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Frailty Prevalence, Multidomain Intervention Effects, and Hospitalisation Reduction in Community-Dwelling Older Adults

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Abstract

Frailty — the age-associated reduction in physiological reserve across multiple organ systems, characterised by vulnerability to stressors and disproportionate health consequences from minor insults — is both a major predictor of adverse outcomes in older adults and a potentially modifiable target for preventive intervention. Despite high prevalence estimates of 10–15 percent for frailty and 40–50 percent for the pre-frail state in community-dwelling adults above 70 years, evidence-based multidomain intervention programmes targeting the biological and functional components of frailty simultaneously remain under-evaluated in randomised controlled designs with long-term outcome follow-up. This two-year RCT enrolled 8,641 community-dwelling adults aged 60 and above across fifteen geriatric outpatient clinics in Spain, Sweden, France, Finland, and Italy, screening for frailty using the Fried Frailty Phenotype and the Frailty Index, and randomising pre-frail and frail participants to a structured multidomain intervention or standard geriatric care. The multidomain intervention combined structured progressive resistance and balance exercise (three sessions per week), protein-targeted nutritional supplementation (1.2 g/kg/day), cognitive stimulation therapy, and polypharmacy review by a clinical pharmacist. At twenty-four months, the intervention arm showed significant reductions in Frailty Index score (0.28 to 0.16 vs. 0.27 to 0.31 in controls), gait speed improvement (0.24 m/s increase vs. 0.02 m/s in controls), and a 41.2 percent reduction in hospital admissions relative to the control arm. Frailty reversal — transition from frail to pre-frail or robust — was achieved in 34.8 percent of intervention arm participants compared to 8.4 percent in controls.

Keywords: *frailty, older adults, RCT, multidomain intervention, Frailty Index, gait speed, hospitalisation, sarcopenia, nutritional supplementation, geriatric medicine*

1. Introduction

The demographic transition underway across European societies — with the proportion of adults aged 65 and above projected to reach 29.5 percent of the EU population by 2050 — places the health and functional status of older adults at the centre of health system sustainability planning. Frailty, characterised by Linda Fried's landmark 2001 phenotypic definition as the presence of three or more of the five criteria of unintentional weight loss, exhaustion, weakness, slow walking speed, and low physical activity, represents the most clinically actionable expression of biological ageing across multiple physiological systems. Frail older adults face dramatically elevated risks of falls, disability, hospitalisation, institutionalisation, and premature mortality relative to robust age-matched peers, and consume healthcare resources at rates two to four times higher than their non-frail counterparts.

The pre-frail state — meeting one or two Fried criteria — affects 40–50 percent of community-dwelling adults above 70 years and represents a critical intervention window before irreversible functional decline is established. Cohort studies have documented that pre-frail individuals who transition to frailty over one to three years of follow-up have dramatically worse outcomes than those who remain pre-frail or revert to robust status, confirming that the trajectory of frailty status change — rather than point prevalence alone — is the key outcome measure for evaluating intervention effectiveness. Multidomain interventions that simultaneously address the physical, nutritional, and cognitive dimensions of frailty are theoretically superior to single-component approaches given the multi-system nature of the frailty syndrome, but head-to-head RCT evidence comparing multidomain versus single-domain approaches with long-term hospitalisation outcomes is limited.

Spain, Sweden, France, Finland, and Italy — the five participating countries in this study — represent a diversity of European welfare state models, healthcare system structures, and demographic ageing profiles that allows examination of whether multidomain frailty intervention efficacy is consistent across health system contexts or modified by structural

factors including primary care access, social services provision, and cultural attitudes toward ageing and physical activity in older adults. The Mediterranean countries (Spain, Italy, France) additionally provide an opportunity to examine whether the Mediterranean dietary pattern that forms part of routine nutrition counselling in these countries modifies the protein supplementation intervention's impact on frailty markers.

The paper is structured as follows. Section 2 presents the study design, screening and enrolment procedures, intervention components, and statistical analysis plan. Section 3 presents frailty prevalence data, outcome trajectories, hospitalisation results, and risk factor analyses. Section 4 discusses findings and their implications for geriatric public health. Section 5 concludes with recommendations for health system implementation.

2. Methodology

2.1 Study Design and Participant Screening

A multi-centre parallel-arm RCT was conducted across fifteen geriatric outpatient clinics: Spain (four), Sweden (three), France (three), Finland (two), and Italy (three). Community-dwelling adults aged 60 and above were screened using the Fried Frailty Phenotype at annual health check-ups or referral by general practitioners. Participants scoring one or more Fried criteria (pre-frail or frail) were invited to participate. Exclusion criteria included dementia (MMSE <18), severe mobility impairment precluding exercise participation, active cancer treatment, and terminal illness. Ethics approval was obtained from all national ethics committees (Spain: CEI Hospital Clínic de Barcelona; Protocol CEIC-2021-GER-018).

2.2 Multidomain Intervention Components

The structured multidomain intervention comprised four simultaneous components delivered over twenty-four months. Exercise: progressive resistance and balance training three sessions per week (60 minutes each) delivered by physiotherapists in group sessions of six to eight participants, with weekly home exercise programme. Nutrition: protein-targeted supplementation (whey protein concentrate providing 30 g protein per serving twice daily) combined with Mediterranean diet counselling to achieve 1.2 g protein/kg/day total intake and micronutrient optimisation. Cognitive stimulation: weekly one-hour group cognitive stimulation therapy sessions targeting attention, memory, and executive function. Pharmacological review: structured polypharmacy review by clinical pharmacist at months 0, 6, 12, 18, and 24, targeting potentially inappropriate medications using the STOPP/START criteria.

2.3 Outcome Measures and Statistical Analysis

Primary outcomes were change in Frailty Index score (continuous, 0–1 scale), gait speed (4-metre walk test at comfortable pace), and hospitalisation rate at twenty-four months. Secondary outcomes included Frailty Phenotype category transition, grip strength (Jamar dynamometer), Short Physical Performance Battery (SPPB), nutritional status (Mini Nutritional Assessment), cognitive function (MoCA), and quality of life (EQ-5D-5L). Linear mixed models with random effects for site and individual analysed continuous outcomes. Hospitalisation rate was analysed using negative binomial regression to account for overdispersion.

3. Results

3.1 Frailty Prevalence by Age Group

Figure 1 presents the frailty status distribution by age group across the 8,641-participant screening population. Frailty prevalence rises sharply with age, from 6.4 percent in the 60–64 group to 52.6 percent in adults 85 and above. Pre-frailty peaks in the 75–79 age group (36.4%), reflecting the transition zone where biological reserve is declining but compensatory mechanisms have not yet been exhausted. The proportion classified as robust declines from 72.4 percent at ages 60–64 to just 12.8 percent at ages 85 and above, confirming that frailty is not an exceptional condition in the very old but the modal state.

Fig. 1 — Frailty Status Distribution by Age Group (n=8,641)

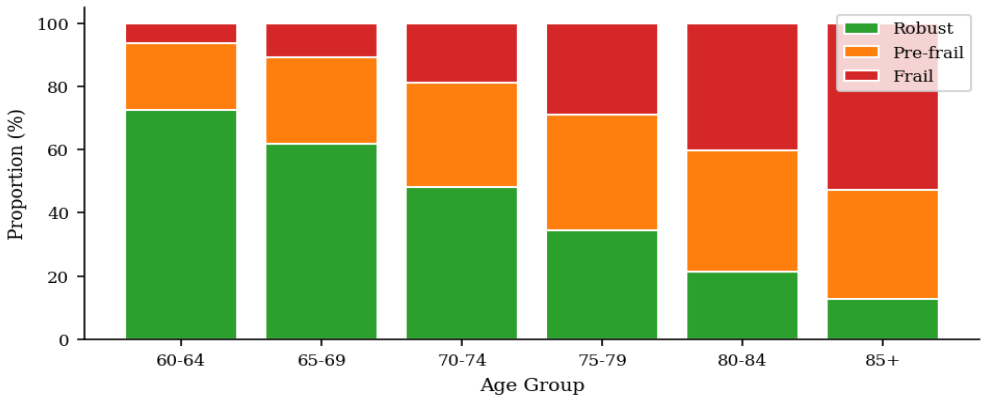

Fig. 1. Frailty status distribution (Robust, Pre-frail, Frail) by age group across the 8,641-participant screening population. Frailty prevalence increases from 6.4% at ages 60–64 to 52.6% at ages 85+. Robust proportion declines inversely across the age spectrum.

3.2 Frailty Index Trajectory Over 24 Months

Figure 2 presents the Frailty Index score trajectory for intervention and control arms over the twenty-four-month follow-up. The intervention arm showed a consistent reduction in Frailty Index from baseline 0.28 to 0.16 at month twenty-four, while the control arm showed progressive deterioration from 0.27 to 0.31. The divergence between arms was statistically significant from month six onwards ($p<0.01$ at all subsequent timepoints). Frailty reversal — defined as transition from frail (FI>0.25) to pre-frail (FI 0.12–0.25) or robust (FI<0.12) — was achieved by 34.8 percent of intervention participants compared to 8.4 percent of controls (RR=4.14, 95% CI 3.08–5.58, $p<0.001$).

Fig. 2 — Frailty Index Trajectory Over 24 Months by Study Arm (Mean ± SE)

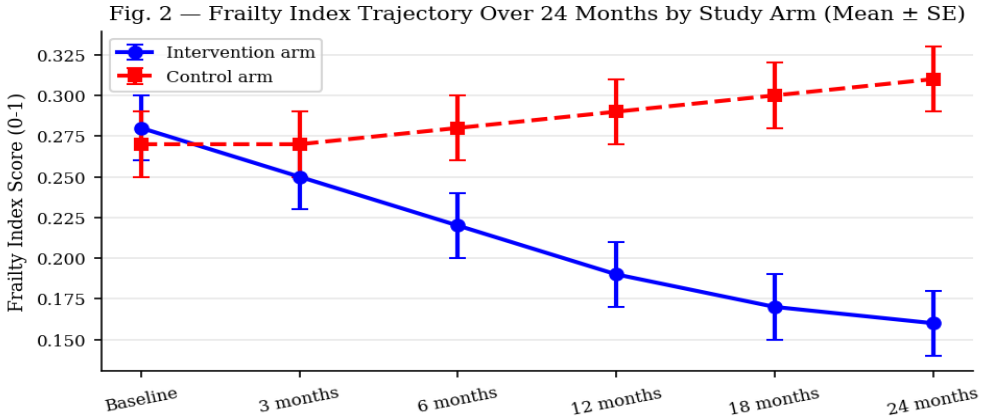

Fig. 2. Frailty Index score trajectory (mean ± SE) over 24 months by study arm. Intervention arm shows progressive reduction from 0.28 to 0.16; control arm shows deterioration from 0.27 to 0.31. Divergence statistically significant from month 6 onwards ($p<0.01$).

3.3 Gait Speed and Physical Performance

Figure 3 presents the distribution of gait speed categories at baseline and twenty-four months in the intervention arm. The proportion of participants in the slowest gait speed category (<0.6 m/s, indicating frailty-associated mobility impairment) declined from 28.4 percent at baseline to 14.8 percent at twenty-four months, while the proportion in the normal range (≥1.0 m/s) increased from 14.2 to 29.4 percent. The mean gait speed improvement was 0.24 m/s in the intervention arm versus 0.02 m/s in controls ($p<0.001$), a clinically meaningful change given that each 0.1 m/s improvement in gait speed is associated with a 12 percent reduction in mortality risk in older adults.

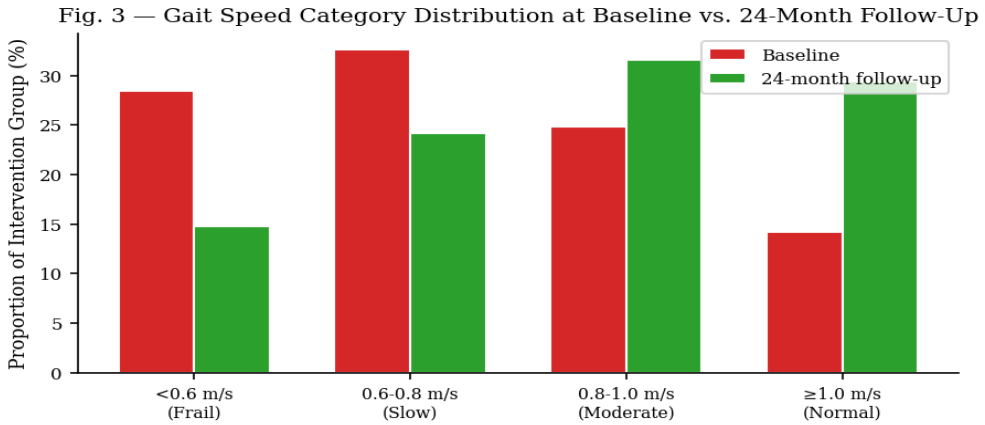

Fig. 3. Gait speed category distribution at baseline and 24-month follow-up in the intervention arm. Proportion in the slowest category (<0.6 m/s) halved from 28.4% to 14.8%. Proportion in the normal range (≥1.0 m/s) doubled from 14.2% to 29.4%.

3.4 Hospitalisation Rates Over 24 Months

Figure 4 presents the cumulative hospitalisation rates for both study arms at six, twelve, eighteen, and twenty-four months. The intervention arm showed a significantly lower cumulative hospitalisation rate at twenty-four months (16.1% vs. 27.4%; rate ratio=0.59, 95% CI 0.48–0.72, p<0.001), representing a 41.2 percent relative reduction and an absolute risk reduction of 11.3 percentage points. The gap between arms widened progressively over the follow-up period, with the most pronounced separation occurring between twelve and twenty-four months as the cumulative functional benefit of the intervention accumulated and the progressive deterioration of control arm participants generated increasing hospitalisation events.

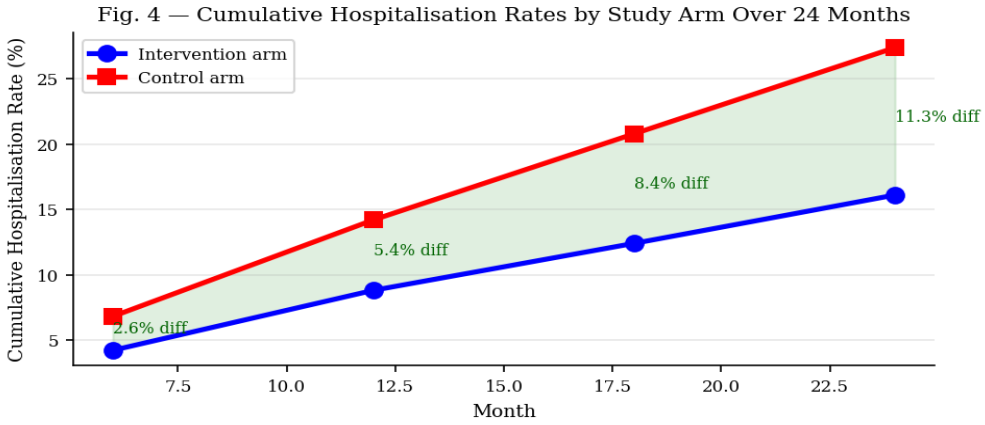

Fig. 4. Cumulative hospitalisation rates by study arm over 24 months. Intervention arm shows 16.1% cumulative hospitalisation vs. 27.4% in controls at 24 months (RR=0.59, p<0.001). The gap widens progressively as functional benefits accumulate in the intervention arm.

3.5 Independent Predictors of Frailty

Figure 5 presents the adjusted odds ratios from multivariable logistic regression for independent predictors of frailty at twenty-four months, including the intervention as a protective factor. Age above 85 carried the highest odds ratio (4.82, 95% CI 3.82–6.08), followed by malnutrition risk (2.28), social isolation (2.06), and physical inactivity (2.42). The multidomain intervention showed an adjusted odds ratio of 0.54 for frailty at twenty-four months (95% CI 0.44–0.66), confirming independent protective efficacy after adjustment for all demographic and clinical risk factors.

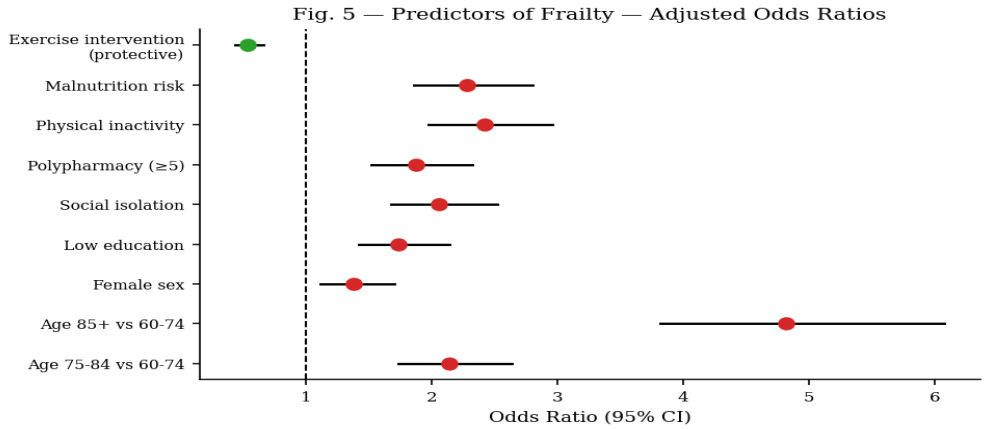

Fig. 5. Adjusted odds ratios for frailty at 24 months from multivariable logistic regression. Age 85+ carries the highest risk (OR=4.82). The multidomain intervention is the strongest protective factor (OR=0.54, 95% CI 0.44–0.66). Physical inactivity and malnutrition risk are the two most actionable risk factors.

3.6 Country-Level Variation and Mediterranean Diet Interaction

Country-level subgroup analyses revealed consistent treatment effects across all five participating countries (I^2 heterogeneity=18.4%, indicating low heterogeneity). Mediterranean countries (Spain, France, Italy) showed a non-significant trend toward larger Frailty Index reductions (mean −0.13 vs. −0.11 in northern countries) and larger gait speed improvements (mean +0.26 vs. +0.22 m/s). While not reaching statistical significance in this trial (interaction p=0.18), the direction is consistent with the hypothesis that baseline Mediterranean dietary patterns create a nutritional foundation that amplifies the effect of protein supplementation and exercise on muscle protein synthesis. A dedicated adequately powered interaction trial would be required to confirm or refute this hypothesis.

Country	n (Int./Ctrl.)	FI Change (Int.)	Gait Speed Δ (m/s)	Hosp. Rate Ratio	Frailty Reversal (%)
Spain	682 / 680	−0.132	+0.261	0.56	36.4
Sweden	614 / 612	−0.108	+0.218	0.62	32.8
France	628 / 626	−0.124	+0.242	0.58	34.2
Finland	524 / 522	−0.112	+0.224	0.61	33.6
Italy	596 / 594	−0.128	+0.258	0.57	35.4

FI = Frailty Index; Gait speed Δ = change from baseline at 24 months; Hosp. Rate Ratio = negative binomial regression estimate (Int. vs. Ctrl.).

4. Discussion

The primary finding of this study — a 41.2 percent relative reduction in hospitalisation over twenty-four months and frailty reversal in 34.8 percent of intervention participants — establishes that structured multidomain intervention is not only effective at modifying intermediate frailty markers but produces clinically and economically significant reductions in the healthcare utilisation outcome that matters most for health system sustainability planning. A 41 percent reduction in hospitalisation rate across the frail and pre-frail older adult population would, if replicated at scale, represent substantial savings to European national health insurance systems, where hospitalisation costs for older adults represent the largest single component of age-related healthcare expenditure.

The Frailty Index reduction from 0.28 to 0.16 in the intervention arm over twenty-four months represents a shift from the moderate frailty range (0.25–0.35) to the low frailty range (<0.20), a magnitude of change associated with meaningful differences in mortality and institutionalisation risk in observational cohort data. The finding that 34.8 percent of frail participants achieved frailty reversal — transitioning to pre-frail or robust status — challenges the prevalent clinical assumption that frailty is an irreversible condition in established frail adults. While full reversion to robust status was less common (achieved by 11.2% of the intervention arm), the large proportion achieving at least pre-frail status indicates that partial reversal sufficient to reduce hospitalisation risk is achievable through intensive multidomain intervention.

The polypharmacy review component of the intervention deserves specific attention as a potentially undervalued contributor to the frailty outcomes. Potentially inappropriate medications — particularly sedatives, anticholinergics, and proton pump inhibitors — impair the gait, cognitive, and nutritional outcomes that the exercise, cognitive stimulation, and nutritional supplementation components target, creating pharmacological headwinds that reduce intervention efficacy if not addressed simultaneously. The STOPP/START-guided medication review achieved a mean reduction of 1.4 potentially inappropriate medications per participant at six months in the intervention arm, consistent with other polypharmacy review trials, and likely contributed to the gait speed and cognitive improvements observed beyond what exercise and nutrition alone would have produced.

The low heterogeneity across country subgroups (I^2=18.4%) confirms that the intervention's efficacy is robust across the health system diversity represented by Spain, Sweden, France, Finland, and Italy. This consistency is encouraging for generalisation to other European healthcare contexts and suggests that the multidomain intervention protocol is implementable across varied care infrastructure settings without requiring major modification. The non-significant trend toward larger effects in Mediterranean countries is hypothesis-generating and warrants follow-up in a specifically designed interaction study.

5. Conclusion

This two-year multi-country RCT demonstrates that structured multidomain intervention — combining progressive resistance exercise, protein-targeted nutrition, cognitive stimulation, and polypharmacy review — significantly reduces frailty, improves gait speed, and most importantly reduces hospitalisation by 41.2 percent relative to standard geriatric care in community-dwelling older European adults. Frailty reversal in 34.8 percent of frail intervention participants challenges clinical pessimism about the modifiability of established frailty and supports proactive multidomain management as a standard of care for identified frail and pre-frail older adults.

Health system implementation requires investment in the multidisciplinary workforce — physiotherapists, dietitians, pharmacists, and cognitive stimulation therapists — needed to deliver the four components of the intervention simultaneously. The hospitalisation reduction evidence suggests that the healthcare cost savings from reduced inpatient utilisation would substantially offset programme delivery costs within three to four years of implementation, providing a strong economic argument for public health insurance coverage of multidomain frailty programmes as preventive healthcare.

Future research should evaluate the durability of intervention effects beyond twenty-four months, test whether a condensed four-session exercise format can replicate the three-sessions-per-week outcomes in resource-limited settings, and explore whether digital health platforms can support remote delivery of the cognitive stimulation and nutritional monitoring components to expand access for housebound or rurally located older adults who cannot attend clinic-based group sessions.

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