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Hybrid model of care for older persons for improvement of frailty index—a community-based interventional study in an urban setting

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Abstract

Background An older person undergoes a 'disablement' process with aging. A comprehensive geriatric assessment centered around the functional status informs the healthcare provider of their frailty status, based on which tailored interventions may be designed to help prevent/reverse frailty. This study was conducted to assess the improvement in frailty index by training older persons for self-care practices using a multi-domain behavioural intervention, assisted by their caregivers.

Methods It is a community-based interventional trial among older persons aged ≥ 60 years and their primary caregivers conducted in an urban community for a period of 15 months. A hybrid model, which exploits the advantages of every indigenous geriatric model of care, in providing a holistic care to old persons, was developed and adopted. Intervention was designed to incorporate all domains of frailty assessed, based upon self-efficacy and social interdependence theory. Frail-VIG scale and SPPB scores were used to measure the outcomes.

Results 128 older persons and their primary caregivers were recruited. Median age was 70 and 67 years in the intervention and control group respectively, with majority being males. The median frailty index at baseline was 0.36 in both the groups, with improvement in intervention group (0.20) and worsening in control group (0.44) at end-line. From the DID analysis, a reduction of 0.19 points of frailty index was observed (even after adjustment for co-variates) in the intervention group, as compared to the control group. Also, it was observed that age and gender of the old person, their per capita income and the family support played an interactive effect in improvement of the frailty index. There was a significant difference in SPPB scores as well, between the groups [5 (1) in CG vs. 7 (2) in IG, $p < 0.001$].

Conclusion Frailty could be reversed with appropriate interventions designed on the pillars of self-efficacy, and social interdependence among family members. The hybrid model of care delineates the role of caregivers, who reinforce the old persons to follow prescribed interventions.

Keywords Frailty, Older persons, Hybrid model of care, Self-care practices, Caregivers

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Introduction

An ageing population presents a plethora of new vulnerabilities, such as the old-age dependency, and reduced levels of economic and social support, accompanied by limited knowledge on their disease burden and their public health needs. A person growing old begins to accumulate deficits in various dimensions of health, and the elderly continues to *live* with these chronically 'disabling' conditions rather than *die* from them. The disablement process, as described by Verbrugge and Jette in 1994, considers 'disability' as the end-point in a disease or pathology [1].

Owing to these reasons, extrapolation of a 'disease-specific' approach of clinical medicine to an older person seeking care is regarded threatening to the sustainability of the health system rather than being of help, as ageing blurs the consistency of pathology with manifestation of a disease, primarily because of co-existing chronic morbidities and the decremental functional ability. With that respect, an old person has to be assessed in as many domains as possible with functional status at the core, which is the basis of "Comprehensive Geriatric Assessment" [2, 3].

Amongst a wide range of definitions, experts define 'frailty' under two approaches, viz., "syndromic" as defined by Fried et al. [4] and "clinical" as explained by Rockwood et al. [5]. Fried et al. defined frailty as a syndrome characterised by functional dependence (loss of strength, weight, or speed, lack of energy, or the inability to perform demanding activities). To the contrary, Rockwood et al. expressed frailty as deficit accumulation (medical, surgical, functional, social, and psychological), assessed by the 'frailty index'. A bibliometric analysis by our team on exploring domains of 'frailty' revealed that it is linked strongly with multiple domains, and these factors are to be considered during design of interventions for the older persons. Also it was understood that frailty in older persons is linked to various outcome measures, such as survival, disease severity, and progress of complications [6].

A comprehensive evaluation, with frailty as a tool [7], followed by tailored interventions in a patient-centred fashion with assistance from the caregivers shall prevent frailty, and may also reverse it. Multi-domain interventions which focus on the domains of frailty assessed, such as physical functioning, nutrition, cognition, mental status [3, 8, 9], have been devised throughout the world in concordance to the population's standards of living, culture and practices. Many studies suggest that dietary management along with training for improvement of physical functioning status, but not limited to them, is a very promising strategy for preventing or reversing frailty. The role of caregivers for assistive care and self- care practices in the elderly are very important to improve the quality of life [10] and to reduce the frailty.

The present study was conducted among the geriatric persons in an urban dwelling to assess the improvement in frailty index by training them for self-care practices using a multi-domain behavioural intervention, assisted by the caregivers.

Methods

The study was a community-based interventional trial among older persons aged 60 years or more and their primary caregivers, of either sex, in an urban community of Jodhpur district of Rajasthan, India. Older persons who had a frailty index of 0.12 or higher (pre-frail or frail) were recruited.

Sample size calculation

In a study done by *Ng Tze Pin* et al. [8] in 2015, at 12 months from baseline, it was found that 15.2% in the control group had reduction in frailty score, while it was 47.8% in the group which received a combination of all the interventions in the study. Based on these findings, the sample size for this study was calculated and 62 older persons were recruited in each group, with 15% non-response and 30% attrition, summing to a total of 124. One primary caregiver nominated by the older person him/herself was also recruited.

$$n = \frac{\left\{z1\sqrt{[2P(1-p)]} + z2\sqrt{[P1(1-P1) + P2(1-P2)]}\right\}^2}{(P1-P2)^2}$$

n = Minimum sample per group.

P1 = Probability of outcome in the control group = 15.2% = 0.152.

P2 = Probability of outcome in the intervention group = 47.8% = 0.478.

P = Pooled probability (arithmetic average of P1 and P2) = 0.315.

α = Set level of confidence = 95%

1-β = Set level of power = 80%

z1 = Z value associated with set level of = 1.96.

z2 = Z value associated with set level of β = 0.842.

In probability theory, when a discrete distribution is approximated by a continuous distribution, continuity correction is applied as an adjustment [11].

So, continuity correction (added to n for each group) = 1/(Q2*|P2-P1|) = 5.88 ~ 6.

After continuity correction, the sample size in each group is, 31 + 6 = 37.

Assuming 15% non-response rate, the sample size in each group is, 37 + 7 = 44.

Assuming 30% attrition, the sample size in each group is, 44 + 18 = 62.

Process of recruitment

Facility-based screening of the participants were done for recruitment in the study. The residences of the eligible participants were mapped. The entire geographical area was arbitrarily divided into two, by a road (considered as a natural imaginary line) adjoining the health facility, and to avoid contamination, a zone of buffer was created between the two zones, wherein the residences on the face of the road, on either sides, were excluded. The group (intervention or control) to be assigned to the participants from either of the two zones, was decided based on flipping a coin. The zone opposite the health facility was decided as the intervention group, while the one behind was the control group.

Development of the hybrid model of care for old persons

Geriatric models of care existing in practice were found to address independently one or several issues in the health care delivery system, but never all (Refer to the supplementary material for different types of model for geriatric care). Hence in practice, a model comprising components from every model of care, to address the lacunae of each other, would be better and also suiting the individual's needs. In order to set in place such a geriatric model of care, the identification of contextual issues is emphasized.

In view of this, the study adopted a hybrid model for providing care of the older persons (Fig. 1). The model exploits the advantages of every indigenous geriatric model of care, in providing a holistic care to the elderly, with emphasis on improvement of self-care practices. The model facilitates the elderly to be proactive for his/her health, supported by the caregiver and reinforced by the healthcare system, as and when required. Rather than an "one-size-fits-all" approach, the model tailored the care individually to every patient enrolled in the study, built upon the base of self-care practices and assistance by caregiver. With outpatient evaluation and care for all the elderly, a community-based approach is set up by understanding the contextual issues of the participant, and the other models of care (transition care, home-based care, and acute care model) are incorporated by tailoring to their needs. A continuum-of-care is established in the model of care, where at every level the patient is maintained in the loop of the healthcare system available.

Study tools

- Semi-structured questionnaire for socio-demographic details, general physical examination, and blood parameters.
- Frail-VIG Scale (VIG is the Catalan/Spanish abbreviation for CGA), developed by *Amblàs-Novellas J* et

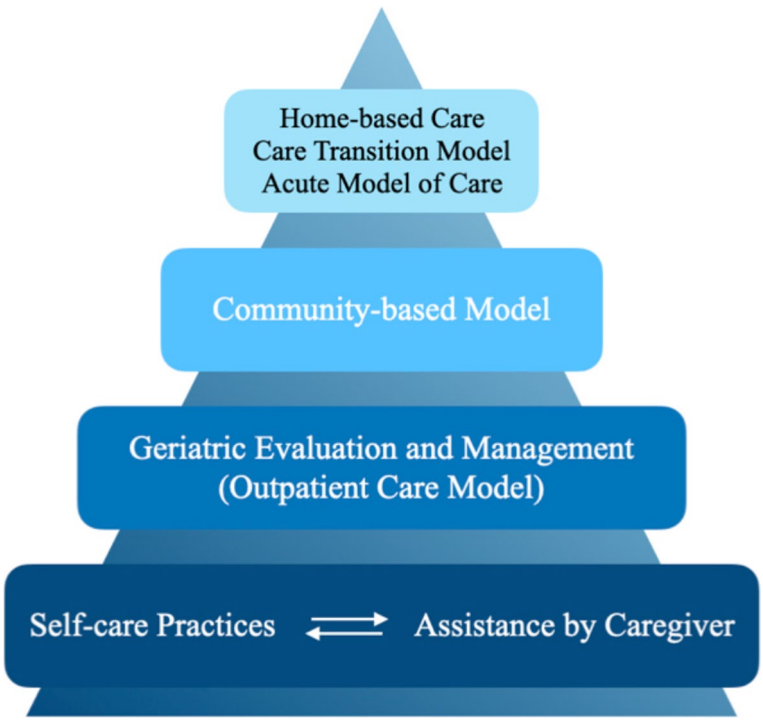


Fig. 1 Conceptualised hybrid model of care for old persons

al. [12] based on the approach of the CGA (Comprehensive Geriatric Assessment), and the methodology of Frailty Index defined by *Rockwood* et al. [13].

- *Operational definition of Frailty Index*
- The frailty index, proposed by Rockwood and associates, is expressed as a ratio of deficits present to the total number of deficits considered [13]. Current frailty indices assess frailty on a scale ranging from 0 to 1, with scores indicating 0.25 to 0.7 as frailty [12], whereas a score of 0.12 to 0.24 is considered as pre-frail [14]. A score of 0.7 is considered the cut-off to indicate the limit of homeostasis and any additional deficit would result in death [12]. When a minimum of 20 deficits are considered, Frailty index shows a consistent list at about two-third deficits that are considered [13].
- Short Physical Performance Battery (SPPB) developed by the National Institute on Ageing [15]. The tests included in the tool include a three-stage balance test (feet side-by-side, semi-tandem and tandem positions), a 5-m gait speed test (time spent to walk the length) to measure the lower extremity strength, and a five-time chair rise test to assess the functional capacity. The person is considered frail, if the total composite score is less than or equal to five out of 12 [16].

Development of Intervention

The modules of intervention were developed to incorporate all domains of frailty assessed in the study, based upon self-efficacy theory and social interdependence theory of behaviour change, reviewed from literature *(Elaborate description of the intervention module used in the present study is attached as a supplementary material).*

Statistical analysis

The data was entered in Microsoft Excel and all entries were checked again for errors. The data was analysed using R studio ver. 4.2.2, Jamovi ver.1.8.2.0 and IBM SPSS ver. 23, Inc., Chicago, IL. The data was checked for normality using Shapiro–Wilk test and found to be not normally distributed. Hence, non-parametric tests of significance were applied for the outcome variables. Quantitative variables are presented in median and interquartile range, and analysed using the Mann–Whitney-U test and Kruskal–Wallis test. Categorical variables are presented in proportions and percentages, and analysed using the Chi-square test. For the primary outcome, i.e. change in the frailty index, a difference-in-difference analyses was conducted, adjusting for the socio-demographic variables. The participants who passed away (three in intervention group, two in control group), and those who moved out of town (two in control group) even before the beginning of the intervention period were completely removed from analysis. (Fig. 2) Intention-to-treat analysis is done, as the real-time effectiveness of the intervention is desired to be studied. For two participants in the control group who expired during the intervention period, a frailty index of 0.7 was considered in the follow-up, according to the definition of frailty index. For other missing values in both the groups, imputation was done by regression method, adjusting for socio-demographic factors and baseline frailty index.

Ethical considerations

Ethical approval was obtained from Institutional Ethics Committee of AIIMS Jodhpur. The trial was registered under Clinical Trial Registry-India with registration number CTRI/2019/08/020726 (14/08/2019). All participants were informed about the objectives of the study and benefits of participating in the study. Informed consent was obtained from all the participants, before recruitment into the study. They were assured of complete confidentiality of information and were also informed about withdrawing from the study at any point of time. The intervention was delivered to the participants in the control group as well after the end of the study.

Results

A total of 128 elderly participants and their primary caregivers were recruited after initial screening for eligibility. Baseline assessment was done in the residences of the eligible participants for three months for 63 persons in the intervention group and 65 in the control group. Intervention to the participants were delivered over a period of six months, with compliance being ensured through telephonic reminders, and wherever required, the elderly in both the groups were tele-consulted and appropriate referrals were made. The follow-up assessment was done for a period of three months after the intervention period. Three in the intervention group and two older persons in the control group had expired, and two more in the control group had moved out of town even before the intervention period. So they were completely excluded from the study. Following the intervention period, follow-up assessment was done among 57 participants in the intervention group and 52 in the control group. (Fig. 2).

Socio-demographic profile of the older persons and primary caregiver

The median age of the old persons in the study was 68.5 years in the intervention group and 67 years in the control group (IQR: 65–72 years in both the groups), with the majority being males. The median monthly income of the old persons was Rs. 5000 (Rs.750-Rs.11250) in the

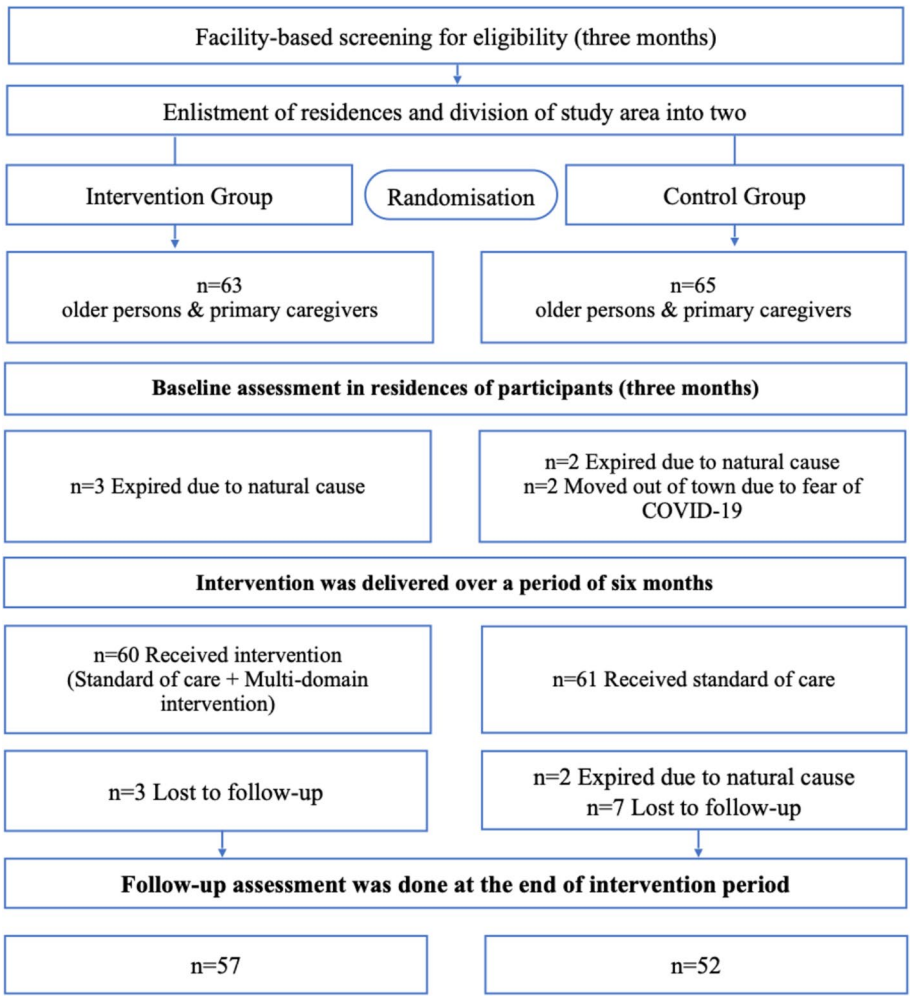


Fig. 2 Flow of participants in the study

intervention group and Rs. 1000 (Rs.750-Rs.11000) in the control group (Table 1).

The median age of the primary caregivers in the study was 40 years in both the groups (IQR: 34.3–47.3 years in intervention group and 35–45 years in control group), ranging between 18 and 73 years. The median family members was six in both the groups (IQR: 5–8 in intervention group and 5–7 in control group). The median total family income was Rs. 30,750 (Rs.20,937.5—41,000) in the intervention group and Rs. 31,000 (Rs. 21,000—41,000) (Table 2).

Frailty Index by Frail-VIG Scale

The distribution of individual variables in the Frail-VIG scale is presented in the Table 3 below. At baseline, all the variables were comparable between the groups.

At end-line, among the variables assessing IADL, there was significant difference in self-administration of medicines between groups. There were slight improvements in the other variables of the IADL in the intervention group, though the change was not statistically significant between the groups. ADL, assessed by Barthel's Index, had also improved in the intervention group, with the participants reversing to mild-moderate dependency from moderate-severe dependency, but the difference not being statistically significant from the control group. A similar result was observed in the degree of cognitive impairment between the groups at end-line.

The proportion of participants with malnutrition improved in the intervention group, with a statistically significant difference from the control group, similar to insomnia in the emotional domain. It can also be observed that the old persons in the intervention group had overcome social vulnerability, with a statistically significant difference from the control group. While the intervention helped alleviate geriatric syndromes such as falls, ulcers and dysphagia, and the severe symptoms such as pain and dyspnea among the old persons, it did

Table 1 Socio-demographic profile of the elderly

S.No.	Variables		Intervention Group [Total = 60] *n* (%)	Control Group [Total = 61] *n* (%)	χ^2value	*p* value
1	Age distribution	Young Old (60-74 years)	53 (88.3)	48 (78.7)	1.563	0.211
		Middle Old (75-84 years)	7 (11.7)	12 (19.7)		
		Oldest Old (≥85 years)	0 (0)	1 (1.6)[#]		
2	Gender	Males	36 (60.0)	32 (52.5)	0.699	0.403
		Females	24 (40.0)	29 (47.5)		
3	Religion	Hindu	42 (70.0)	43 (70.5)	0.134	0.935
		Muslim	13 (21.7)	12 (19.7)		
		Jain	5 (8.3)	6 (9.8)		
4	Marital Status	Married	53 (88.3)	55 (90.2)	0.106	0.744
		Widow/Widower/Single[¶]	7 (11.7)	6 (9.8)		
5	Education	No formal education	18 (30.0)	14 (22.9)	3.863	0.569
		Primary School	11 (18.3)	9 (14.8)		
		Middle School	4 (6.7)	8 (13.2)		
		High School	8 (13.3)	13 (21.2)		
		Intermediate/Diploma	10 (16.7)	11 (18.1)		
		Graduate and above	9 (15.0)	6 (9.8)		
6	Occupation	Housewives	23 (36.5)	29 (44.6)	6.503	0.089
		Salaried	18 (28.6)	7 (10.8)		
		Self-employed	10 (15.8)	14 (21.6)		
		Unemployed/Retired	12 (19.1)	15 (23.0)		
7	Source of Income	Dependent on caregiver	23 (36.5)	29 (44.7)	1.995	0.368
		Income from business/salary	28 (44.4)	21 (32.3)		
		Pension	12 (19.1)	15 (23.0)		
8	Enrolled in Insurance Schemes	Yes*	25 (41.7)	28 (45.9)	0.220	0.639
		No	35 (58.3)	33 (54.1)		
9	No. of older persons residing alone		9 (15.0)	16 (26.7)	2.327	0.127
10	Socio-economic status of the families	Upper Class (≥26)	1 (1.7)	0 (0)		
		Upper Middle Class (16-25)	27 (45.0)	27 (44.3)	0.515	0.772
		Lower Middle Class (11-15)	21 (35.0)	25 (40.9)		
		Upper Lower Class (5-10)	11 (18.3)	9 (14.8)		

#The maximum age of the elderly recruited in the study was 85 years. [¶]1 person in intervention group and 2 in control group were single

*Only one participant in the intervention group had enrolled in an health insurance scheme other than Bhamashah Yojana scheme

not affect the disease status of the participants, except for improvement in disorders related to the digestive system.

To assess the change in scores of frailty index, intention-to-treat analysis was done, wherein the missing values at end-line were imputed by regression method. The median frailty index at baseline was 0.36 in both the groups (IQR: 0.02 in CG, 0.08 in IG). From the Fig. 3, it can be observed that there was a statistically significant change in frailty index between groups at end-line, with improvement in the intervention group and worsening in the control group, This implies a positive effect of the hybrid model of care in the intervention group, as frailty index is also treated as a measure of effect for the model.

It was hypothesised that a comparable within-group frailty index (at end-line) among sub-groups convey the feasibility in delivery of the intervention, and an all-inclusive nature of it. From Table 4, it can be observed that the frailty index did not vary across the sub-groups of socio-demographic characteristics, such as age, gender, source of income, or the educational status of the old persons. On the other hand, a statistically significant difference in frailty index between males and females of the control group indicates faster progression of frailty among females, if not intervened.

Table 2 Socio-demographic profile of the primary caregivers

S.No.	Variables		Intervention Group [Total = 60] *n* (%)	Control Group [Total=61] *n* (%)	χ^2value	*p* value
1	Age distribution (in years)	<20	0 (0)	1 (1.7)*		
		21-40	32 (53.3)	35 (57.4)	0.057	0.811
		41-59	25 (41.7)	25 (40.9)		
		≥60	3 (5.0)	0 (0)		
2	Marital Status	Married	55 (91.7)	56 (91.8)	0.001	0.974
		Single	5 (8.3)	5 (8.2)		
3	Relationship with the elderly	Children	51 (85.0)	50 (82.0)	3.469	0.176
		Spouse/Partner	4 (6.7)	1 (1.6)		
		Others	5 (8.3)	10 (16.4)		
4	Educational status	No formal education	4 (6.7)	5 (8.2)	4.841#	0.564#
		Primary School	5 (8.3)	2 (3.3)		
		Middle School	4 (6.7)	6 (9.8)		
		High School	11 (18.3)	14 (23.0)		
		Intermediate/Diploma	11 (18.3)	13 (21.3)		
		Graduate	24 (40.0)	15 (24.6)		
		Professional Degree	1 (1.7)	6 (9.8)		
5	Occupation	Salaried	29 (48.4)	22 (36.1)	1.627#	0.653#
		Business	23 (38.3)	30 (49.1)		
		Housewives	6 (10.0)	7 (11.5)		
		Student	2 (3.3)	2 (3.3)		

*The youngest caregiver in the study was 18 years

Yates' corrected

Difference-in-difference (DID) analysis

A DID analysis was undertaken to assess the effectiveness of the interventions provided, adjusted for the socio-demographic co-variates. It is observed from the DID plot (Fig. 4) that the mean frailty index has reduced in the intervention group towards end-line, while it has increased in the control group. The mean difference between the groups at end-line was -0.202 (-0.230 to -0.175), with an effect size of -0.197 (-0.554 to -0.160).

The regression equation for difference-in-difference between groups, accounted for time is as below.

$Y_{it} = \alpha + \beta\ Group_i + \gamma\ Time_t + \delta\ (Group_i\ x\ Time_t) + \varepsilon_{it,}$

The regression equation for DID, adjusted for socio-demographic co-variates is as below.

$Y_{it} = \alpha + \beta\ Group_i + \gamma\ Time_t + \delta\ (Group_i\ x\ Time_t) + (Socio\text{-}demographic\ co\text{-}variates) + \varepsilon_{it.}$

The estimate of group and time interaction, as observed from Table 4 shows a reduction of at-least 0.19 points of frailty index in the intervention group as compared to the control group. Among the socio-demographic variables adjusted, it is observed that age and gender of the older person, their per capita income, and the family support that they receive play an important role in the improvement of frailty index. From Table 4 and 5, it can be interpreted that frailty progresses faster among females, if not intervened.

Supplementary Fig. 2 and supplementary Table 1 show the distribution of frailty index among the older persons in the study. It can be observed from the density plot that the distribution of frailty index shifted towards left in the intervention group with a majority (68.4%) reversing to mild frailty (0.26–0.35). In the control group, over the discourse of time, there was worsening of frailty in the elderly with 90.4% being moderately frail (0.36–0.55).

Studies have shown that the risk of adverse outcomes in an elderly, including hospitalisation and mortality, is higher when the frailty index is more than 0.35 [17]. Based on this observation, with 0.35 as a single point cut-off for the frailty index, the proportion of old persons in each group was ascertained at baseline and at end-line. It can be observed from Table 6 that at end-line, the proportion of old persons with frailty index < 0.35 was different with statistical significance between the groups. This emphasises the importance of establishing the continuum of care for the patients, which is a component of the hybrid model of care.

Table 7 and Fig. 5 shows the comparison of total SPPB scores between two groups, at baseline and at end-line. The median total SPPB score had increased in the

Table 3 Distribution of Individual Variables in the Frail-VIG Scale

Domain	S.No.	Variable		Description	Baseline				End-line			
					Intervention Group (*N*=60) n(%)	Control Group (*N*=61)n(%)	χ^2value	*p* value	Intervention Group (*N*=57) n(%)	Control Group (*N*=52) n(%)	χ^2value	*p* value
Functional	1	IADL	Money management	Needs help managing financial matters	15 (25.0)	11 (18.0)	0.870	0.351	11 (19.3)	9 (17.3)	0.072	0.78
	2		Telephone use	Needs help using the telephone	43 (71.7)	49 (80.3)	1.250	0.264	39 (68.4)	43 (82.7)	2.972	0.08
	3		Medications	Needs assistance in preparing or administering medications	46 (76.7)	51 (83.60	0.916	0.338	11 (19.3)	45 (86.5)	49.215	**0.001**
	4	ADL*	Barthel Index (BI)	No dependency (BI ≥95)	1 (1.7)	0 (0.0)	-	-	1 (1.7)	0 (0.0)	-	-
				Mild - moderate dependency (BI 90-65)	45 (75.0)	46 (75.4)	0.12	0.912	46 (80.7)	38 (73)	1.282	0.25
				Moderate - severe dependency (BI 60-25)	14 (23.3)	15 (24.6)			10 (17.6)	14 (26.9)		
				Absolute dependency (BI ≤20)	0 (0.0)	0 (0.0)	-	-	0 (0.0)	0 (0.0)	-	-
Nutrition	5	Malnutrition		Weight loss ≥5% in the last 6 months	33 (55.0)	32 (52.5)	0.08	0.779	8 (14.0)	36 (69.2)	34.415	**0.001**
Cognitive[#]	6	Degree of cognitive impairment		No impairment (GDS=1)	49 (81.7)	51 (83.60)	0.079	0.778	46 (80.7)	44 (84.6)	0.289	0.59
				Mild - moderate (GDS 2-5)	11 (18.3)	10 (16.4)			11 (19.3)	8 (15.4)		
				Severe - very severe (GDS ≥6)	0 (0.0)	0 (0.0)	-	-	0 (0.0)	0 (0.0)	-	-
Emotional	7	Depressive syndrome		Need for antidepressants	0 (0.0)	1 (1.5)	-	-	0 (0.0)	2 (3.1)	-	-
	8	Insomnia/anxiety		Frequent need for antipsychotics with a sedative effect	46 (73.0)	46 (75.0)	0.03	0.871	20 (35.1)	45 (69.2)	29.903	**0.001**

Table 3 (continued)

Domain	S.No.	Variable	Description	Baseline				End-line			
				Intervention Group (*N*=60) n(%)	Control Group (*N*=61)n(%)	χ^2value	*p* value	Intervention Group (*N*=57) n(%)	Control Group (*N*=52) n(%)	χ^2value	*p* value
Social	9	Social vulnerability	Healthcare professional perceives the presence of social vulnerability	21 (35.0)	24 (39.0)	0.24	0.621	12 (21)	24 (36.9)	7.746	**0.005**
Geriatric syndromes	10	Delirium	Presence of delirium and/or behaviour requiring antipsychotic drugs in the last 6 months	1 (2.0)	1 (2.0)	-	-	0 (0.0)	2 (3.8)	-	-
	11	Falls	In the last 6 months, ≥ 2 falls or hospitalisation due to a fall	24 (40.0)	33 (54.0)	2.028	0.15	3 (5.3)	18 (34.6)	15.062	**0.001**
	12	Ulcers	Presence of ulcer (pressure or vascular, any grade)	1 (1.6)	4 (6.5)	-	-	1 (1.7)	10 (19.2)	9.154	**0.002**
	13	Polypharmacy	Taking ≥ 5 drugs	59 (98.3)	58 (95.1)	-	-	51 (89.5)	52 (100.0)	-	**-**
	14	Dysphagia	While eating or drinking? Presence of aspiration or respiratory infections during the last 6 months?	35 (58.3)	35 (57.3)	0.01	0.915	9 (15.8)	42 (80.8)	46.117	**0.001**
Severe symptoms	15	Pain	Need for ≥ 2 conventional analgesics and/or strong opioids for pain control	58 (97.0)	57 (93.0)	-	-	35 (61.4)	49 (94.2)	16.579	**0.001**
	16	Dyspnea	Impeding the ability to leave house and/or opioids are frequently needed	37 (61.6)	38 (62.3)	0.018	0.89	25 (43.9)	48 (92.3)	28.856	**0.001**

Table 3 (continued)

Domain	S.No.	Variable	Description	Baseline				End-line			
				Intervention Group (*N*=60) n(%)	Control Group (*N*=61)n(%)	χ^2value	*p* value	Intervention Group (*N*=57) n(%)	Control Group (*N*=52) n(%)	χ^2value	*p* value
Diseases	17	Cancer	Active cancer on treatment	1 (1.6)	0 (0.0)	-	-	1 (1.7)	0 (0.0)	-	-
	18	Respiratory	COPD or Asthma on treatment	9 (15.0)	13 (21.3)	0.809	0.368	8 (14)	11 (21.2)	0.957	0.32
	19	Cardiac	Chronic Heart Disease on treatment	8 (13.3)	10 (16.4)	0.223	0.636	8 (14)	9 (17.3)	0.221	0.63
	20	Neurological	CVA/Paresis/Stroke on treatment	3 (5.0)	2 (3.3)	-	-	2 (3.4)	2 (3.8)	-	-
	21	Digestive	GERD/Chronic liver or bowel disorders on treatment	23 (38.3)	27 (44.3)	0.438	0.508	10 (17.5)	30 (57.7)	18.868	**0.001**
	22	Renal	Chronic renal failure on treatment	2 (3.3)	0 (0.0)	-	-	1 (1.7)	0 (0.0)	-	-

Empty boxes indicate that p value could not be computed, as there were either zeroes present or the expected frequency was less than 5 in more than at least 20% of the cells

*For ADL, chi-square is calculated by excluding no dependency and absolute dependency

#Degree of cognitive impairment was assessed using the Global Deterioration Scale

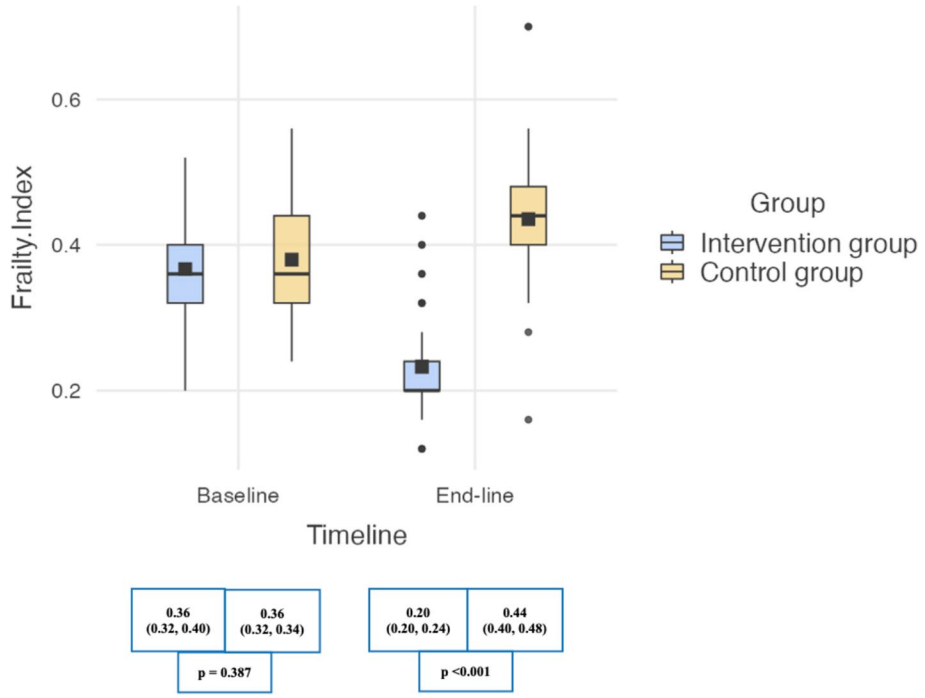


Fig. 3 Clustered box-plots showing the Frailty Index of the participants between groups at baseline and at end-line. The black squares (■) indicate the mean scores in each group. Mann–Whitney U test was applied to test for differences between the groups

Table 4 Comparability of Frailty Index across various socio-demographic variables within Groups

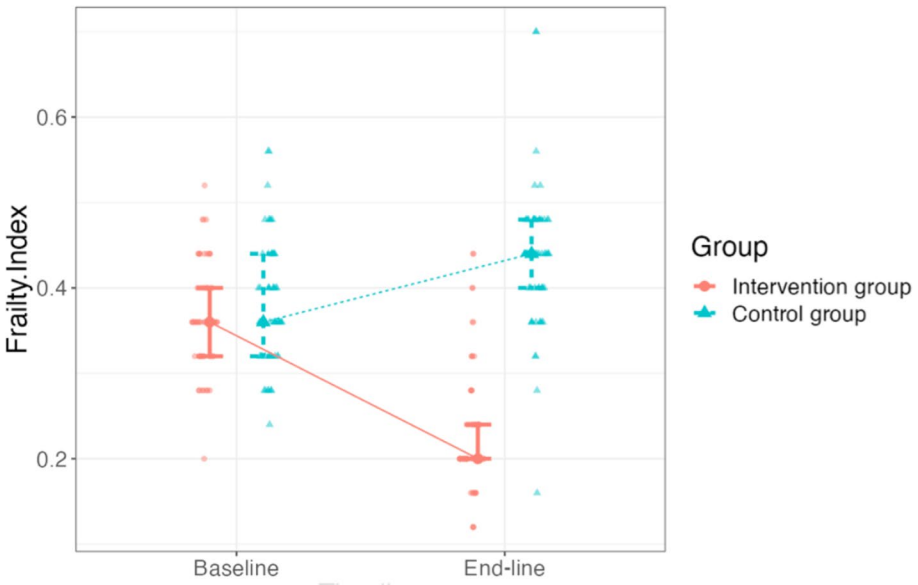
	n	Intervention Group [Median (IQR)]	*p* value	*n*	Control Group [Median (IQR)]	*p* value
Age#(in years)						
60-74	51	0.20 (0.20-0.24)	0.152	43	0.44 (0.40-0.48)	0.833
≥75	6	0.26 (0.20-0.34)		9	0.44 (0.38-0.48)	
Gender#						
Male	34	0.20 (0.20-0.24)	0.294	29	0.44 (0.36-0.44)	0.028
Female	23	0.24 (0.20-0.26)		23	0.44 (0.42-0.48)	
Source of Income#						
Salaried/Self-employed	13	0.24 (0.20-0.32)	0.175	12	0.42 (0.39-0.44)	0.155
Pension/Dependent on caregiver	44	0.20 (0.20-0.24)		40	0.44 (0.40-0.48)	
Educational Status*						
No formal education	18	0.24 (0.20-0.28)	0.912	16	0.40 (0.36-0.44)	0.271
Primary-High school	24	0.24 (0.20-0.28)		20	0.44 (0.43-0.48)	
Intermediate & above	15	0.20 (0.16-0.24)		16	0.44 (0.39-0.45)	

#Mann Whitney U test

*Kruskal-Wallis Test

intervention group at end-line, but decreased in the control group, with a statistically significant difference between the groups. As for the improvement within the intervention group, there was statistically significant increase of the score in every sub-component of the tool. The SPPB scores at end-line, signifies the effect of the hybrid model and the intervention in improvement of physical functioning among the elderly.

A composite score of ≤ 5 out of 12 in SPPB conveys that a person is frail [16]. From the Table 8, it can be observed that, towards the end-line, there are more number of participants in the intervention group who are not frail,



	Baseline		End-line	
	IG	CG	IG	CG
Mean ± SD	0.37 ± 0.06	0.38 ± 0.07	0.23 ± 0.07	0.43 ± 0.08
Mean difference (95% CI)	-0.013 (-0.036 to 0.010)		-0.202 (-0.230 to -0.175)	
Cohen's d (95% CI)	-2.639 (-3.125 to -2.1477)		-0.197 (-0.554 to 0.160)	
p value	0.280		<0.001	

Fig. 4 DID plot showing the difference in mean frailty index between two groups at baseline and end-line. The box below mentions the mean difference, effect size (Cohen's d) between two groups at both baseline and end-line

Table 5 Unadjusted and adjusted estimates for change in frailty index through DID analysis

Variables	Unadjusted			Model 1			Model 2		
	Estimate	SE	*p* value	Estimate	SE	*p* value	Estimate	SE	*p* value
(Intercept)	0.353	0.021	<0.001	0.199	0.065	0.002	0.167	0.062	0.007
Group	0.013	0.013	0.318	0.005	0.013	0.691	0.005	0.012	0.685
Timeline	-0.324	0.029	<0.001	-0.326	0.027	<0.001	-0.324	0.027	<0.001
Age				0.002	8.581×10^{-04}	0.063	0.002	8.010×10^{-04}	0.015
Sex				0.030	0.009	0.001	0.032	0.009	0.001
Family support				0.003	0.011	0.026	0.025	0.011	0.025
Per capita income				-2.581×10^{-06}	1.105×10^{-06}	0.020	-2.307×10^{-06}	1.093×10^{-06}	0.035
Marital.Status				0.013	0.011	0.263			
Religion				-0.010	0.007	0.179			
Age of caregiver				-1.277×10^{-04}	0.005	0.790			
Group:Timeline	0.190	0.018	0.001	0.190	0.017	0.001	0.190	0.175	0.001

Table 6 Frailty Status of the participants based on single point cut-off for Frailty Index

Frailty Status	Baseline				End-line			
	Intervention Group (*N*=60) *n*(%)	Control Group (*N*=61) *n*(%)	χ^2value	*p* value	Intervention Group (*N*=57) *n*(%)	Control Group (*N*=52) *n*(%)	χ^2value	*p* value
Frailty Index <0.35	20 (33.33)	17 (27.86)	0.425	0.514	51 (89.5)	4 (7.7)	72.754	0.001
Frailty Index >0.35	40 (66.67)	44 (72.13)			6 (10.5)	48 (92.3)		

Table 7 SPPB scores of the participants in the study

S.No.	Components [Median (IQR)]	Baseline			End-line		
		Intervention Group (n=60)	Control Group (n=61)	p value	Intervention Group (n=57)	Control Group (n=52)	p value
1	Balance Test	2 (2-2.5)	2 (1-2)	0.049	3 (2-3)	2 (1-2)	0.001
2	Chair Rise Test	2 (1-2)	2 (1-2)	0.178	2 (2-3)	1 (1-2)	0.001
3	5m Gait Speed Test	2 (1-2)	2 (1-2)	0.831	2 (2-3)	2 (1-2)	0.001
4	Total SPPB score	5 (5-6)	5 (4-6)	0.768	7 (6-8)	5 (4-5)	0.001

Mann Whitney U test

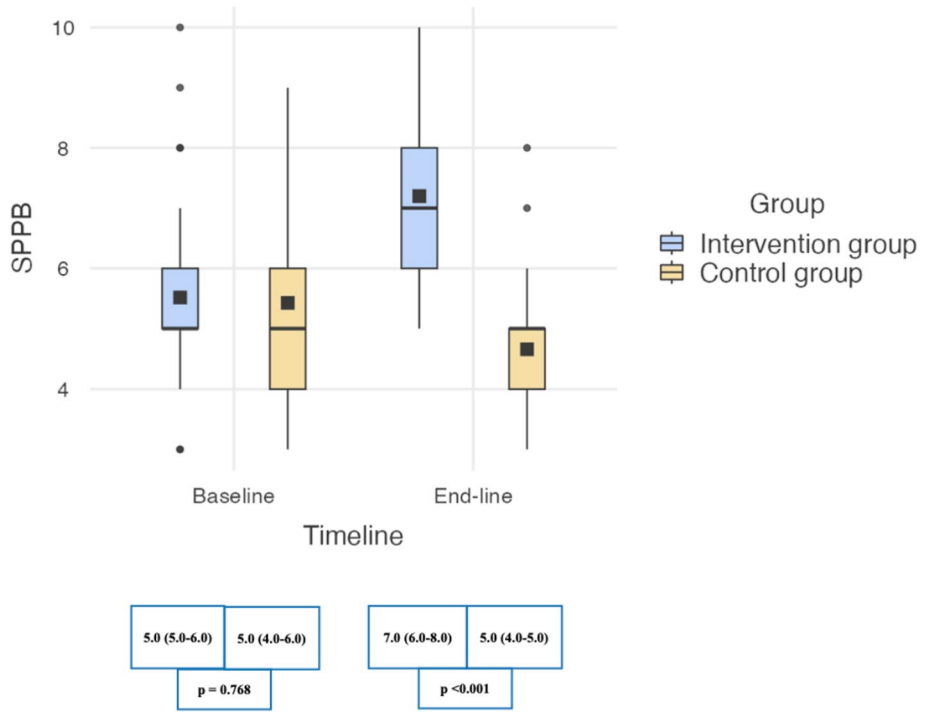


Fig. 5 Clustered box-plots showing the Frailty Index of the participants between groups at baseline and at end-line. The black squares (■) indicate the mean scores in each group. Mann–Whitney U test was applied to test for differences between the groups

Table 8 Frailty Status of participants based on SPPB Score

Frailty Status	Baseline				End-line			
	Intervention Group (*N*=60) *n*(%)	Control Group (*N*=61) *n*(%)	χ^2value	*p* value	Intervention Group (*N*=57) *n*(%)	Control Group (*N*=52) *n*(%)	χ^2value	*p* value
Frail (≤5/12)	32 (53.3)	31 (50.8)	0.076	0.782	9 (15.8)	43 (82.7)	48.788	0.001
Not Frail (>5/12)	28 (46.7)	30 (49.2)			48 (84.2)	9 (17.3)		

whereas the number of non-frail persons in the control group has decreased, when compared with the baseline.

Discussion

The community-based trial conducted over a period of fifteen months has demonstrated that a comprehensive geriatric assessment followed by a behavioural multi-domain intervention to improve self-care practices, improves their frailty. The intervention has also shown to shift the distribution of frailty status among participants in the intervention group towards lower levels of frailty, with also a significant decrease in median score of frailty index, after adjusting for the socio-demographic co-variates.

The median age of the participants in the present study was lesser than most of the other studies in the literature, the probable reason being the difference in definition of older persons in India, allowing recruitment of persons aged even 60 years or more. The study highlights the poor coverage of health insurance among the older population, which also is reflected at the national level, as mentioned in the report of the *Longitudinal Aging Study of India (LASI)* Wave I [18]. Only one out of 128 participants had enrolled in a health insurance scheme other than the *Bhamashah Yojana* (an initiative of the Government of Rajasthan).

Assessment of physical, psychological and social functioning in an individual, which the Frail-VIG scale incorporates in a shell, is considered as a proxy evaluation for health-related quality of life [10]. The median frailty index in the present study had improved in the intervention group towards end-line. The findings are similar to other studies [3, 8, 19, 20], which evaluated the effects of various multi-domain interventions in improvement of frailty index among older persons, though these studies evaluated the outcome on different scales of frailty index (CHS Scale [8] and Fried Frailty Phenotype [3, 19, 20]. It is also noticed that almost all studies that evaluate the frailty index among old persons, include physical exercise and nutritional education as a part of their intervention, along with other domains such as cognition [8], problem solving therapy [21], medication review and psychosocial consultation [19]. Some studies have evaluated only the role of physical exercise [22, 23] and nutrition [24] on frailty. Whatever be the intervention, the results of these studies are similar to the findings of the present study, implying the importance of behavioural interventions in the improvement of frailty and also its role in prevention of deterioration of intrinsic capacity of the elderly.

Upon analysis of individual variables in the Frail-VIG scale, it was found that certain variables had no significant change from the control group, at end-line. But in the intervention group, there was evident reduction in the proportion of individuals experiencing symptoms related to chronic diseases such as insomnia, falls, ulcers, dysphagia, dyspnea and pain, which also had led to reduction in polypharmacy among older persons in the intervention group. The rate of falls in the past six months decreased in the intervention group with a statistically significant difference from the control group, similar to the findings of Arrieta Haritz et al. [22], but such a difference was not appreciated in the studies by other authors [8, 25, 26].

Dependency for ADL was assessed by Barthel Index, which showed no significant difference from control group at end-line, in concordance with those of other studies [21, 22, 27–29]. While the intervention significantly improved the functional performance of the individuals, as is evident from the improvement of the SPPB scores, it had limited effect on the ADL as majority of the participants in both the groups of the present study had only mild dependency at baseline, for which the intervention could have exhibited a saturation (ceiling effect). A similar effect was also observed in the cognitive status of the participants, wherein the majority had no impairment at end-line. There was improvement in the malnutrition status of the participants in the intervention group towards end-line, with a statistically significant difference from the control group. This was in line with the findings of other studies [19, 24, 26], which emphasise the importance of including nutritional education in the improvement of frailty among older persons. The nutritional education in the present study, despite improving the malnutrition status, has also significantly improved

the status for the diseases of the gastrointestinal tract (GERD, bowel disorders) among the participants.

The effect of interventions on the participants who received it, was uniform across socio-demographic characteristics, implying the all-inclusive, far-reaching nature of the intervention, and feasibility of applying and replicating them in the field (elaborate description of intervention is provided in the supplementary material). From the analysis of the control group, it was also highlighted that females progressed faster to higher levels of frailty, if not intervened, though other characteristics did not show significance. A study by Kerminen et al. [17] showed that frailty index above 0.35 increased the risk of adverse outcomes in an elderly, including hospitalisation and mortality. When the participants in the study were analysed based on this observation, with 0.35 as a single point cut-off for the frailty index, it was observed that the intervention had significantly increased the proportion of participants with frailty index < 0.35, with a statistically significant difference from the control group.

Of late, SPPB is considered as a proxy for indirect measure of physical frailty. The studies whichever had this measure as an outcome, assessed the effect of a physical activity programme (stand-alone or in combination with other disciplines) in their studies. In the present study, the median scores of SPPB in the intervention group increased at end-line, with a statistically significant difference from the control group. These findings are parallel to the findings by Romera-Liebana L et al. [30], who also had tried a multidisciplinary intervention involving nutritional supplement, cognitive workshops and medication review along with physical exercise. Also, studies which had considered only physical exercise and nutritional interventions [31–34], showed similar results to the present study.

The study by Drey M et al. [31], which was a three-arm trial involving two types of physical training compared with a control group, concluded that any type of physical exercise could improve the physical function of an old person. Some studies [34, 35] had utilised the caregivers of the older persons in delivering the interventions, and had shown significant results concordant to the present study.

Impact of the Hybrid Model of Care on Outcomes of the Study

The hybrid model of care in the study was conceptualised to bridge the lacunae in existing indigenous models of care. For this purpose, improvement of the self-care practices in the elderly assisted by the caregiver was considered the base, upon which the other models are placed upon. In this regard, improvement of the outcome measures (frailty index, SPPB score), implicitly reinforces the effect of the hybrid model through the multi-domain intervention delivered. A promotive interaction, as explained in the social interdependence theory, is established by use of the hybrid model, where the improvement of self-care practices had led to improvement of frailty index among the old persons.

Geriatric evaluation on the basis of CGA is done at an outpatient setting using frailty index, comprising various domains as used in the present study. With such a model of healthcare trying to establish a continuum-of-care, healthcare utilisation among the elderly could also be maintained, even at unforeseen disruption of services, such as the COVID-19 pandemic. As the participants in the intervention group were reinforced at regular intervals, and with improvement of self-care practices by informed decisions, it was noted that the loss-to-follow-up was limited to only three in the intervention group, while it was seven in the control group.

Though the model could not be formally evaluated in the present study, with use of measurement tools inclined to the theoretical constructs of the model, it can be indicated that the model is effective in improving the frailty among community-dwelling old persons, with emphasis on improvement of self- care practices assisted by caregiver and a continuum-of-care established with the healthcare system.

The impact of the hybrid model of care on the basis of the behavioural theories considered for the present study is explained below.

> Self-efficacy theory—Proposed by Bandura (1977), this theory is an important aspect of human motivation and is referred to "people's judgments about their capability to perform tasks". With increase in self-efficacy, the effort and persistence towards challenging tasks also increases, such that the likelihood for completion of the task is enhanced. The elements of the theory are as follows:
>
> • Performance outcomes—The most important source of self-efficacy is the past experience of an outcome. It shapes the ability of an individual to perform the task.
>
> • Vicarious experiences—Influence of performance by a person in a similar position, is next only to one's own lived experience. Self-efficacy improves when people watch someone similar to them able to perform the task.
>
> • Verbal persuasion—The words of encouragement by a credible source directly effects the ability of an individual to perform.
>
> • Physiological feedback (emotional arousal)—The belief of self-efficacy is strengthened by the response of sensations from one's own body and their perception to it.

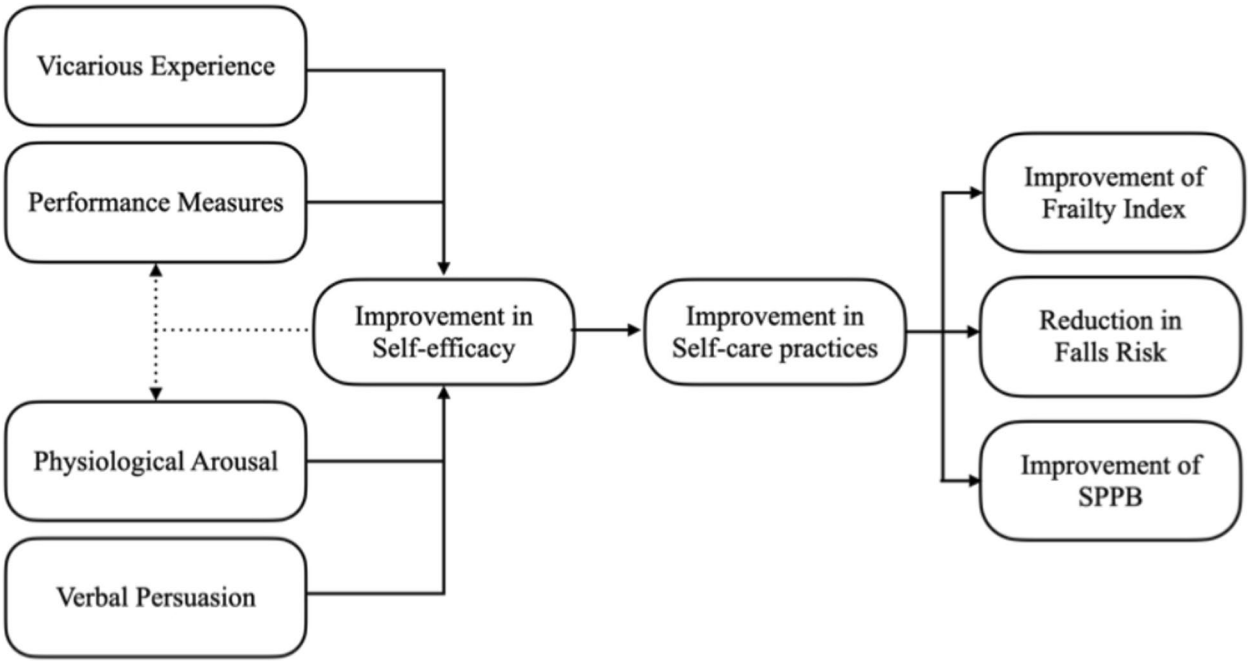


Fig. 6 Schematic representation of self-efficacy theory in the present study

Use of the theory in the present study (Fig. 6)

With improvement of self-efficacy of the old persons, an improvement in the self-care practices were observed. In order to establish a vicarious experience for the old persons in the study, the module for physical exercise was developed with an expert of Yoga and Aerobics, who by himself was an old person. A separate note for the primary caregivers on the ways in which they can verbally persuade the old persons in practicing the interventions was included. These, in turn, improved the performance measures of the old persons and thereby arousing, a sense of satisfaction (physiological feedback).

Social Interdependence Theory

The theory posits that the improvement is better in the essence of a group, interdependent on each other. Kurt Lewin conceptualised two types of social interdependence—positive and negative. Positive interdependence (cooperation) helps an individual attain his/her goals, supported by the other members of the group, while a negative interdependence (competition) exists when individuals discern achievement of their goals linked to failure of other group members. Three psychological processes are involved in the theory of interdependence: substitutability (defined as "the degree to which actions of one person substitute for the actions of another person"), cathexis (defined as "investment of psychological energy in objects outside of oneself, such as friends, family, and work"), and inducibility ("openness to being influenced and being influenced"). Based on the three psychological processes, positive interdependence leads to promotive interaction, wherein the individual is encouraged and facilitated of his efforts to complete the tasks.

Use of the theory in the present study (Fig. 7)

The positive interdependence can be applied for the caregivers in the family who work towards supporting the old persons in improvement of their frailty index. Though the study identifies only one primary caregiver nominated by the old person, the delivery of intervention utilising this theory, establishes a positive interdependence among all family members, which in turn also led to decrease in the burden or stress perceived by the primary caregiver, and also improve the health of the old person.

It is proven that self-efficacy and social support has a direct correlation with frailty, and also in social participation [36]. Social participation, in a loop, further enhances the self-efficacy of the old person through vicarious feedback. The role of increased self-efficacy in reduction of falls risk and frailty is also described in the literature [37]. Furthermore, considering self-efficacy and social support in design of multi-domain interventions is proven to improve adherence of the older persons to care programs [38].

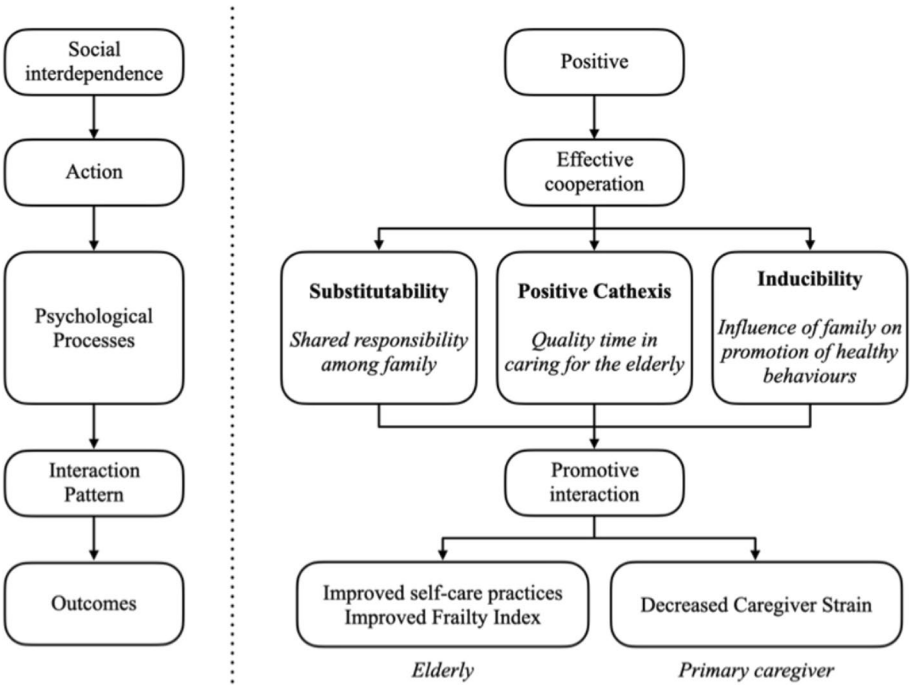


Fig. 7 Schematic representation of social interdependence theory in the present study

Strengths, limitations and challenges

The study helped devise the hybrid model of care in facilitating healthy ageing. This has helped improve self-care practices in the elderly, leading to improvement of frailty index. The intervention module developed for the study was found to have uniform effect across all socio-demographic variables, implying that it is replicable in all settings. The variables of the primary outcome measure (Frailty Index) are partly self-reported, which could have led to bias in the study. But, inclusion of a performance-based measure (SPPB) as an adjunct to the primary outcome, helps partially overcome such biases. In-person delivery of intervention could not be done, keeping in mind the safety of the older participants in the study during the pandemic. But, throughout the study period, adherence to the interventions was ensured by reinforcement and reminders at constant intervals through mobile SMS reminders and telephonic calls, tele-consultations and appropriate referral (for both groups), if required.

Conclusion

The results optimistically convey that frailty could be reversed with appropriate interventions designed on the pillars of self-efficacy of the old person and social interdependence among family members. The hybrid model of care delineates the role of caregivers, who reinforce the old persons to follow the interventions prescribed. These findings reinforce the fact that frailty should be viewed as the basis of providing care, rather than considering it as an unavoidable course to death. The findings support the multifactorial causation of frailty, and with improvement of even reversible conditions such as malnutrition, falls, polypharmacy, frailty status is proven to improve. Frailty should be considered as a vital determinant for health-related quality of life in the old persons, considering the certitude that frailty is both preventable and reversible, if diagnosed early.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12877-024-05351-0.

Supplementary Material 1.

Supplementary Material 2.

Authors' contributions

PB—Conceptualisation of idea, methodology, Data collection, investigation, formal analysis, visualisation and software, writing—original draft. PR—Conceptualisation of idea, methodology, Writing—review and editing, supervision, resources. NKHS—Writing—review and editing, supervision, resources All authors reviewed the manuscript.

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Availability of data and material
The datasets used and/or analysed during the current study will be made available from the corresponding author on reasonable request.

Ethics approval and consent to participate
Ethical approval was obtained from Institutional Ethics Committee of AIIMS Jodhpur. The trial was registered under Clinical Trial Registry-India with registration number CTRI/2019/08/020726 (14/08/2019). Informed consent was obtained from all the participants, before recruitment into the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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