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Preventing autonomy loss with multicomponent geriatric interventions: A resource-saving strategy? Evidence from the SPRINT-T study

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ABSTRACT

Background: The objective of healthy aging strategies is to support interventions targeting autonomy loss prevention, with the assumption that these interventions are likely to be efficient by simultaneously improving clinical outcomes and saving costs.

Methods: We compare the economic impact of two interventions targeting frailty prevention in older European populations: a multicomponent intervention including physical activity monitoring, nutrition management, information and communications technology use and a relatively simple healthy aging lifestyle education program based on a series of workshops. Our sample includes 1,519 male and female participants from 11 European countries aged 70 years or older. Our econometric model explores trends in several outcomes depending on intervention receipt and frailty status at baseline.

Results: Implementing a multicomponent intervention among frail older people does not lead to a lower use of care and do not prevent quality of life losses associated with aging. However, it impacts older people's sense of priorities and interest in the future. We find no statistically significant differences between the two interventions, suggesting that the implementation of a multicomponent intervention may not be the most efficient strategy. The impact of the interventions does not differ by frailty status at baseline.

Conclusions: Our results show the need to implement healthy aging strategies that are more focused on people's interests.

1. Background

Over the past 20 years, a major focus of long-term care (LTC) research has been to explore the economic consequences of autonomy loss. Several literature reviews have provided evidence that physical frailty and sarcopenia (PF&S), which are major determinants of disability in older populations, are associated with greater use (Kojima, 2016; Roquebert, Sicsic, Rapp, & SPRINT-T Consortium, 2021; Wang et al., 2013). Moreover, recent work has identified the incremental cost associated with frailty in older populations (Bock et al., 2016; Ensrud et al., 2020; Sirven et Rapp 2017), showing that frail older people are often "high needs-high costs" patients (Sicsic et al., 2020).

Based on this literature, an important focus of healthy aging strategies has been to support interventions targeting PF&S prevention, assuming that these interventions are likely to be cost-effective and cost-saving compared to the standard of care (Sirven, et. al., 2017; Afzali et al., 2019; Groessl et al., 2016). Nevertheless, also due to the lack of strong evidence, a common health technology assessment approach to inform health policy making in this specific context is still needed.

Indeed, healthy aging policies rely on the assumption that preventing autonomy losses among older adults will improve their quality of life and reduce the use of medical and social care resources. Such policies are promoted by global aging initiatives, such as the Integrated Care for Older People (ICOPE) model, which is an integrated approach to promote healthy aging and prevent PF&S in older populations recently proposed by the World Health Organization (WHO, 2018). This approach, which includes the deployment of a large-scale digital platform, has already been included in the LTC policy of some countries,

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such as the French Presidential "*Plan Grand Age*" (Sanchez-Rodriguez et al., 2021; Tavassoli et al., 2021). The rationale for such policies relies on the assumption that PF&S prevention is likely to reduce future LTC spending. Indeed, the predictions provided by the European Commission show that a healthy aging strategy could help mitigating the increase in future LTC spending that is expected due to European population aging (European Commission, 2018).

However, exploring the impact of healthy aging interventions on the efficiency of LTC systems is not straightforward. Indeed, such interventions often require comprehensive approaches involving physical training, nutritional monitoring, educational training, the use of digital devices and regular geriatric assessments (Azzolino and Cesari 2021; Cesari et al., 2015; Fougère and Cesari 2019; Marzetti et al., 2018) that may foster to greater resource use. While there is evidence in the literature suggesting that these strategies can be successful in preventing PF&S (Cesari et al., 2015; Yu et al., 2020) and be cost-saving and cost-effective compared to the standard of care (Groessl et al., 2016), prior work also shows that the implementation of multicomponent interventions - involving multiple care providers/technologies and objectives - among older adults may sometimes lead to inefficient results (Rolland et al., 2020). Indeed, frail older people are often complex patients with multiple comorbidities and different objective and subjective needs, and comprehensive geriatric care interventions may not always fulfill their expectations (Osborn et al., 2017; Serra-Prat et al., 2017; Roquebert et. al., 2021). Therefore, one may ask whether it is better to implement multicomponent interventional programs or to implement simpler (and less expensive) educational prevention workshops. Tackling this question is important because older people's perceptions of the social benefits associated with physical interventions (for instance, in terms of social connection) is key to the success and acceptability of these intervention (Devereux-Fitzgerald et al., 2016).

In this article, we compare the economic impact of two interventions targeting PF&S prevention in older European populations: (i) a multicomponent intervention including physical activity monitoring, nutrition management, and information and communications technology use *versus* (ii) a relatively simple healthy aging lifestyle education program based on workshop series. Both interventions were implemented in the SPRINT-T (Sarcopenia and Physical fRailty IN older people: multicomponenT Treatment strategies) study, sponsored by the European Commission's Innovative Medicine Initiative (Jyväkorpi et al., 2021; Marzetti, 2018). While most interventions tested in the literature faced several limitations (often due to small sample sizes, absence of a randomization or estimation strategy successfully mitigating unobserved confounders, and reduced follow-up), the SPRINT-T study was a randomized controlled trial that included more than 1,500 participants in eleven European countries who were followed over a 4-year period.

A recent publication showed that the multicomponent intervention was more successful in preventing and delaying PF&S than the simpler education program (Bernabei et al., 2022). Following this article, we explore whether the effect obtained by the multicomponent intervention in terms of PF&S prevention led to a significant decrease in the use of medical care, non-medical care (i.e., meals-on-wheels, help for administrative tasks, help for household work) and improved participants' quality of life compared to the simpler education program. Our findings suggest that while both strategies had some impact on care use and participants' well-being, there was no significant difference between them. From a policy perspective, this paper provides new information to help design appropriate (cost-effective) healthy aging strategies.

2. Methods

2.1. The SPRINT-T intervention

We use longitudinal data collected from the SPRINT-T study; a randomized controlled trial implemented in 2015 (ClinicalTrials.gov identifier: NCT02582138). The SPRINT-T sample consisted of 1518 elderly people aged 70+ who were recruited in eleven European countries (Austria, Czech Republic, Finland, France, Germany, Iceland, Italy, Netherlands, Poland, Spain and United Kingdom) between 2015 and 2017 and followed over a 4-year time period (Bernabei et al., 2022).

Participants were recruited among community-dwelling older people. The inclusion criteria were as follows: age older than 70; a score on the Short Physical Performance Battery (SPPB) test higher than 3/12 (i.e., excluding disabled individuals) and lower than 9/12 (i.e., excluding moderately frail subjects); completion of the 400-m walk test within 15 min; presence of low muscle mass based on the results of a dual energy X-ray absorptiometry (DXA) scan, according to the cut-off points indicated by the Foundation for the National Institutes of Health (FNIH) Sarcopenia Project; and a score on the Mini Mental State Evaluation (MMSE) higher than 24/30 (i.e., excluding subjects who were likely to have cognitive impairment or dementia) (Jyväkorpi et al., 2021; Marzetti, 2018).

Each center was assigned a specific recruitment target, ranging from 54 to 108 participants, and implemented a specific recruitment plan, which included not only direct mailing but also newspapers, radio, and television advertisements. Healthcare providers, medical clinics, and hospitals were also informed of the study to find eligible participants. After a phone or in-person prescreening phase, eligible participants were invited to undergo a screening visit to determine their final eligibility.

The participants of the SPRINT-T trial were randomized into two groups: a multicomponent intervention (MCI) group and a healthy aging lifestyle education (HALE) program group. Participants in the MCI group received physical activity mentoring and nutrition advice and were monitored with the use of an ad hoc technological device to record actimetry data to support the elaboration of a personalized training program (Jyväkorpi et al., 2021; Marzetti, 2018). After going to center-based physical sessions twice a week, participants progressively received physical activity sessions at home: "*once weekly during weeks 1-4, twice weekly during weeks 4-8, and up to four times weekly during weeks 9-52*" (Jyväkorpi et al., 2021; Marzetti, 2018). Physical activity mentoring was of moderate intensity and included aerobic, strength, flexibility, and balance training. Physical training was performed under the direct supervision of an instructor. The nutritional intervention combined both individual nutritional assessment and personalized dietary recommendations directly provided by a dietician/nutritionist to achieve a daily total energy intake of 25–30 kcal/kg body weight and an average protein daily intake between 1.0 and 1.2 g/kg/body weight (Jyväkorpi et al., 2021; Marzetti, 2018). Participants in the HALE group followed a program based on a workshop series. Participants received information on a variety of topics of relevance to older adults (e.g., recommended preventive services and screenings at different ages). The program also included a short instructor-led session (5–10 min) on upper extremity stretching exercises or relaxation techniques that were performed at the end of each workshop. The study was designed for a 4-year follow-up, with a visit occurring every 6 months in both groups. A final visit was performed at the end of the 4-year follow-up thus leaving up to 9 observations per subject.

Further details concerning the study objectives, design and methodology are provided in prior work (D'angelo et al., 2019; Serafini et al., 2019; Landi et al., 2017; Marzetti et al., 2018; Jyväkorpi et al., 2021). The sample was restricted to individuals with complete information (no missing values) for all dependent and independent variables. All clinical research was conducted according to institutional review board standards and local legislations. Data quality checks were performed by dedicated statisticians in the project.

2.2. Analytical sample

The initial longitudinal sample for the SPRINT-T study included 8,975 person-wave observations. For our study, we included individuals who had at least 2 waves of observations and who face frailty issues at the first (inclusion) visit. We did not include data from visits 8 and 9 (the last two visits) in our analyses due to a lack of observations (important attrition).

All variables regarding care use were collected in self-reported questionnaires that asked participants about the presence of any care use since prior visit, about the frequency of services used (e.g., number of ambulatory care visits, number of hospitalizations). Self-reported questionnaires were administered at each visit to the hospital under the supervision of a dedicated staff person involved in the study. We removed from our analysis individuals with missing information on our main variables of interest, in order to work a consistent final study sample. These variables concern the use of emergency care, hospitals, general practitioners, nurses and specialists, as well as the use of formal care, both measured at the extensive (any visit) and intensive (number of visits) margins. Finally, individuals with nonresponses on the quality-of-life dimensions studied in this paper were also excluded. The final sample available for our analyses comprises 5,809 person-wave observations obtained from 1,332 subjects (mean = 4.5 observations per individual). The difference between our analysis sample and the original sample (8,975 person-wave observations) is explained by the sample attrition (v1 = 1,037; v2 = 987; v3 = 933; v4 = 909; v5 = 826; v6 = 701 and v7 = 416 observations). We explore potential bias related to attrition in our data (i.e., non-random missing pattern) in section 2.4. of the paper, and conclude that it does not impact our findings and conclusions for all outcomes expect for one preference measure. Table A1in Appendix also shows that both MCI and HALE groups were similar both in terms of socio-professional characteristics and the various outcomes.

2.3. Econometric model

We examine to what extent frail participants had specific outcomes when receiving the MCI compared to the HALE intervention. Specifically, our econometric model explores trends in health care and LTC use between subgroups, according to the MCI/HALE group assignment and frailty level at baseline (Short Physical Performance Battery test/ SPPB<8: severe frailty or SPPB≥8: moderate frailty). As the data are longitudinal, we use a fixed effects specification to eliminate time-invariant individual heterogeneity, including country-specific heterogeneity. Indeed, fixed effects models rely only on *within-individual* variation in independent and dependent variables. We also control for time-fixed effects by including a variable measuring the time span between two visits since the start of the study. We decompose the time trend between subgroups to compare the influence of the MCI vs. HALE intervention on various outcomes: health care use (emergency care use, hospital use, general practitioner visits, specialist visits, and nurse visits), LTC use (domestic help for work at home and paperwork, presence of a home nurse, transportation services use) and quality of life indicators (a subjective health score ranging from 0 (lower) to 10 (higher), a quality of life score derived from the EQ-5D-5L questionnaire), and several variables measuring participants' preferences and expectations associated with aging, obtained from several questions all recoded as "yes" vs. "no" ("*Are you afraid of losing your autonomy*?"; "*Would you say that aging changed your sense of priorities in life?*"; "*Would you say that aging changed your interest in the future?*"; "*Did aging increase your fear of getting sick?*").

Our econometric models can be written as a system of two equations:

$$y_{it} = \delta_1^{HALE} t_i^{HALE} + \delta_2^{MCI} t_i^{MCI} + c_i + u_{it} \tag{1}$$

$$\left\{ \begin{aligned} y_{it} = {} & \delta_1^{HALE\times SFrail} t_i^{HALE\times SFrail} + \delta_2^{MCI\times SFrail} t_i^{MCI\times SFrail} + \delta_3^{HALE\times MFrail} t_i^{HALE\times MFrail} + \\ & \delta_4^{MCI\times MFrail} t_i^{MCI\times MFrail} + c_i + u_{it} \end{aligned} \right. \tag{2}$$

where y_{it} is respondent i's outcome (we use several measures of health care use, LTC use, self-reported health, quality of life, and preferences) at time t, u_{it} is the residual, c_i stands for the individual fixed effect (netted out by within transformation of variables), t_i is the time-span variable and δ is the corresponding coefficient to be estimated. Because visits were biannual (every 6 months) and the outcomes are binary, δ represent the average biannual effect of one intervention on the probability of y_{it} (and multiplied by 100 for an interpretation as percentage points increase). Because randomization was successful (Jyväkorpi et al., 2021; Marzetti, 2018) and the two groups were perfectly comparable, our models did not control for any other (time-varying) covariates.

The model specification evolves from (1) to (2). In Equation (1), we introduce two interaction terms between time and each of the following dichotomous variables indicating whether the patient was in the MCI group or in the HALE group (t_i^{HALE} and t_i^{MCI}, respectively). In Equation (2), the interaction is extended to the frailty level, as we decompose the previous time trends among four groups: severely frail subjects in the

Table 1
Descriptive statistics.

	Severe Frailty (SPPB<8)			Moderate frailty (SPPB≥8)		
	MCI	HALE	Difference[a]	MCI	HALE	Difference[b]
Health care use (%)						
Emergency	18.37	15.61	2.76**	11.30	9.74	1.56
Hospital	7.99	8.02	−0.03	6.40	6.31	0.09
General practitioner visit	80.84	80.63	0.21	76.26	76.46	−0.20
Specialist practitioner visit	68.96	67.43	1.53	66.21	67.68	−1.47
Nurse	20.67	21.22	−0.55	15.49	17.24	−1.75
Formal care						
Extensive margin						
Homework (%)	24.44	24.56	−0.12	18.01	11.18	6.19
Paperwork (%)	22.34	24.67	−2.33	1.41	1.54	−0.13
Nurse (%)	4.89	4.88	0.01	2.50	1.89	0.60
Meals on wheels (%)	5.24	6.52	−1.28	1.14	1.05	0.09
Intensive margin among formal care users (N = 1540)						
Homework (hours/ week)	23.27	27.31	−4.04	18.01	11.82	6.19
Paperwork (hours/ week)	0.89	0.43	0.46	0.16	0.29	−0.13
Nurse (hours/ week)	2.20	1.66	0.54	0.76	1.51	−0.75
Meal on wheels (meals/ week)	4.97	7.23	−2.26	1.36	0.93	0.43
Quality of life						
Visual analogue scale (subjective health)	61.56	61.12	0.44	68.02	67.02	1.00*
EQ-5D (index)	67.13	65.56	1.57	75.85	74.22	1.63***
Risk of losing autonomy to perform activities of daily livings (ADLs) (%)	93.99	94.16	−1.68	89.57	88.51	1.06
Sense of priorities and aging (%)	84.63	86.01	−1.38	84.21	83.27	0.94
Interest in future (%)	78.16	78.51	0.35	76.02	76.41	−0.39
More afraid of sickness (%)	84.02	84.47	0.45	82.59	84.42	−1.83
Observations	1,263	1621		1,672	1253	

Notes: [a]Difference between the two subsamples of intervention group (MCI; column 2–4), [b] and nonintervention group (HALE; column 5–7). Statistical significance: 10% (*), 5% (**), 1% (***). The results of Student's *t*-test for continuous variables and $\chi 2$ test for categorical variables. Source: SPRINT-T longitudinal data.

HALE group (HALE × SFrail), severely frail subjects in the MCI group (MCI × SFrail), moderately frail subjects in the HALE group (HALE × MFrail) and moderately frail subjects in the MCI group (MCI × MFrail). We use Wald tests to assess whether the coefficients (slopes) are significantly different between the intervention and control by comparing δ_1^{HALE} vs. δ_2^{MCI} in equation (1); $\delta_1^{HALE\times SFrail}$ vs. $\delta_2^{MCI\times SFrail}$ and $\delta_3^{HALE\times MFrail}$ vs. $\delta_4^{MCI\times MFrail}$ in equation (2). Models (1) and model (2) are estimated using linear fixed effects models using cluster-adjusted standard errors (at the individual level).

2.4. Addressing attrition

A total of 1,332 subjects (i.e., 22.93% of the sample) had complete information with no missing data and participated in all waves of the study. We explored whether attrition is exogenous. Attrition in cohort data is potentially harmful since respondents who drop out of the survey because of death or other health issues may very well bias the results of the intervention. Following a methodology described in prior work (Contoyannis et al., 2004), we tested whether attrition could be considered exogenous by comparing the coefficients obtained on the unbalanced sample with those obtained on a balanced sample (no missing observations for all subjects) using a Hausman test. Significant differences between the estimates in the two samples at the 5% level were considered to provide evidence against non-exogenous attrition and thus could impact our estimates.

2.5. Sensitivity analyses

Our fixed-effect estimates focus only on transitions in our main dependent and independent variables that may neglect long-term effects. To overcome this limitation, we calculated (per individual) the number of cumulative waves in which they were exposed to frailty. We

Table 2
Impact of the intervention on health care use using fixed effect models (extensive margin).

Variable	Coefficient	t-stat	Wald test	Coefficient	t-stat	Wald-test
Emergency						
Time* HALE	0.012***	2.49	0.1429			
Time * MCI	0.003	0.55				
Time * HALE * SFrail				0.004	0.23	0.7532
Time * MCI * SFrail				0.001	0.71	
Time * HALE * MFrail				0.008*	1.79	0.3609
Time * MCI * MFrail				0.002	0.59	
Constant	0.101***	7.72		0.112***	8.21	
Hospital						
Time* HALE	0.005	1.48	0.8059			
Time * MCI	0.004	1.17				
Time * HALE * SFrail				−0.001	−0.15	0.9501
Time * MCI * SFrail				0.000	−0.04	
Time * HALE * MFrail				0.006	1.66	0.8084
Time * MCI * MFrail				0.005	1.44	
Constant	0.054***	5.59		0.060***	6.37	
General practitioners visit						
Time* HALE	−0.001	−0.12	0.8052			
Time * MCI	0.001	0.24				
Time * HALE * SFrail				−0.003	−0.52	0.7511
Time * MCI * SFrail				−0.001	−0.03	
Time * HALE * MFrail				−0.001	−0.04	0.9608
Time * MCI * MFrail				−0.001	−0.12	
Constant	0.786***	51.83		0.779***	54.82	
Specialist visit						
Time* HALE	0.025***	4.16	0.4900			
Time * MCI	0.032***	5.21				
Time * HALE * SFrail				0.025***	3.54	0.8004
Time * MCI * SFrail				0.022***	2.59	
Time * HALE * MFrail				0.022***	3.47	0.4749
Time * MCI * MFrail				0.028***	4.86	
Constant	0.572***	32.59		0.576***	34.44	
Nurse						
Time* HALE	0.007	1.58	0.2805			
Time * MCI	0.001	0.03				
Time * HALE * SFrail				0.006	1.18	0.5682
Time * MCI * SFrail				0.001	0.24	
Time * HALE * MFrail				0.005	1.07	0.3750
Time * MCI * MFrail				−0.000	−0.18	
Constant	0.169***	13.61		0.165***	14.51	
Observations	4,772			4,772		

Note: HALE: Healthy Aging Lifestyle Education; MCI: Multicomponent Intervention SFrail: Severely frail at baseline (SPPB<8); MFrail: moderately frail at baseline (SPPB≥8); Statistical significance: ***p < 0.01 **p < 0.05 *p < 0.1, Source: SPRINT-T trial (visits 1 to 7).

thus observed that 55.85% (resp. 44.15%) of our sample were frail in less than 3 waves (resp. at least 3 waves). In a sensitivity analysis, we focused on this second new subsample to retain only frequently frail elderly people, and replicated estimations from models (1) and (2). We found similar results compared to our main estimates, suggesting that the effect of the intervention did not change according to the duration of exposure to frailty (results not shown, but available upon request).

3. Results

3.1. Descriptive statistics

Table 1 shows the differences in terms of health care use, formal care consumption (for health problems), and quality of life between the MCI and HALE groups among severely frail (columns 2–4) and moderately frail (columns 5–7) older people. There were significant differences in emergency care use between MCI and HALE groups among severely frail subjects (diff = 2.79 percentage points, $p < 0.005$). The intervention seems to have increased quality of life as indicated by a higher EQ-5D-5L index (75.85 for MCI versus 74.22 for HALE, $p = 0.003$). Self-reported health (on a scale of 0–100) was also higher among initially moderately frail individuals in the MCI group (68.02) than in the HALE group (67.02), at the 10% level. There were no statistically significant differences in all other dimensions.

3.2. Impact of the MCI vs. HALE intervention

Table 2 shows that among moderately frail older people, emergency room admissions increased only for those who were in the HALE group (by a biannual average of 1.2 percentage points). Specialist care use increased significantly ($p < 0.01$): by a biannual average of 2.5 percentage points (pp) among the HALE group and by a biannual average of 3.2 pp among the MCI group. Notably, however, no significant differences in trends were found between the MCI and HALE groups for any outcome (the p-values of the Wald test were all higher than 5%). In other words, the MCI and HALE interventions had similar impacts on healthcare use.

Table 3 shows the results obtained for LTC use. The use of domestic help with work at home increased significantly in both groups (HALE and MCI), with a slightly sharper increase (though not significantly different) in the HALE group (1.2 pp biannual average increase) compared to the MCI group (0.8 pp biannual average increase). The use of domestic help for completing paperwork decreased significantly only in the HALE group (average biannual decrease = 0.4 pp). Home nurse use increased significantly only among severely frail older people in the MCI group (average biannual increase = 1.1 pp) compared to the HALE group (p-value of Wald test = 0.0548). Finally, while meals on wheels use increased significantly in the HALE and MCI groups overall, there effect was statistically significant only in the MCI group when

Table 3
Impact of the intervention on formal care consumption (extensive margin) using fixed effect models.

Variable	Coefficient	t-stat	Wald test	Coefficient	t-stat	Wald-test
Homework						
Time* HALE	0.012**	2.39	0.6012			
Time * MCI	0.008*	1.70				
Time * HALE * SFrail				0.011*	1.80	0.3295
Time * MCI * SFrail				0.020***	3.14	
Time * HALE *MFrail				0.008*	1.73	0.7943
Time * MCI * MFrail				0.010**	2.20	
Constant	0.178***	12.11		0.173***	12.00	
Paperwork						
Time* HALE	−0.004***	−2.55	0.4363			
Time * MCI	−0.002	−1.46				
Time * HALE * SFrail				−0.006***	−2.57	0.5971
Time * MCI * SFrail				−0.004**	−2.18	
Time * HALE *MFrail				−0.003**	−1.98	0.7468
Time * MCI * MFrail				−0.003**	−2.07	
Constant	0.030***	7.02		0.034***	7.25	
Nurse						
Time* HALE	0.005**	1.99				
Time * MCI	0.006***	2.71	0.6782			
Time * HALE * SFrail				0.002	0.95	**0.0548**
Time * MCI * SFrail				0.011***	3.08	
Time * HALE *MFrail				0.003	1.29	0.9312
Time * MCI * MFrail				0.003	1.52	
Constant	0.013***	1.99		0.018***	2.64	
Meals on wheels						
Time* HALE	0.006***	2.47	0.9401			
Time * MCI	0.005***	3.93				
Time * HALE * SFrail				0.005	1.54	
Time * MCI * SFrail				0.010***	3.58	0.2081
Time * HALE *MFrail				0.002	1.39	
Time * MCI * MFrail				0.006***	4.02	0.2097
Constant	0.008	1.49		0.006	1.54	
Observations	4,772			4,772		

Note: HALE: Healthy Aging Lifestyle Education; MCI: Multicomponent Intervention SFrail: Severely frail at baseline (SPPB<8); MFrail: moderately frail at baseline (SPPB≥8); Statistical significance: ***$p < 0.01$ **$p < 0.05$ *$p < 0.1$, Source: SPRINT-T trial (visits 1 to 7).

distinguishing severely frail (+1 pp biannual increase) and moderately frail (+0.6 biannual increase) older people.

To summarize, for all LTC use dimensions, the differences between the MCI and HALE groups were statistically significant only for the use of nursing care, with the MCI group having significantly greater use than the HALE group (p = 0.0548).

Table 4 shows the impact of the interventions on LTC use measured at the intensive margins (volume of care). Overall, the use of care at the intensive margin did not significantly vary over time for all participants. Moreover, there was no statistically significant difference in LTC use between the MCI and HALE groups. Yet, there was a reduction in the use of help for paperwork only among the moderately frail who received the HALE intervention ($p < 0.1$), and the use of meals on wheels significantly increased over time only among the MCI group ($p < 0.005$).

Table 5 shows the results obtained for subjective health, quality of life, and participants' preference measures. Subjective health decreased significantly (at the 10% level) among moderately and severely frail older participants who received the MCI intervention, while it did not vary in the HALE group. Quality of life (EQ-5D index) significantly decreased among all groups, showing that none of the interventions were successful in improving participants' quality of life. Participants' fears of losing their autonomy did not change over time for any group. However, participants in the MCI group (independent of their frailty status at baseline) experienced a significant change in their sense of priority ($p < 0.01$). Participants' interest in the future increased significantly in both the HALE and MCI groups, though there were no statistically significant differences between both groups (p-value of Wald test = 0.79). Finally, fear of sickness increased significantly over time in all groups ($p < 0.01$). Notably, the differences between the HALE and MCI groups were never statistically significant for all outcomes.

3.3. *Attrition tests*

The results of the Hausman tests comparing the estimates in the balanced and unbalanced samples revealed that potential non-exogenous attrition could impact the results only for the outcome "Sense of priorities and aging" (p = 0.0492). Our results thus remain robust and our conclusions are not affected by potential non-exogenous attrition for all the other outcomes.

4. Discussion

Our results provide three new findings. First, we show that despite its clinical effectiveness, the multicomponent intervention implemented in the SPRINT-T study did not reduce people's care cudeuse and did not significantly impact their quality of life, compared to the simpler intervention. Second, we show that none of the interventions (MCI or HALE) contributed to reducing the use of specialist care and domestic

Table 4
Impact of the intervention on formal care consumption (intensive margin) among formal care users using fixed effect models.

Variable	Coefficient	t-stat	Wald test	Coefficient	t-stat	Wald-test
Homework (hours/month)						
Time* HALE	3.056	1.09	0.3424			
Time * MCI	−0.241	−0.12				
Time * HALE *SFrail				3.929	1.36	0.2108
Time * MCI * SFrail				−0.326	−0.18	
Time * HALE *MFrail				2.344	1.19	0.1658
Time * MCI * MFrail				−1.572	−0.78	
Constant	15.97**	2.20		17.49***	2.89	
Paperwork (hours/month)						
Time* HALE	−0.036	−0.93	0.5303			
Time * MCI	−0.242	−0.74				
Time * HALE *SFrail				−0.077	−1.73	0.4246
Time * MCI * SFrail				−0.314	−1.07	
Time * HALE *MFrail				−0.064*	−1.83	0.3850
Time * MCI * MFrail				−0.336	−1.08	
Constant	1.033	1.49		0.414***	4.33	
Nurse (hours/month)						
Time* HALE	0.057	0.19	0.2104			
Time * MCI	1.717	1.33				
Time * HALE *SFrail				0.055	1.37	0.2622
Time * MCI * SFrail				−0.801	−0.60	
Time * HALE *MFrail				0.022	1.47	0.2684
Time * MCI * MFrail				−0.549	−0.51	
Constant	−0.894	−0.32		4.114***	3.22	
Meals on wheels (meals/month)						
Time* HALE	0.895*	1.95	0.9262			
Time * MCI	0.953**	2.22				
Time * HALE *SFrail				0.520	1.12	0.2300
Time * MCI * SFrail				1.430***	2.39	
Time * HALE *MFrail				0.313	0.86	0.3748
Time * MCI * MFrail				0.758**	2.19	
Constant	−0.065	−0.05		0.803	0.66	
Observations	1,192			1,192		

Note: HALE: Healthy Aging Lifestyle Education; MCI: Multicomponent Intervention SFrail: Severely frail at baseline (SPPB<8); MFrail: moderately frail at baseline (SPPB≥8); Statistical significance: ***$p < 0.01$ **$p < 0.05$ *$p < 0.1$, Source: SPRINT-T trial (visits 1 to 7).

Table 5
Impact of the intervention on quality of life using fixed-effect models.

Variable	Coefficient	t-stat	Wald test	Coefficient	t-stat	Wald-test
Subjective health						
Time* HALE	−0.112	−0.60	0.6952			
Time * MCI	−0.214	−1.20				
Time * HALE * SFrail				−0.128	−0.60	0.3354
Time * MCI * SFrail				−0.435*	−1.84	
Time * HALE *MFrail				−0.138	−0.07	0.2196
Time * MCI * MFrail				−0.327*	−1.87	
Constant	65.111***	120.61		65.328***	127.77	
EQ-5D						
Time* HALE	−0.010***	−4.51	0.4485			
Time * MCI	−0.008***	−3.58				
Time * HALE * SFrail				−0.010***	−4.14	0.7396
Time * MCI * SFrail				−0.009***	−3.50	
Time * HALE *MFrail				−0.007***	−3.46	0.3985
Time * MCI * MFrail				−0.004**	−2.31	
Constant	0.739***	113.40		0.732***	126.38	
Risk for losing autonomy						
Time* HALE	−0.003	−1.03	0.5208			
Time * MCI	−0.000	−0.08				
Time * HALE * SFrail				−0.001	−0.39	0.7817
Time * MCI * SFrail				0.000	0.02	
Time * HALE *MFrail				−0.005	−1.44	0.2814
Time * MCI * MFrail				0.000	0.07	
Constant	0.925***	100.36		0.923***	113.09	
Sense of priorities						
Time* HALE	0.007	1.55	**0.0713**			
Time * MCI	0.018***	4.24				
Time * HALE * SFrail				0.042	0.86	**0.0750**
Time * MCI * SFrail				0.162***	3.52	
Time * HALE *MFrail				0.005	1.09	**0.0997**
Time * MCI * MFrail				0.015***	3.70	
Constant	0.798***	62.26		0.810***	70.07	
Interest in future						
Time* HALE	0.016***	2.79	0.7901			
Time * MCI	0.014***	2.61				
Time * HALE * SFrail				0.010	1.63	0.7851
Time * MCI * SFrail				0.012**	1.99	
Time * HALE *MFrail				0.010*	1.75	0.9090
Time * MCI * MFrail				0.009*	1.80	
Constant	0.722***	45.33		0.743***	51.69	
More afraid of sickness						
Time* HALE	0.008***	1.80	0.2811			
Time * MCI	0.001***	0.19				
Time * HALE * SFrail				0.008*	1.73	0.6070
Time * MCI * SFrail				0.005	0.85	
Time * HALE *MFrail				0.006	1.46	0.3656
Time * MCI * MFrail				0.001	0.16	
Constant	0.827***	62.66		0.827***	68.86	
Observations	4,772			4,772		

Note: HALE: Healthy Aging Lifestyle Education; MCI: Multicomponent Intervention SFrail: Severely frail at baseline (SPPB<8); MFrail: moderately frail at baseline (SPPB≥8); Statistical significance: ***$p < 0.01$ **$p < 0.05$ *$p < 0.1$, Source: SPRINT-T trial (visits 1 to 7). The difference between the analysis samples and to samples reported in the regression tables (5809 vs. 4772 is essentially) is due to the fact that the fixed effect regression makes use of the first wave of the data. Subjective health (from 0 to 100), EQ-5D index; the four subsequent variables correspondent to answers to the following questions: "What do you think is the risk of losing your own autonomy to perform activities of daily living (cooking, dressing, bathing, etc.), "Would you say that aging changed your sense of priorities in life?", "Would you say that aging changed your interest in the future?" and "Are you more afraid of sickness than you were at 50 years old?".

help among participants. On the contrary, the use of caresignificantly increased over time in both groups. Third, while none of the interventions were successful in reducing the age-related quality of life losses or reducing participants' fear of sickness associated with aging, the more complex intervention (MCI) impacted older people's sense of priorities, and both interventions (MCI and HALE) increased older people's interest in the future.

These results have several policy implications. First, we show that interventions targeting older adults should not differentiate severely vs. moderately frail people because both groups tend to be similarly impacted by these interventions. Second, we show that policies aiming at reducing the economic effects of PF&S (e.g., in terms of care use) in older populations should focus on simple interventions involving training programs promoting physical exercise, at least in the short run. While multicomponent interventions can have an impact over time on specific subgroups, they do not provide significant immediate economic benefits compared to simple interventions. One potential mechanism explaining the lack of effect on resource utilization is inertia in care decisions, whereby people may not change their care use due to developed habits or care routine for which they attached value. Third, the success of interventions targeting older adults should not be measured only in terms of clinical outcomes and care use measures. Indeed, our results show that additional factors (fear of sickness, sense of priorities, interest in the future) should be considered by these interventions. Therefore, our results call for healthy aging policies that are more focused on people's interests, and they underline that priority should be given to the implementation of value-based aging policies (Rapp et Swartz 2021). This implies the need for a higher engagement of older adults during the process of informing the agenda of health technology assessment bodies and the broader public policy enterprise.

Our study has several strengths. First, our data comes from a randomized controlled trial, allowing to assess the causal effect of interventions on our outcomes. Second, we have access to longitudinal data (7 data points over a 4-year period) thus allowing to assess variations and trends in our outcomes of interest. Third, we used a wide range of outcomes, comprising health care use, long-term care use, and (subjective) health as well as preferences variables.

Our study also faces several limitations. First, even though our study includes data from 7 waves, one could argue that the impact of the intervention on our outcomes could increase in the long term. While this may be true, note that prior work showed that frailty significantly increases hospital use over a 2-year time period (Sicsic et Rapp 2019). Thus, the 4 years span in our study period may be long enough to measure an impact. Second, our results are based on RCT data, which may pose generalizability issues when comparing to real-world setting (Deaton et Cartwright 2018). Third, while our frailty indicator is based on objective medical measures, our outcomes are based on self-reported questionnaires, suggesting possible reporting biases that are difficult to measure. However, we think that the magnitude of the bias is likely limited because our estimation strategy based on fixed-effects estimations – which relies exclusively on within individual variations - corrects for time invariant differences in reporting biases between individuals and countries. As such, fixed effects estimations allow netting out possible heterogeneity due to for instance lack of understanding of the intervention, discouragement in front of multiple objectives, or lack of accessibility. Thus, our findings should not be explained by other mechanisms than the impact of the intervention. Fourth, despite we have shown that the intervention seemed to have little effect on participants' preferences, we cannot rule out that the multicomponent program simultaneously (i) improved health and (ii) made participants sensitive to the importance of preventative measures inducing more consumption of preventive care. Unfortunately, we did not collect any measures of prevention preferences to test this hypothesis. Finally, our results regarding participants' preferences (interest in the future, sense of priorities) must be taken with caution: first because no specific explanations were provided to them, and second because we did not collect information regarding psychological and emotional characteristics. Therefore, it is likely that these variables capture very heterogenous effects among participants. To summarize, theses analyses suggest that future work should include either additional cognitive/psychological modules or qualitative interviews to better investigate effects or mechanisms related to participants' perception of the intervention and changes in their preferences. Finally, one could argue that some patients may fail to comply with the intervention requirements, reducing its impact on health. However, patients enrolled in the SPRINT-T study were closely monitored by health care professionals who made sure that the goals and content of the intervention were clearly understood by all participants. Even if there was time varying heterogeneity in participants compliance to the protocol, there is no sufficient evidence supporting its systematic impact on our outcomes.

In conclusion, our results raise some questions that should be addressed in future research. First, our results could suggest that the intensity of future interventions should be tailored to older people's needs and expectations. Indeed, prior work suggests that re-ablement programs, focused on frail older people's interests, have a significant impact on their life trajectories and could be cost effective (OECD, 2020). Second, while the impact of the interventions did not differ by frailty status, it would be interested to explore in future research if interventions targeting subpopulations (poorest, less educated, isolated) who face greater risks of disability may have a greater impact. Finally, future research should explore the cost-effectiveness of the SPRINT-T interventions within those specific subgroups.

Ethical approval

The study protocol was approved by the ethics committee of the Università Cattolica del Sacro Cuore, Rome, Italy (protocol No 15611/15), and was subsequently ratified by the ethics committees of all participating institutions.

Authors statement

All authors were included in the conception, drafting, and analysis of the data of the manuscript.

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Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2023.101507.

Appendix

Table A.1
Descriptive statistics differentiated by intervention group (at base*line)*

	MCI	HALE	Difference MCI - HALE
Socio-Demographic variables			
Age (Mean)	79.66	79.78	−0.11
Male (%)	29.94	29.65	0.29
Living along (%)	29.65	29.94	0.00
Years of education	10.95	10.87	0.07
Level of incomes ($)			
[0–10,000[	22.37	21.54	−0.83
[10,000–15,000[	15.37	20.00	−4.63*
[15,000–25,000[	20.82	19.81	1.01
[25,000- + [	20.62	18.85	1.77
Health care use			
Emergency (%)	14.34	13.05	1.29
Hospitalization (%)	70.87	72.72	−1.85
Practitioner (%)	78.23	78.81	−0.58
Specialist (%)	67.39	67.54	−0.15
Nurse (%)	17.72	19.48	−1.76
Formal care use (extensive margin)			

(*continued on next page*)

Table A.1 (*continued*)

	MCI	HALE	Difference MCI - HALE
Homecare (%)	21.32	22.46	−1.14
Paper (%)	3.30	3.07	−0.23
Nurse (%)	1.55	2.69	−1.14
Meal on wheels (%)	1.74	3.26	−1.52
Quality of life			
Subjective health (0–100)	62.82	62.53	0.29
EQ-5D (%)	71.29	70.56	0.73
Risk for losing autonomy (%)	92.44	91.93	0.51
Number of observations	516	521	1037

Notes: T-test for binary variables, Prtest for binary variables. **Significance:** * p-value <10% **p-value<5% ***p-value<1%.

Source: author's calculation (SPRINTT panel data)

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