replicates the procedure previously described for the Swiss RAI-HC [44] on a clinical sample of 3714 homecare recipients which supported the choice of the items notably as concerns avoiding floor and ceiling effects in deficit rates [19]. Yet, because the Swiss RAI-HC is slightly different from the interRAI-HC, six of the 52 original items used for the FI's derivation were not available in the interRAI-HC and had to be replaced. This replacement followed a two-step procedure. First, two raters separately identified candidate alternative items in the interRAI-HC. Second, inter-rater agreement was used to reach consensus in identifying replacement items. Table 1 displays the final set of 52 interRAI-HC items used to derive the FI. Each item is provided along with a short description, the corresponding

question code (both for the Swiss RAI-HC and the interRAI-HC) and the response coding algorithm used to qualify the presence or absence of a deficit. The FI was computed as the sum of the reported deficits (ranging from 0 to 53) divided by the theoretical maximum deficit value [53], resulting in a score varying between 0.00 and 1.00.

Table 1. The 52 items used to derive the FI from the interRAI-HC, with corresponding question codes for the Swiss RAI-HC and the interRAI-HC, a short description, the dimension, and the deficit-coding algorithm.

#	Swiss RAI Code	inter RAI Code	Description	Dimension	Deficit coding
1	B2	C1	Global cognitive functioning [B]	Attention/cognition	(0 = 0) (ELSE = 1)
2	B3a	C3a	Distractibility [B]	Attention/cognition	(0 = 0) (ELSE = 1)
3	B1a	C2a	Short-term memory [B]	Attention/cognition	(0 = 0) (ELSE = 1)
4	B1b	C2b	Procedural memory [B]	Attention/cognition	(0 = 0) (1 = 1)
5	C1	D1	Expression [O]	Language	(0 = 0) (1 = 0.5) (ELSE = 1)
6	C2	D2	Comprehension [O]	Language	(0 = 0) (1 = 0.5) (ELSE = 1)
7	B3b	C3b	Incoherent speech [B]	Orientation	(0 = 0) (ELSE = 1)
8	E2a	E3a	Wandering [B]	Orientation	(0 = 0) (ELSE = 1)
9	E1a	E1a	Negativity [B]	Emotion and affect	(0 = 0) (ELSE = 1)
10	E1b	E1b	Anger [B]	Emotion and affect	(0 = 0) (ELSE = 1)
11	E1c	E1c	Fears [B]	Emotion and affect	(0 = 0) (ELSE = 1)
12	E1d	E1d	Repeated complaints [B]	Emotion and affect	(0 = 0) (ELSE = 1)
13	E1e	E2c	Sadness [B]	Emotion and affect	(0 = 0) (ELSE = 1)
14	F4	F2	Loneliness [B]	Emotion and affect	(0 = 0) (1 = 1)
15	K1d	E1i	Withdrawal from activities [1,B]	Emotion and affect	(0 = 0) (ELSE = 1)
16	C3	D3	Hearing [O]	Sensory abilities	(0 = 0) (1 = 0.5) (ELSE = 1)
17	D1	D4	Vision [O]	Sensory abilities	(0 = 0) (1 = 0.5) (ELSE = 1)
18	H2a	G2i	Mobility in bed [O]	Functional health	(0 = 0) (1 = 0.5) (ELSE = 1)
19	H2b	G2g	Transfer [O]	Functional health	(0 = 0) (1 = 0.5) (ELSE = 1)
20	H2c	G2e	Walking inside [O]	Functional health	(0 = 0) (1 = 0.5) (ELSE = 1)
21	H2e	G3a	Primary mode of locomotion [1,O]	Functional health	(0 = 0) (1 = 0.5) (ELSE = 1)
22	H2f	G2c, G2d	Dress [2,O]	Functional health	(0 AND 0 = 0), (1 OR 1 = 0.5) (ELSE = 1)
23	H2g	G2j	Eat [O]	Functional health	(0 = 0) (1 = 0.5) (ELSE = 1)
24	H2h	G2h	Using the toilet [O]	Functional health	(0 = 0) (1 = 0.5) (ELSE = 1)
25	H2i	G2b	Self-care [O]	Functional health	(0 = 0) (1 = 0.5) (ELSE = 1)
26	H2j	G2a	Bathing [O]	Functional health	(0 = 0) (1 = 0.5) (ELSE = 1)
27	H4	G1fc	Climbing stairs [O]	Functional health	(0 = 0) (1 = 0.5) (ELSE = 1)
28	H5a	G4a	Physical activity [B]	Functional health	(4 = 0) (ELSE = 1)
29	H5b	G4b	Outing [B]	Functional health	(3 = 0) (ELSE = 1)
30	K6a	J3d	Gait [B]	Functional health	(0 = 0) (ELSE = 1)
31	K6b	J1	Falls [1,B]	Functional health	(0 = 0) (ELSE = 1)
32	L2a	K2c	Fluid intake [B]	Nutrition	(0 = 0) (1 = 1)
33	L2b	K2d	Fluid output exceeding input [1,B]	Nutrition	(0 = 0) (1 = 1)

Table 1. *Cont.*

#	Swiss RAI Code	inter RAI Code	Description	Dimension	Deficit coding
34	L3	K3	Mode of nutritional intake [B]	Nutrition	(0 = 0) (ELSE = 1)
35	BMI	K1a, K1b	BMI [2, B]	Nutrition	((BMI < 21 OR BMI ≥ 30) = 1) (ELSE = 0)
36	P1	M1	Medication [2,O]	Medication	Sum M1; (0,1,2 = 0) (3,4,5,6,7,8 = 1) (>8 = 2)
37	I1	H1	Bladder incontinence [O]	Physiology	(0,1 = 0) (2 = 0.5) (ELSE = 1)
38	I2	H3	Bowel incontinence [O]	Physiology	(0,1 = 0) (2 = 0.5) (ELSE = 1)
39	I3	H2, H4	Incontinence device [2,O]	Physiology	(0 AND 0 = 0) ((H2 = 0 AND H4 = 1) = 0.5) (ELSE = 1)
40	K1b	J3l	Constipation [1,B]	Physiology	(0 = 0) (ELSE = 1)
41	K1c	J3m	Diarrhea [1,B]	Physiology	(0 = 0) (ELSE = 1)
42	K1d	J3n	Vomiting [B]	Physiology	(0 = 0) (ELSE = 1)
43	K1g	J3u	Edema [B]	Physiology	(0 = 0) (ELSE = 1)
44	K1h	J3o, J3p	Sleep disturbance [2,O]	Physiology	(0 AND 0 = 0), (1 OR 1 = 0.5) (ELSE = 1)
45	K2	J4	Dyspnea [B]	Physiology	(0 = 0) (ELSE = 1)
46	K3	J5	Fatigue [B]	Physiology	(0 = 0) (ELSE = 1)
47	L6	K2a	Weight loss [B]	Physiology	(0 = 0) (1 = 1)
48	M1	L4	Skin problems [B]	Physiology	(0 = 0) (1 = 1)
49	M4	L7	Feet problems [B]	Physiology	(0,1 = 0) (ELSE = 1)
50	K4a	J6a	Frequent pain [B]	Pain	(0 = 0) (ELSE = 1)
51	K4b	J6b	Intense pain [B]	Pain	(0 = 0) (ELSE = 1)
52	P5e	M1	Analgesics [2,B]	Pain	Sum in M1 but not PRN; (0 = 0) (ELSE = 1)

[1] An interRAI-HC item that replaced the original Swiss RAI-HC items. [2] Item computed from multiple responses in the interRAI-HC. [B] Binary variable. [O] Ordered categorical variable.

As for the FI derived from the Swiss RAI-HC, 33 items were recoded into binary variables, as 0 (absence of deficit) or 1 (deficit), and 19 variables were recoded into ordered categorical variables, as 0 (no deficit), 0.5 (moderate deficit), or 1 (deficit). Six variables were computed from multiple-item responses. “Medication” was computed as the sum of the regular medications documented in section M1, which was further recoded as 0 if the sum ranged from 0 to 2, as 1 if the sum ranged from 3 to 8, or as 2 if the sum was greater than 8. “Body mass index” (BMI) was computed using height (K1a) and weight (K1b) as BMI = kg/m^2, further recoded as 0 (no deficit) if BMI ranged from 21 to 29.9 or as 1 (deficit) if BMI < 21 or BMI ≥ 30, suggesting either undernutrition [66] or obesity [67]. “Dress” was computed from the items of dressing the upper (G2c) and lower (G2d) body. Each was first coded as 0 for independent, 0.5 for setup help only, and 1 for all other types of help. Dress was coded as 0 (no deficit) if both upper and lower dressing were independent, as 0.5 (moderate deficit) if either upper or lower dressing only required help for setup, and as 1 (deficit) if both upper and lower dressing required other types of help. “Incontinence device” was computed as a compound of urinary collecting devices (H2) and pads or briefs being worn (H4). The absence of both a

collecting device and pads was coded 0 (no deficit), the use of pads in the absence of collective devices was coded as 0.5 (moderate deficit), and the use of collecting devices was coded as 1 (deficit). “Sleep disturbance” was coded based on difficulties falling or staying asleep (J3o) as well as too much sleep (J3p); the absence of disturbances on both items was coded 0 (no deficit), the presence of disturbances on one of them was coded as 0.5 (moderate deficit), and disturbances on both items was coded as 1 (deficit). Finally, “analgesics” was computed based on information on medication collected on section M1. The absence of regular use of analgesics was coded as 0 (no deficit), and the presence of at least one analgesic taken on a regular basis was coded as 1 (deficit).

As mentioned earlier, the FI is a reliable score for screening for frailty [23] but is not readily interpretable by non-experts. Converting the score into categories is a workaround method to overcome this disadvantage. Following good practices, the validity of the categorization should be assessed against the risk of adverse outcomes [26,35,41,68]. In the absence of such information, the FI was categorized using the cutoff values published in the literature for binary coding (nonfrail vs frail, with a cut point for frailty of FI > 0.21 [27–32]) and for multinomial coding (nonfrail, prefrail, and frail [27–29]).

Statistical Analyses

The preliminary analysis consisted of assessing potential confounding effects due to group differences on sociodemographic variables. ANOVA (*F*) tests were used for continuous outcomes, Kruskal-Wallis (*H*) tests were used for categorical ordered outcomes, and chi-square (χ^2) tests were used for categorical unordered and binary outcomes. A threshold of $\alpha \leq 0.05$ was used to reject the null hypothesis.

A subsequent set of analyses was conducted to assess group differences on each of the 52 items used to build the FI. The rate of observed deficit by item was computed for the total sample and for each of the three groups separately. Group differences were assessed through logistic regressions for the 33 binary variables and through ordered logistic regressions for the 19 ordered categorical variables. Dummy variables were used to code for the groups: one dummy coded for the assistance group against the other groups, and another dummy coded for the care group against the other groups. The control group was used a reference. Because age was significantly different across groups, age was introduced in the models so to adjust the estimations of the group effects. The analyses first consisted of assessing the overall model fit, by means of chi-square (χ^2) statistics. A significance threshold of $\alpha \leq 0.05$ was used to reject the null hypothesis. In order to reduce the likelihood of coming about a significant result by pure chance, *p*-values were adjusted for multiple comparisons. Specifically, we applied a Bonferroni correction that consisted in dividing α by 52 (i.e., the number of repeated analyses) to determine the critical p value used to reject the null hypothesis. The resulting adjusted *p*-values were of $p \leq$

0.00096 for α ≤ 0.05, of $p \leq 0.00019$ for α ≤ 0.01 and of $p \leq 0.00002$ for α ≤ 0.001. Whenever the model fit was significant, we further examined the effect of each of the predictors by means of Wald (χ^2) tests. The *p*-value threshold used to reject the null hypothesis was adjusted to the number of hypotheses tested within each model (i.e., 3). By applying a Bonferroni correction, the critical *p*-value corresponding to α ≤ 0.05 was of $p \leq 0.01667$.

A final set of analyses was conducted to assess group differences at the level of the FI (range 0 to 1). For these two outcomes, descriptive statistics were computed for the total sample and for each of the three groups. Group differences were assessed using linear regressions. Dummy variables were used to code the groups, and age was entered as covariate. The overall model fit was assessed by means of *F* statistics. Whenever significant, the predictors' effects were further assessed by means of *t*-statistics. Again, a threshold of α ≤ 0.05 was used to consider the effects as significant. For the t-statistics, an adjusted *p*-value of $p \leq 0.01667$, corresponding a Bonferroni correction of 0.05/3, was used to reject the null hypothesis. Ultimately, exploratory analyses were conducted to assess group differences with respect to the categorized FI. Logistic regression modeling was used to estimate the odds of a participant belonging to the frail category (FI > 0.21 [27–32]), and ordered logistic regression modeling was used to estimate the probability of belonging to the nonfrail (FI ≤ 0.21), prefrail (>0.21 FI ≤ 30), or frail (FI > 0.30) category [27–29]. Modeling was done with age and groups as predictors. The objective of the analyses was to assess the overall model fit by means of chi-square (χ^2) statistics. The effect of each of the predictors was subsequently examined by means of Wald (χ^2) tests. The p-value threshold used to reject the null hypothesis was adjusted to the number of hypotheses tested within each model (i.e., 3). By applying a Bonferroni correction, the critical *p*-value corresponding to α ≤ 0.05 was of $p \leq 0.01667$.

All analyses were performed listwise; missing data were not replaced or imputed. The SPSS 25 statistical software (IBM Corp.) was used to compute all statistics.

Ethics Approval and Consent to Participate

Version 2.0 of the study protocol was qualified as a prospective observational study using coded data on non-genetic health personal data and received approval from the Ethical Committee of the canton of Geneva, Switzerland (affiliated with Swissethics), on August 7, 2018. The protocol registration number is 2018-01039.

RESULTS

Sample Characteristics

Inclusion rates and group assignment

Nearly 1000 flyers were disseminated over the recruitment period, and 307 individuals expressed interest in taking part in the study (30% response rate). Among these 307 persons, 63 (20.5%) declined to participate after being informed about the full protocol, 10 were not eligible (3.3%), and 3 (1.0%) were lost of sight after first contact. The final study sample consisted of 231 persons (75.2% inclusion rate), slightly below the sample size of *N* = 260 expected at baseline. Among these 231 persons, 91 were assigned to the control group, 73 to the assistance group, and 67 to the care group. Table 2 reports the characteristics of the formal home care and assistance the participants received on a weekly basis. All of the interviews were carried out during a single appointment (with the exception of one participant in the assistance group because the participant did not anticipate having enough time); the average duration of each interview was 107 ± 24 min (m ± SD, range 50 to 180).

Table 2. Home care and assistance received by the "fraXity" study sample at baseline.

Type of home service	Total sample	Control	Assistance	Care
N	231 (100%)	91	73	67
Weekly homecare				
By nurse	39 (16.9%)	0	0	39
By nurse assistant	20 (8.7%)	0	0	20
By other professional	39 (16.9%)	0	0	39
All combined	67 (29.0%)	0	0	67
Care time (in min)				
M	-	0.00	0.00	51.94
95% CI	-	-	-	(27.26–76.62)
Weekly assistance				
Meal delivery	28 (12.1%)	0	15	13
Home assistance	113 (48.9%)	0	65	48
All combined	125 (54.1%)	0	73	52
Assistance time (in min)				
m	-	0.00	81.86	99.31
95% CI	-	-	(63.6–100.1)	(68.6–130.0)

Demographic characteristics and patient-reported health outcomes

Table 3 reports the sample's demographic characteristics. The overall sample comprised 22.5% men and 77.5% women, revealing an over-representation of women. The average age was 79.41 ± 8.06 years (m ± SD). The participants were highly educated (42% reached tertiary-level education), and most of them reported high professional attainment (20.8% leaders and 61.0% white-collar employees). The most represented marital

status was widowhood (40.4%). A large majority of the participants (90.0%) was Swiss citizens, and slightly more than half of the sample (56.7%) reported an income below the Swiss median. Inferential statistics conducted to assess group differences in the outcomes reported in Table 2 revealed no significant differences, with the exception of age, $F(2, 228) = 27.25$, $p < 0.001$. Post-hoc pairwise comparisons using Bonferroni corrections revealed that the Control group ($m_{age} = 75.19$) was significantly younger than the assistance group ($m_{age} = 80.99$, mean difference of 5.80, $p < 0.001$) and the care group ($m_{age} = 83.42$, mean difference of 8.23, $p < 0.001$). The assistance and care groups did not significantly differ in age (mean difference of 2.43, $p = 0.148$).

Table 3. Demographic characteristics at baseline for the total fraXity sample and by group.

Sociodemographic outcomes	Total sample	Control	Assistance	Care
N	231 (100%)	91	73	67
Sex				
Men	52 (22.5%)	19	19	14
Women	179 (77.5%)	72	54	53
Age				
m (SD)	79.4 (8.1)	75.2 (6.6)	81.0 (7.5)	83.4 (7.9)
95% CI	(78.4–80.4)	(73.8–76.5)	(79.3–82.7)	(81.5–85.3)
Education				
Primary	49 (21.2%)	13	13	23
Secondary	85 (36.8%)	37	30	18
Tertiary	97 (42.0%)	41	30	26
Prof. attainment				
Leader	48 (20.8%)	20	17	11
White-collar	141 (61.0%)	58	41	42
Blue-collar	22 (9.5%)	7	9	6
Other	20 (8.7%)	6	6	8
Born in Switzerland				
Yes	151 (65.4%)	60	42	49
No	80 (34.6%)	31	31	18
Swiss citizen				
Yes	208 (90.0%)	83	64	61
No	23 (10.0%)	8	9	6
Marital status				
Single/never married	27 (11.7%)	12	5	10
Married/partnership	49 (21.3%)	24	17	8
Divorced/separated	61 (26.5%)	27	18	16
Widowed	93 (40.4%)	27	33	33
Income				
Below Swiss median [(1)]	118 (56.7%)	43	40	35
Above Swiss median	90 (43.3%)	42	27	21

[1] The Swiss median income for 2018 was 48,000 CHF/year/capita.

Frailty Index

Analyses at the item level

The first set of analyses were aimed at assessing the deficit rates reported for the 52 items used to derive the FI and at testing group differences for each item. The results summarized in Table 4 and graphically represented in Figures 1 and 2. As displayed in Table 4 and Figure 1, the percent of deficits reported by the total sample varied between 0 and 76%. Six items showed no deficits at all (wandering, mobility in bed, transfer, eat, using the toilet, and vomiting). Fourteen items showed less than 10% of participants with deficits. Fourteen items showed between 10% and 25% of participants with deficits. Thirteen items showed between 25% and 50% of participants with deficits, and 5 items showed 50% or more participants with deficits (short-term memory, medication, intense pain, frequent pain, and physical activity). When looking at the results of the regression analyses, findings first reveal that for five items, the regression models could not be adjusted because there was quasi-separation of data across groups; deficits of incoherent speech, expression, dressing, self-care and bathing were reported in most cases only in the Care group. Regression modelling allowed estimating the effect of age and group on deficit rates for forty-one items. For twenty-five items, the overall fit of the model did not reach the significance threshold of $\alpha \leq 0.05$ (adjusted *p*-value of $p \leq 0.00096$), suggesting no reliable age-related differences or group differences in deficit rates (see Table 4). Interestingly enough, many of them belong to the emotion and affect domain (anger, 20.9%; negativity 21.7%; repeated complaints, 22.6%; loneliness, 23.4%; and sadness, 33.3 %). Some items of the physiology (feet problems, 21.0%; constipation, 32.0%; sleep disturbances, 41.0%), nutrition (BMI, 24.3%), cognition (short-term memory, 61.0%) and pain (intense pain, 73.0%; frequent pain, 73.0%) are also concerned by such a pattern of results. Finally, the overall fit of the regression model reached significance (adjusted *p*-value of $p \leq 0.00096$) for sixteen items. The pattern of deficits highlighted for the assistance group concerned bladder incontinence, primary mode of locomotion and medication (see Figure 2, Panel C). The pattern of deficits highlighted for the care group (see Figure 2, Panel D) concerned medication, functional health (physical activity, gait, locomotion, and climbing stairs), systemic problems (bladder incontinence, dyspnea, fatigue, and edema), procedural memory and pain (analgesics). Finally, significant age-related increases (see Figure 2, Panel B) in deficit rate were reported in the language (comprehension), sensory (vision and hearing), physiology (incontinence device, bladder incontinence, dyspnea, and fatigue) and functional health (climb stairs, outing, primary mode of locomotion, gait) domains.

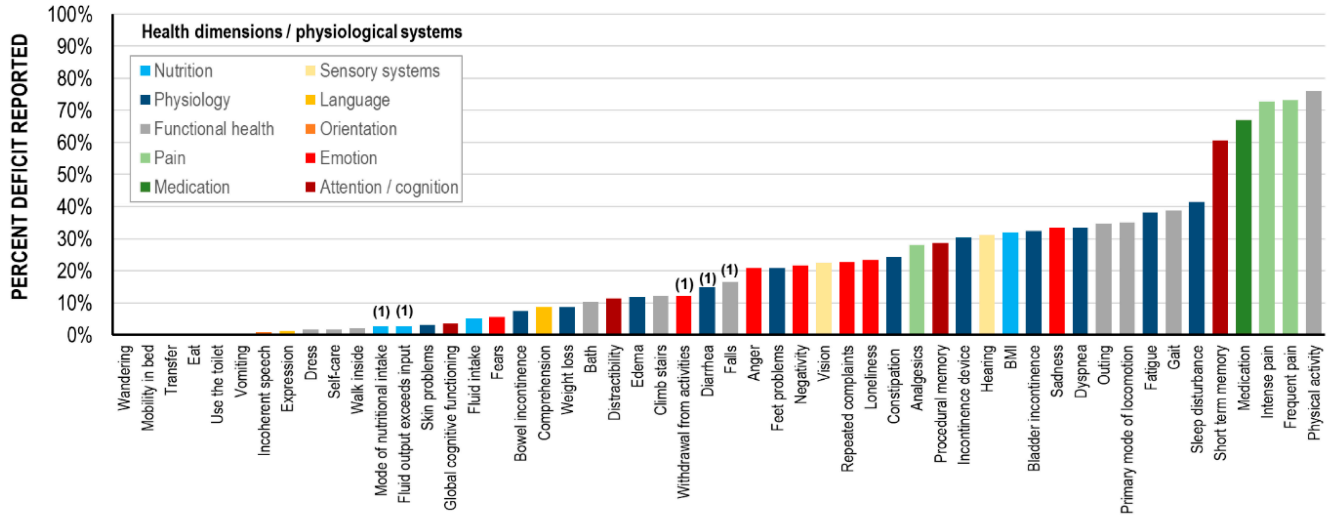

Figure 1. Percent of deficit reported for each of the 52 items considered for the FI. Health dimensions/physiological systems (N = 10) are color-coded. [1] interRAI-HC items that replaced the original Swiss RAI-HC items for derivation of the FI.

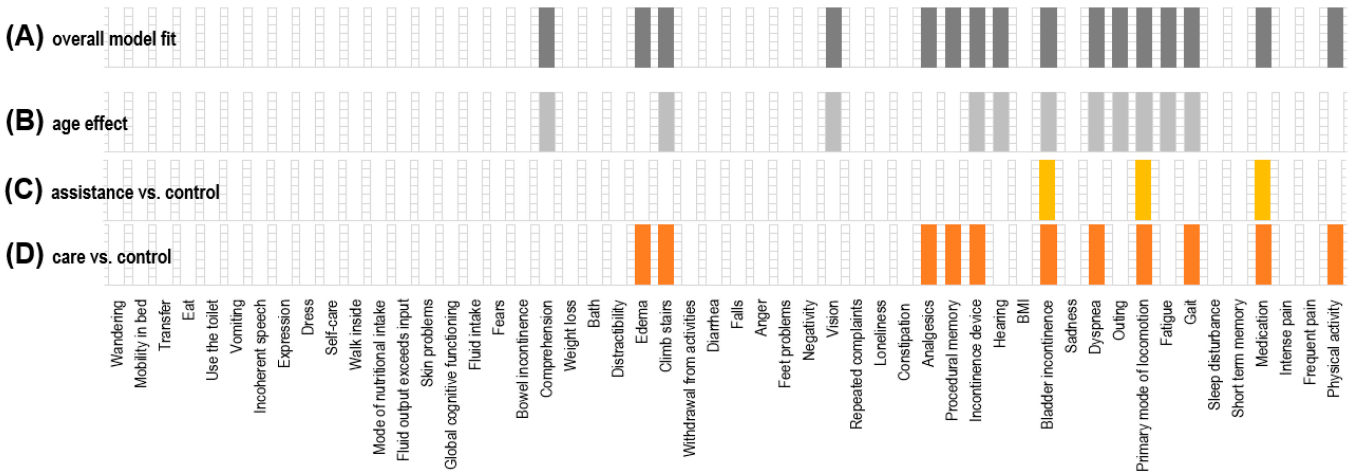

Figure 2. Schematic representation of the results of the regression analyses for the 52 items considered for the FI. (**A**). Items in dark grey showed a significant overall model fit ($\alpha \leq 0.05$, p-values adjusted for multiple comparisons) assesses by of chi-square (χ^2) statistics. (**B**) Items in light grey showed a significant effect of age ($\alpha \leq 0.05$ for Wald χ^2 statistics, p-values adjusted for multiple comparisons). (**C**) Items yellow showed a significant difference between the assistance and the control groups ($\alpha \leq 0.05$ for Wald χ^2 statistics, p-values adjusted for multiple comparisons). (**D**) Items yellow showed a significant difference between the care and the control groups ($\alpha \leq 0.05$ for Wald χ^2 statistics, p-values adjusted for multiple comparisons).

Table 4. Percent of deficits reported for the 52 items used to derive the FI and the corresponding results of the regression analyses assessing (overall fit, and specific effects of age, assistance and care groups).

			Observed values				Overall model fit			Age	Assi.	Care
#	Code	Description	Total	Cont.	Assi.	Care	χ^2	*p*	sig[3]	sig[4]	sig[4]	sig[4]
			N = 231	*N* = 91	*N* = 73	*N* = 67						
8	E3a	Wandering [B]	0.0	-	-	-	[1]	-	-	-	-	-
18	G2i	Mobility in bed [O]	0.0	-	-	-	[1]	-	-	-	-	-
19	G2g	Transfer [O]	0.0	-	-	-	[1]	-	-	-	-	-
23	G2j	Eat [O]	0.0	-	-	-	[1]	-	-	-	-	-
24	G2h	Use the toilet [O]	0.0	-	-	-	[1]	-	-	-	-	-
42	J3n	Vomiting [B]	0.0	-	-	-	[1]	-	-	-	-	-
7	C3b	Incoherent speech [B]	0.9	0.0	0.0	3.0	[2]	-	-	-	-	-
5	D1	Expression [O]	1.3	0.0	1.4	3.0	[2]	-	-	-	-	-
22	G2c, G2d	Dress [O]	1.7	0.0	0.0	6.0	[2]	-	-	-	-	-
25	G2b	Self-care [O]	1.7	0.0	0.0	6.0	[2]	-	-	-	-	-
20	G2e	Walk inside [O]	2.2	1.1	2.7	3.0	1.88	0.59683	∅			
34	K3	Mode of nutritional intake [B]	2.6	0.0	2.7	6.0	15.46	0.00146	∅			
33	K2d	Fluid output exceeding input [B]	2.6	1.1	2.7	4.5	2.76	0.43041	∅			
48	L4	Skin problems [B]	3.0	1.1	2.7	6.0	3.27	0.35236	∅			
1	C1	Global cognitive functioning [B]	3.5	1.1	2.7	7.5	4.62	0.20183	∅			
32	K2c	Fluid intake [B]	5.2	5.5	4.1	6.1	0.33	0.95360	∅			
11	E1c	Fears [B]	5.7	5.5	1.4	10.6	6.97	0.07282	∅			
38	H3	Bowel incontinence [O]	7.4	4.4	5.5	13.4	5.35	0.14760	∅			
6	D2	Comprehension [O]	8.7	2.2	9.6	16.4	20.18	0.00016	√√	√	∅	∅
47	K2a	Weight loss [B]	8.7	7.8	4.1	14.9	5.29	0.15164	∅			
26	G2a	Bathing [O]	10.4	0.0	1.4	34.3	[2]	-	–	–	–	–
2	C3a	Distractibility [B]	11.3	4.4	12.3	19.4	13.94	0.00299	∅			
43	J3u	Edema [B]	11.7	3.3	9.6	25.4	18.63	0.00033	√	∅	∅	√√
27	G1fc	Climbing stairs [O]	12.1	1.1	12.3	26.9	33.89	0.00001	√√√	√	∅	√
15	E1i	Withdrawal from activities [B]	12.2	4.4	11.0	24.2	14.97	0.00184	∅			
41	J3m	Diarrhea [1, B]	14.8	10.0	15.1	20.9	3.65	0.30137	∅			
31	J1	Falls [1, B]	16.5	19.8	11.0	17.9	7.28	0.06352	∅			
10	E1b	Anger [B]	20.9	20.9	19.2	22.7	0.56	0.90618	∅			
49	L7	Feet problems [B]	20.9	14.3	20.8	29.9	5.62	0.13154	∅			
9	E1a	Negativity [B]	21.7	17.6	17.8	31.8	5.26	0.15374	∅			
17	D4	Vision [O]	22.5	14.3	21.9	34.3	21.55	0.00008	√√	√√	∅	∅
12	E1d	Repeated complaints [B]	22.6	18.7	21.9	28.8	4.74	0.19154	∅			
14	F2	Loneliness [B]	23.4	19.8	21.9	29.9	2.60	0.45744	∅			
40	J3l	Constipation [1,B]	24.3	18.9	27.4	28.4	5.77	0.12348	∅			
52	M1	Analgesics [B]	28.1	14.3	31.5	43.3	19.83	0.00018	√√	∅	∅	√√
4	C2b	Procedural memory [B]	28.7	15.4	30.6	44.8	22.64	0.00005	√√	∅	∅	√

Table 4. *Cont.*

			Observed values				Overall model fit			Age	Assi.	Care
#	Code	Description	Total	Cont.	Assi.	Care	χ^2	*p*	sig[3]	sig[4]	sig[4]	sig[4]
			N = 231	*N* = 91	*N* = 73	*N* = 67						
39	H2, H4	Incontinence device [2,O]	30.3	14.3	37.0	44.8	31.32	0.00001	√√√	√√	∅	√
16	D3	Hearing [O]	31.2	24.2	35.6	35.8	25.99	0.00001	√√√	√√√	∅	∅
35	K1a, K1b	BMI [2,B]	32.0	32.2	37.5	25.8	4.44	0.21766	∅			
37	H1	Bladder incontinence [O]	32.5	16.5	42.5	43.3	24.67	0.00002	√√√	√	√	√
13	E2c	Sadness [B]	33.3	33.0	26.0	41.8	4.05	0.25590	∅			
45	J4	Dyspnea [B]	33.3	18.7	37.0	49.3	23.52	0.00003	√√	√	∅	√
29	G4b	Outings [B]	34.6	24.2	31.5	52.2	20.43	0.00014	√√	√	∅	∅
21	G3a	Primary mode of locomotion [O]	35.1	7.7	43.8	62.7	73.27	0.00001	√√√	√√	√√√	√√√
46	J5	Fatigue [B]	38.1	26.4	37.0	55.2	20.24	0.00015	√√	√	∅	∅
30	J3d	Gait [B]	38.7	16.5	42.5	65.2	62.49	0.00001	√√√	√√√	∅	√√√
44	J3o, J3p	Sleep disturbance [O]	41.5	33.3	50.0	43.3	8.73	0.03310	∅			
3	C2a	Short-term memory [B]	60.6	50.5	60.3	74.6	16.26	0.00100	∅			
36	M1	Medication [2,O]	67.1	46.2	79.5	82.1	39.28	0.00001	√√√	∅	√√√	√√√
51	J6b	Intense pain [B]	72.7	62.6	75.3	83.6	10.28	0.01630	∅			
50	J6a	Frequent pain [B]	73.2	62.6	76.7	83.6	10.88	0.01241	∅			
28	G4a	Physical activity [B]	76.1	61.5	81.9	89.6	23.81	0.00003	√√	∅	∅	∅

[B] Binary variable, analyzed using binary logistic regressions. [O] Ordered categorical variable, analyzed using ordered logistic regressions. [1] No deficit was reported; the regression was not computed. [2] There was a quasi-separation of data across groups; the regression was not computed. [3] Significance thresholds based on omnibus chi-squared tests *p*-values adjusted for multiple comparisons (α/52). [4] Significance thresholds based on Wald chi-squared tests associated *p*-values adjusted for multiple comparisons (α/3). The symbols represent the adjusted probability thresholds: ∅ non-significant; √ = $p \leq 0.05$; √√ = $p \leq 0.01$; √√√, $p \leq 0.001$.

Analyses at the index level

The second set of analyses were aimed at assessing group differences at the index level. A threshold of 80% completion (42/52 valid items) was initially set as a conditional minimal requirement for FI computing. None of the 231 participants was below the threshold: 217 had no missing values (94.0%), 10 had one missing value (4.3%), 2 had two missing values (0.9%), 1 had three (0.4%) and 1 had five (0.4%). For all the participants with missing values, the FI denominator was reduced accordingly (set respectively to 52, 51, 49 and 47 instead of 53). Table 5 provides the descriptive statistics for the FI and for the FI when categorized as a binary variable [24–26] and as an ordinal variable, using the thresholds proposed for the FI-MDS [26,41]. Figure 3 reports the distribution of the observed FI values. The results showed that the number of deficits ranged from 0 to 26.50, with an average of 10.27 (SD 5.13). The corresponding FI ranged from 0 to 0.50, with an average of 0.19 (SD 0.10). The FI was normally distributed, with an interquartile range of 0.13 and values of 0.02 at the 1st percentile and 0.46 at the 99th percentile. As expected, the FI's distribution did not reach the theoretical maximum of 1.

The linear regression modeling used to assess the group difference on the FI revealed an overall significant model fit, $F(3,227) = 44.53$, $p < 0.001$. The Assistance group had a significantly higher FI value than the control group, estimated to FI = 0.18 (B = 0.04, 95% CI = (0.02–0.07), $p < 0.01$). The Care group, had also a significantly higher FI value than the control group estimated to FI = 0.25 (B = 0.11, 95% CI = (0.08–0.14), $p < 0.001$). The effect of age on the FI was significant, B = 0.003, 95% CI = (0.001–0.005), $t = 4.40$, $p < 0.001$. The variance accounted for the FI by the model (age and groups as predictors) was of $R^2 = 0.370$.

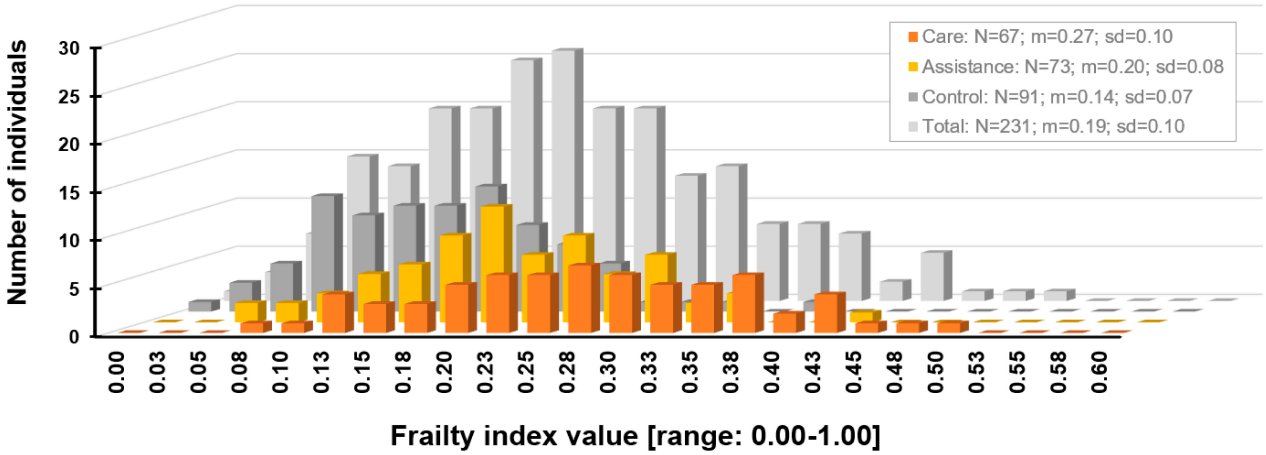

Figure 3. Distribution of observed FI values by group and for the total sample.

Table 5. Descriptive statistics for the sum of deficits, the frailty index and the frailty categories, by group and for the total sample.

FI outcomes	Total sample	Control	Assistance	Care
N	231	91	73	67
Sum of deficits				
m (SD)	10.27 (5.13)	7.19 (3.68)	10.48 (4.04)	14.22 (5.15)
Min–max	0.00–26.50	0.00–19.50	2.00–22.50	4.00–26.50
Frailty Index				
m (SD)	0.19 (0.10)	0.14 (0.07)	0.20 (0.08)	0.27 (0.10)
Min–max	0.00–0.50	0.00–0.37	0.04–0.42	0.08–0.50
5th percentile	0.12	0.08	0.15	0.20
50th percentile	0.19	0.13	0.20	0.26
95th percentile	0.37	0.25	0.33	0.43
FI category [1]				
Nonfrail *N* (%)	142 (61.47)	81 (89.01)	42 (57.53)	19 (28.36)
Frail *N* (%)	89 (38.53)	10 (10.99)	31 (42.47)	48 (71.64)
FI-MDS category [2]				
Nonfrail *N* (%)	142 (61.47)	81 (89.01)	42 (57.53)	19 (28.36)
Prefrail *N* (%)	56 (24.24)	8 (8.79)	25 (34.25)	23 (34.33)
Frail *N* (%)	33 (14.29)	2 (2.20)	6 (8.22)	25 (37.31)

[1] Thresholds used: nonfrail, FI ≤ 0.21; frail, FI > 0.21 [27–32]. [2] Thresholds used: low, FI ≤ 0.21; intermediate, >0.21 FI ≤ 0.30; high, >0.30 [27–29].

Regarding the odds of being frail, the overall model fit was significant (χ^2 = 76.77, p < 0.001). In addition, the results revealed that the assistance group had higher odds of being frail than the control groups (OR = 4.20, 95% CI (1.82–9.71), χ^2 = 10.74, p < 0.01). A similar pattern of higher odds was reported for the care group (OR = 13.17, 95% CI (5.46–31.77), χ^2 = 11.25, p < 0.001). The effect of age was significant, OR = 1.08, 95% CI (1.03–1.12), χ^2 = 37.81, p < 0.001.

As concerns the probability of belonging to the nonfrail, prefrail or frail category of frailty, the overall model fit was significant (χ^2 = 89.34, p < 0.001). Further the results revealed a significant overall difference between the assistance and control groups (χ^2 = 10.43, p < 0.01) and a significant overall difference between the care and control groups (χ^2 = 37.62, p < 0.001). The estimated age-independent conditional probabilities for being nonfrail (FI ≤ 0.21) were 0.89 for the control group, 0.59 for the assistance group, and 0.26 for the care group. For the prefrail category (0.21 < FI ≤ 0.30), the probabilities were 0.09 in the control group, 0.30 in the assistance group, and 0.39 in the care group. For the frail category (FI > 0.30), the probabilities were 0.02 for the control group, 0.11 for the assistance group, and 0.35 for the care group. The effect of age was significant, independently of the group effect (χ^2 = 14.98, p < 0.001).

DISCUSSION

In this paper, we report a FI computation algorithm based on MDS data collected with the interRAI-HC instrument and adapted from an algorithm initially developed for the Swiss RAI-HC [44]. The rationale underlying the proposed approach is to provide a frailty estimate from routinely collected MDS health data, for use as a screening tool in homecare practice. A second aim of the study was to compare different samples of older populations receiving home services, to document rates of frailty across different types of home service users. The approach served as a proof of concept addressing the potential relevance of applying the proposed methodology not only to care recipients (who routinely benefit from CGA at least at admission), but also to individuals applying only for home assistance (who most often do not benefit from a comprehensive health assessment).

Validity of the Proposed FI-MDS

The FI-MDS derivation methodology benefits from convincing evidence stemming from studies that used the interRAI–Acute Care [38,39], interRAI ED–Contact Assessment [40], interRAI–Home Care [29,41–43], and interRAI–Nursing Home [45]. The results of the present study contribute to showing the relevance of using a comprehensive health assessment to derive a FI and have it ready for professionals to use, without requiring additional assessment time. The surface characteristics of the proposed index—i.e., the fact that the score is normally distributed and that extreme values do not reach the theoretical maximum of 1—comply with previous

descriptions of FIs derived from MDS [38,40,43,44], large-scale health studies [23,46,68], or even survey data [25]. We report a small but significant positive age effect (B = 0.003, 95% CI = (0.001–0.005)) on the FI, as previously documented in community [46] and homecare samples [43,44]. The results correspond to the characteristics of our study sample, composed of 70% community individuals (the control and assistance groups) and 30% individuals receiving homecare (the care group). The sample's composition can further account for the observed average FI value of 0.19 (SD 0.10) and for the "leftward switch" of the FI distribution, which ranged from 0 to 0.46 at the 99th percentile. The FI values reported in the present study are substantially lower than the FI values derived from MDS reported in the literature. Aside from the participants' characteristics, with individuals with few care needs deliberately being targeted, FI values are probably further underestimated due to methodological biases related to the voluntary participation in this study. Indeed, voluntary participation has long been known as a source of bias [69], either because people who volunteer are in condition than their peers (volunteer bias) and/or because people who do not participate are in worse condition than their peers (non-response bias). We cannot exclude that the convenient sampling method further contributed to exacerbate this bias. Notwithstanding, when looking at the FI mean value reported for the care group of 0.27 (SD = 0.10), it is not significantly different from those reported in homecare samples from Switzerland (N = 3714, m = 0.24, SD = 0.13 [44], $p > 0.05$) and New Zealand (N = 5586, m = 0.27, SD = 0.12 [43], $p > 0.05$). This observation suggests that the proposed computation algorithms lead to comparable results to those reported for larger clinical samples, which are usually routinely assessed, thus drastically reducing the risk of this aforementioned bias. The comparability of the results is additional evidence in favor of the proposed FI's measurement validity. Yet, further work remains needed to refine the FI's psychometric properties, notably to assess its predictive validity with respect to adverse health outcomes and its reliability across measurement occasions.

Frailty Differences among Recipients of Home Care and Home Assistance

The study results showed a significant group effect on the FI. As expected from our risk-stratification approach, the FI value increased across groups. It was the lowest in the control group (m = 0.14, SD = 0.07), higher in the assistance group (m = 0.20, SD = 0.08), and the highest in the care group (m = 0.27, SD = 0.10). Arguably, age differences may account for these results, provided that the assistance and care groups (respectively aged 81.0 ± 7.5 years and 83.4 ± 7.9 years, m ± SD) were significantly older than the control group (75.2 ± 6.6 years). If one cannot exclude a confounding effect of age, then it is important to note that group differences were adjusted for age. In addition, the assistance and care groups did not significantly differ in age, yet their FI values significantly

differed. Provided that the FI is viewed as a proxy measure of physiological aging [15], this result is in line with ample evidence showing that physiological resources are heterogeneous at comparable chronological ages and that chronological time is an imperfect proxy measure of senescence [70]. Ultimately, these results provide empirical support to the risk-stratification approach used to assign participants to experimental groups as a function of their use of formal home services (i.e., the amount of compensation required for functional living). Yet, further work is needed to effectively assess risks, by evaluating the odds of adverse events as a function of the proposed FI value. Doing so will allow differential risks to be assessed as a function of a typology of adverse events (falls, physician visits, emergency admissions, hospital stays, and mortality) and eventually also as a function of the service recipients' type. These findings will be of great clinical value for guiding frailty management in practice. Importantly, assessing FI against risks of adverse outcomes will also serve to empirically tests the reliability of the 0.21 cut point borrowed from the literature [27–29] to categorize the sample into nonfrail (FI ≤ 0.21) and frail (FI > 0.21).

The Usefulness of FI Categorization for Frailty Screening

For scholars, turning a continuous variable into a categorical one loses substantial amounts of information, worsens statistical estimates, and leads to misinterpretation of the outcomes [71]. For clinicians and health professionals, the use of categories has an obvious benefit: it facilitates the understanding and interpretation of the results [72]. In the present study, we used thresholds from the literature to transform the FI into categories so as to facilitate its interpretation. The results demonstrated that as compared to the control group (11.0% of frail), the odds of being frail–independently of age was 4.2 times higher for the assistance group and 13.2 higher for the care group. Further, nearly 43% of home assistance and 72% of home care recipients were identified as frail (prefrail or frail). Interestingly, the observed rates among categories in the care group (28.4% nonfrail, 71.6% frail) were seemingly comparable to the rates reported for an Australian sample admitted to a community-based transition care program and assessed with the interRAI-HC (N = 272, 30% low frailty, 70% intermediate or high frailty [41]). Again, the present results are in line with available corresponding evidence. Yet, an obvious limit of the analyses considering frailty categories is that we borrowed the FI threshold values used to categorize frailty from the literature. As previously mentioned, the validity of these thresholds with respect to the proposed IF calculation deserve further assessment using the odds of adverse events documented for the study sample.

Applying the FI Derivation Methodology for Frailty Screening in Homecare Practice

Based on the proposed FI algorithm, a substantial proportion of service recipients were identified as frail (~40% of assistance users and 72% of care users). Accordingly, on the scale of Geneva canton, nearly 10,000 individuals would annually deserve care plans that include frailty management. To this day, frailty scores are not readily available to professionals to design such care plans, but with the proposed methodology, frailty will become readily measurable and manageable [50]. This applies to all situations in which the interRAI-HC is routinely used. In Switzerland, institutional recommendations concern the assessment of any individual requesting care at home. The present findings estimate that more than two thirds of the care recipients would be concerned by an optimization of their care plans. The findings support further development of the methodology and its large-scale implementation, framed by dedicated awareness and clinical assessment protocols, for use by homecare professionals [73]. Yet, the present study further ambitioned to address the potential relevance of applying the same approach to screen for frailty among individuals requiring home assistance and for whom a routine evaluation of care needs is not indicated. The results are clear: nearly half of the assistance recipients displays a FI value that exceeds the frailty threshold. In other words, for these individuals frailty needs are indisputably unmet. This finding is quite innovative and provides valuable insight on frailty rates among individuals who reach for home services but who do not benefit from routine comprehensive assessment. Thus, there is no doubt about the relevance of frailty screening among such service beneficiaries, although the choice of an appropriate screening methodology remains open. The careful exploration of the 52 items used for FI derivation revealed that the assistance group demonstrated significantly more deficits in incontinence, locomotion and medication. Deficits in these dimensions may trigger the need for a comprehensive health assessment with the interRAI-HC. Otherwise, the use of a disability screener or a brief frailty assessment may also be recommended. Additional work is required to refine the recommendations for frailty screening among individuals receiving home assistance. The assessment of risks of adverse outcomes and the estimations of frailty will change over time, which will undoubtedly be useful to refine recommendations for refining the frailty screening among such home service recipients. The analyses of prospective data from follow-up assessments will contribute refining the results beyond the findings stemming from cross-sectional group comparisons.

CONCLUSIONS

The “fraXity” study [54] is a rare opportunity to document frailty in community-dwelling older adults based on data collected with an

instrument primarily used to assess care needs among homecare recipients. The study proposes a computation algorithm to derive a FI from the interRAI-HC and reports convincing findings with respect to its surface and measurement validity. Yet, work remains to do to specify the proposed FI's predictive validity and reliability. The study also provided estimates of the rate of frail individuals among home service recipients, hence highlighting the potential benefits of implementing an interRAI-HC–based systematic frailty assessment, at least for individuals requesting home care. Questions remains open concerning the methodology's appropriateness for individuals requesting assistance. Altogether, the results from the baseline "fraXity" assessment are appealing and call for further developments. Analyses of the data collected on subsequent measurement occasions—with two having been planned as part of the original protocol—will undoubtedly provide additional insight into the remaining open issues.

DATA AVAILABILITY

At the end of the study, the datasets generated during the project will be deposited, coded, and cleared of personal information at DARIS/FORS (http://forscenter.ch), for data sharing and reuse purposes. FORS/DARIS complies with the FAIR (findable, acceptable, interoperable, re-usable) principles.

AUTHOR CONTRIBUTIONS

CL and CB designed the study, drafted the protocol, and developed the FI derivation algorithm. CL analyzed the data. CL and CB interpreted the results. CL prepared the manuscript, while CB further read the manuscript and critically commented on it. All of the authors read and approved the final manuscript.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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