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Association between intrinsic capacities limitations and annual healthcare costs in Nursing Home residents

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Abstract

Background The aim of this study is to analyse the associations of annual Intrinsic Capacities (IC) impairment evolution with the annual cost of care in Nursing Home (NH) residents. This was a prospective, longitudinal and multicenter study. NH residents in the Occitanie region (south of France), 60 years and older with moderate level of dependency were included in the study and were followed during 12 months.

Methods IC was assessed for four of the six IC domains (Cognitive, locomotion, vitality and psychological). Longitudinal IC impairment trajectories of residents were built using the K-means Longitudinal method. Costs were assessed from the healthcare payer's perspective and include direct medical and non-medical costs. Descriptive analyses of costs and characteristics as well as general linear models were carried out.

Results Three hundred forty-five residents (86 years old on average and mostly women) were included. Mild, moderate and severe impairment profiles were clustered. For the cognitive domain, we observe a total cost decrease of 1552€ between the most severe impairment profile and the less severe profile, led by medication costs. For the locomotion, psychological and vitality domains we observed a total cost increase of 1,672€, 3,869 € and 1,709€ for the most severe impairment profile in comparison with the less severe profile, respectively. This cost increase was driven by hospitalisation for the psychological and the vitality domains and by physiotherapist costs for the locomotion domain. Medication costs decrease with the severity of impairment whatever the IC domain considered.

Conclusions Our study is the first aiming to estimate the association between impairment on IC domains and healthcare costs in NH. The implementation of clusterization highlight resident's profiles using data driven process, which may facilitate the implementation of personalized health strategies**.**

Keywords Intrinsic capacities, Nursing home, Care costs

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Introduction

The"World report on ageing and health" of the World Health Organization (WHO) defines healthy aging as "developing and maintaining functional abilities that promote well-being defined by key intrinsic capacity (IC) domains" [1]. The concept of IC relates to the reserve of physical and mental capacities on which an individual can rely. The Integrated Care for Older PEople (ICOPE) program designed by the WHO aims to early screen for loss in IC in primary care settings using several tools that allow the design of specific tailored interventions [2].

The ICOPE program comprises 5 steps from screening (Step1) and in-depth assessments (Step2) to the support of caregivers [3].

Care management of older people have a huge impact on healthcare costs and some parameters such as frailty or other health conditions increase this cost. Frailty increased mean annual healthcare costs in community-dwelling older adults in France in 2012 by €1500 [4]. Studies conducted in nursing home (NH) showed that pneumonia, but not frailty, increase healthcare costs of NH residents from 60 to 90% [5]. A study conducted in pre-frail older people showed that baseline and persistent deficit of some IC domains were associated with increased healthcare costs from 27 to 58% [6]. While a study showed that a deficit on locomotion domain was associated to a higher risk of pneumonia onset in NH residents, no study has assessed the impact of IC deficit on healthcare costs in NH residents [7]. Similarly, how pneumonia and IC loss interact to determine healthcare costs of NH residents is still unknown. Accurate knowledge about cost of particular conditions, such as IC, will help prioritize healthcare policies and interventions to allocate healthcare resources in accordance with budget constraints [8].

Material and methods

The aim of this study is to analyse the associations of annual IC impairment evolution with the annual cost of care in NH residents.

Setting and population

This study used data from the INCUR study (Incidence of Pneumonia and Related Consequences in Resident); a 1-year prospective, observational and multicenter study [9]. NH residents, 60 years and older and who had a group iso-resource (GIR is the French's scale used for funding of disability ranging from 1, totally disabled to 6, independent) score ranging from 2 to 5 were recruited included in the study in 2012, and followed during 12 months. Moreover, to be included in this study, patients must have healthcare consumption available in the French healthcare insurance database and have either complete or partially available IC measures.

Intrinsic capacity domains

Four of the six domains of intrinsic capacity (mobility, mood, vitality/nutrition, and cognition) were assessed at baseline, 6 months, and 12 months. However, the sensory domain (vision and hearing) was only evaluated at baseline, preventing the assessment of its trajectory over the one-year follow-up period. IC domains were assessed using tools and cut-points described in the ICOPE guidelines [10]:

- Locomotion was assessed using the Short Physical Performance Battery (SPPB) test. SPPB score varies from 0 to 12. The threshold to define a locomotion capacity limitation is ≤ 7 [11].
- Cognition was assessed using the French adaptation of the Abbreviated Mental Test Score (AMTS). AMTS score varies from 0 to 10. The threshold to define a cognition capacity limitation is ≤ 6 [12].
- Psychological capacity was assessed using the 10-item Geriatric Depression Scale (GDS- 10) which is the short version of the GDS. This score varies from 0 to 10. Depressive symptoms were considered clinically significant if the score is ≥ 3 [13].
- Vitality was assessed using the Short-Form Mini-Nutritional Assessment (MNA-SF). The MNA-SF score varies from 0 to 14. The threshold to define a poor vitality capacity is ≤ 11, reflecting malnutrition in older people [14].

Costs estimates

Resource consumption was retrospectively gathered from the database of the French Social Health Insurance (FSHI) [5]. Clinical data, collected in the INCUR study and resource consumption gathered in the FSHI database were merge using patient's name, surname, birthdate, place of residence and sex. Economic analysis was conducted from the healthcare payer's perspective and direct medical and non-medical costs were included in this study. Direct costs were hospitalization costs, outpatient costs (ie, visits and medical acts [imaging, and other preventive exams, diagnostic exams and curative acts], paramedical acts [nurse, physiotherapist, speech therapist]), medications, and medical equipment costs. Non-medical costs included transportation costs. Inpatient stays were valued using the French disease-related groups. Outpatient care, medication, medical devices and transportation were valued using tariffs reimbursed by the FSHI. Then we applied the corresponding individual reimbursement rate and we subtracted, if necessary, the medical deductible that is due by the patient and not reimbursed by the FSHI. Costs were recorded during a one-year period and inflated in € 2021.

Covariates

Sociodemographic data (i.e., age, sex, marital status, and education), medical conditions and history, and dependency (i.e. Activity of Daily Living according to Katz scale) were recorded at baseline [15]. Pneumonia events were collected longitudinally and reported at baseline, 6 and

12 months based on the OriG criteria (i.e. 1) Presence of at least 2 of the following symptoms: a) Worsening or onset of cough, purulent sputum, or specific signs at the auscultation, b) Fever (≥ 38 °C), c) Thoracic pain, d) High respiratory rate (≥ 25 breaths per minute), e) Mental confusion or worsening of physical disability, and 2) Clinical evidence documented by a physician of crackles at the thoracic auscultation) that are adapted from criteria proposed by Mc Geer et al. for use in NH population [16, 17]. Comorbidities were classified using the Charlson Comorbidity Index (CCI), that is adapted to predict cost of care, using medical conditions available in the INCUR database [18, 19]. Finally, polypharmacy defined as the intake of ≥ 5 drugs/day [9].

Statistical analyses

We used a longitudinal trajectory clustering method to group similar trajectories of the IC impairment evolution as in the paper of Salinas-Rodriguez et al [20]. K-means Longitudinal (KmL) method, a hill climbing clustering algorithm, was used to investigate longitudinal trajectories of IC scores during the one-year follow-up period. These trajectories were partitioned into k sets while minimizing the distance between trajectories within each partition using the Euclidean distance. The selection of the optimal number of clusters for each IC domain was based upon a combination of various quality criteria: the Calinski and Harabasz score (CH), the Bayes Information Criteria (BIC), and the Akaike Information Criteria (AIC). Trajectories with one or two missing data were imputed using the CopyMean method.

Baseline characteristics of the whole population and of each cluster for each domain are presented in percentages and means (standard deviation) as appropriate. Chi square tests and Mann Whitney non-parametric tests were used to compare characteristics between clusters. Annual cost of care was analyzed using mean and Bias-Corrected and accelerated bootstrap 95% Confidence Intervals (CI). Mann Whitney non-parametric test was used to compare costs between clusters for each IC domain.

Generalized Linear Model (GLM) with a gamma distribution and a log link function were used to examine the associations of IC impairment evolution with cost of care [21]. The predictor of interest was the 4 IC domains, but other clinical and demographic covariates were also included.

Statistical analyses were implemented using the R software, version 4.1.1.

Results

Among the 800 NH residents initially enrolled in the INCUR study, 345 residents have economic data available in the Healthcare insurance database. Among them, 247 residents had complete longitudinal trajectories; missing data were imputed for 98 residents.

Mean age of the 345 NH residents was 85.91 years (etable1—Appendix1) and are most women (77%). A large proportion presented a deficit of IC vitality domain at baseline (77%), while 38% presented a deficit of IC psychological domain at baseline. Finally, 19% of NH residents experienced a pneumonia episode during the 1-year follow-up period.

We observed three profiles of IC impairment for each domain (Fig. 1).

Group 1 is composed of individuals for whom no deficit is observed at baseline and no degradation or little degradation is observed during the follow-up. Group 2 is composed of individuals for whom a low impairment at baseline is observed for all domains and the impairment remain stable for psychological and vitality domains or deteriorate through time for the locomotion domain: when SPPB variates more than 3 points respect basal and for the cognitive domain: when AMTS variates more than two points respect basal. Group 3 is composed of individuals for whom a severe impairment is observed at baseline and no improvement is observed during the follow-up. Characteristics of residents in each cluster are presented in Table1.

Figure 2 presents the total cost of care according to each group for the four IC domains.

For the cognitive domain, we observed a decrease of annual total cost for the group 3 in comparison with the group 1 and 2 ($p = 0.07$ when compared with group 1). For the three others IC domains, we observe a cost increase with the severity of impairment pattern.

Table 2 summarizes the differential costs for according to impairment clusters. Whatever the IC domain considered and the severity impairment profile, hospital costs represent the large part of costs accounting for 42% to 63% of total costs, followed by medication costs. We observe a cost decrease of medication according to clusters. Indeed, they accounted from 21 to 27% of total cost in group 1, while they accounted from 11 to 19% in group 3.

For the cognitive domain, cost decrease between groups 2 and 3 and group 1 is mainly led by medication and medical device accounting for 40% and 45% of total cost difference, respectively ($p \leq 0.05$). This decrease is also lead by transportation that account for 21% and 26% of total cost difference respectively ($p \leq 0.05$ between groups 3 and 1). For the locomotion domain, cost increase between group 3 and 1 is mainly led by paramedic care that account for 37% of total cost difference ($p \leq 0.05$), followed by hospitalization costs that account for 35% of total cost difference. We observed a cost decrease between group 2 and 1 around €627

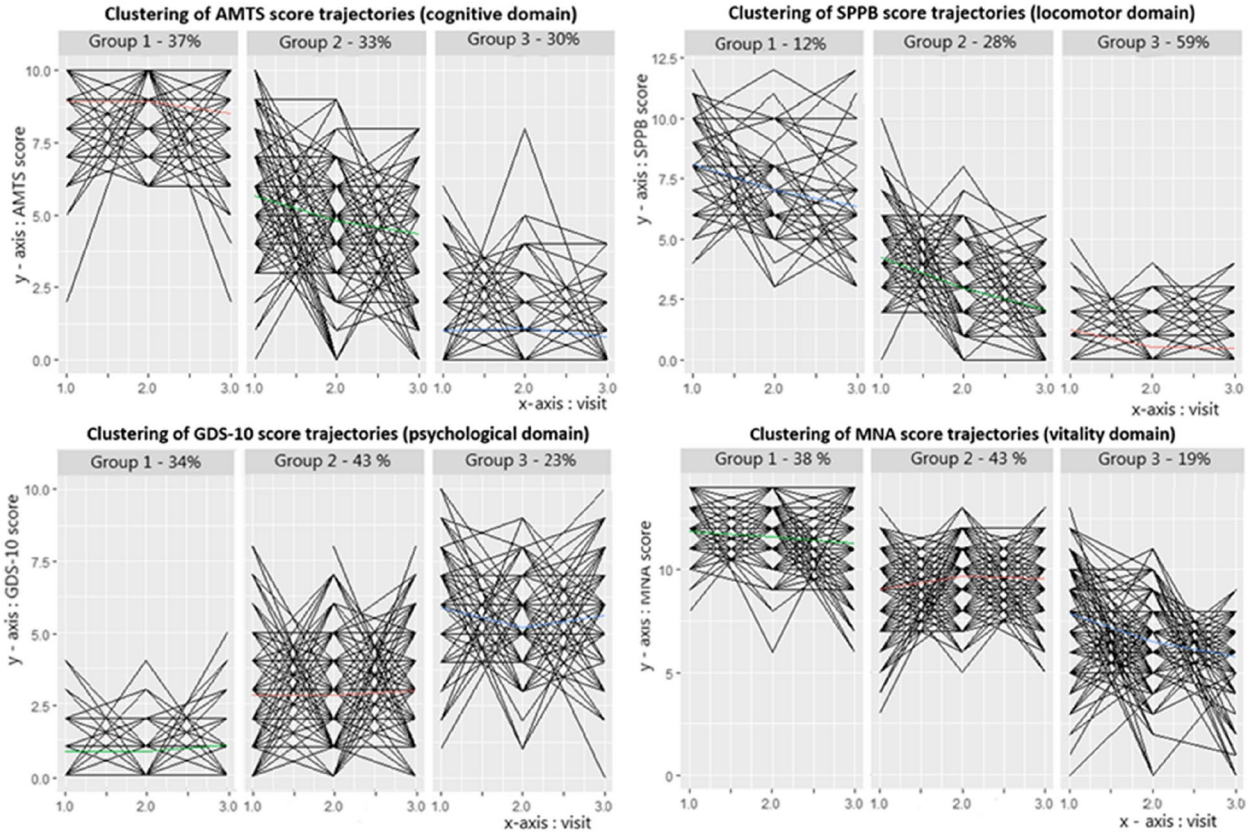

Fig. 1 Clustering of intrinsic capacities impairment. AMTS: Abbreviated Mental test Score; SPPB: Short Physical Performance Battery; GDS- 10: Geriatric Depression Scale; MNA: Mini Nutritional Assessment

that is mainly led by hospital cost. For the psychological domain, cost increase between group 3 and groups 1 and 2 is mainly led by hospitalization costs that account for around 71% of total cost difference. Difference between group 2 and 1 is then explained by consultation costs that explain 15% of total cost increase ($p \leq 0.05$) while difference between group 3 and 1 is then explained by transportation accounting for 13% of total cost difference ($p \leq 0.05$). For the vitality domain, cost increase between groups 2 and 3 and group 1 is mainly led by hospitalization costs.

Results on costs predictors are summarized in the Table 3. Whatever the model considered, moderate or severe impairment evolution (Group 2 and 3) on cognitive and locomotion domain have no statistically significant impact on total annual cost of care. For the psychological capacity domain, group 3 presents a cost increase of 60% ($p = 0.01$) in comparison with group 1 in the unadjusted model while no effect is observed in other models. For the vitality capacity domain, group 2 presents a cost increase of 38% in the unadjusted model ($p = 0.02$) in comparison with group 1. There is a trend of increasing costs from 32 to 35% for group 2 in models 1 and 3 for the vitality domain in comparison with group 1 ($p < 0.1$). Finally, pneumonia increase costs by 75% ($p = 0.06$) and polypharmacy by 68% when model 3 is considered.

Discussion

For the cognitive domain, annual costs decrease with the severity of impairment profile. For the three others IC domains, cost increase with the severity of impairment, particularly for the psychological domain. This study is the first estimating the association between IC and healthcare costs in NH residents. We only identified an article that estimate association between healthcare costs and deficit on IC domain in community-dwelling older adults [6]. That study found that annual moderate and severe impairment evolution (Groups 2 and 3) of the locomotion and psychological domains increase healthcare costs. This is consistent with our results because we found a significant increase of annual healthcare costs for group 3 profile in comparison with the two others groups for the locomotion and the psychological domains.

Mobility impairment may lead to falls and fractures that are the main reason for hospitalization in NH residents

Table 1 Characteristics of residents by groups in each IC domain impairment profile

	Cognitive domain					Locomotion domain					Psychological domain					Vitality domain				
Baseline characteristics	**Group 1**	**Group 2**		**Group 3**		**Group 1**	**Group 2**		**Group 3**		**Group 1**	**Group 2**		**Group 3**		**Group 1**	**Group 2**		**Group 3**	
N	**129**	**103**		**62**		**27**	**63**		**204**		**84**	**157**		**53**		**120**	**129**		**45**	
Sex (N, %)			***p* = 0.02**		***p* = 0.006**			$p = 0.11$		$p = 0.45$			$p = 0.92$		$p = 0.71$			$p = 0.22$		$p = 0.23$
Female	87 (67%)	84 (82%)		54 (87%)		18 (67%)	53 (84%)		154 (75%)		63 (75%)	120 (76%)		42 (79%)		86 (72%)	102 (79%)		37 (82%)	
Male	42 (33%)	19 (18%)		8 (13%)		9 (33%)	10 (16%)		50 (25%)		21 (25%)	37 (24%)		11 (21%)		34 (28%)	27 (21%)		8 (18%)	
Age, mean (SD)	85.1 (7.76)	86.3 (6.77)	$p = 0.46$	86.9 (7.23)	$p = 0.25$	81 (7.70)	85.98 (6.67)	***p* = 0.002**	86.54 (7.26)	***p* < 0.001**	84.80 (8.27)	86.35 (7.31)	$p = 0.33$	86.30 (5.52)	$p = 0.57$	85.47 (7.05)	85.31 (7.33)	$p = 0.73$	88.81 (7.52)	***p* = 0.001**
ADL at baseline (N, %)																				
0 (Severe dependency)	9 (7%)	6 (6%)	$p = 0.93$	13 (21%)	***p* = 0.009**	0 (0%)	1 (2%)	$p > 0.9$	27 (13%)	$p = 0.09$	4 (5%)	17 (11%)	$p = 0.17$	7 (13%)	$p = 0.14$	3 (2%)	9 (7%)	$p = 0.17$	16 (36%)	***p* < 0.001**
[1–3] (Moderate dependency)	38 (29%)	41 (40%)	$p = 0.13$	36 (58%)	***p* = 0.001**	2 (8%)	12 (19%)	***p* = 0.03**	101 (50%)	***p* < 0.001**	24 (28%)	69 (44%)	***p* = 0.02**	22 (42%)	$p = 0.16$	29 (24%)	68 (53%)	***p* < 0.001**	18 (40%)	$p = 0.06$
> 3 (Mild dependency)	81 (63%)	54 (52%)	$p = 0.14$	13 (21%)	***p* = 0.001**	25 (92%)	49 (79%)	$p = 0.16$	74 (36%)	***p* < 0.001**	56 (67%)	69 (44%)	***p* = 0.001**	23 (43%)	***p* = 0.01**	87 (73%)	50 (39%)	***p* < 0.001**	11 (24%)	***p* < 0.001**
IC Impairments at baseline (N, %)																				
Cognitive domain impairment (yes)	127 (99%)	70 (68%)	***p* = 0.006**	53 (85%)	***p* = 0.01**	11 (41%)	30 (48%)	$p = 0.71$	84 (41%)	$p > 0.9$	39 (46%)	66 (42%)	$p = 0.60$	20 (38%)	$p = 0.41$	34 (28%)	62 (48%)	***p* = 0.002**	29 (64%)	***p* < 0.001**
Psychological domain impairment (yes)	77 (60%)	79 (77%)	***p* = 0.009**	57 (92%)	***p* = 0.01**	5 (19%)	16 (25%)	$p = 0.66$	60 (29%)	$p = 0.33$	0 (0%)	38 (24%)	***p* < 0.001**	43 (81%)	***p* < 0.001**	32 (27%)	41 (32%)	$p = 0.45$	8 (18%)	$p = 0.32$
Locomotion domain impairment (Yes)	73 (57%)	59 (57%)	$p > 0.9$	30 (48%)	$p = 0.36$	8 (30%)	53 (84%)	***p* < 0.001**	101 (50%)	$p = 0.08$	52 (62%)	84 (53%)	$p = 0.26$	26 (49%)	$p = 0.19$	81 (67%)	63 (49%)	***p* = 0.004**	18 (40%)	***p* = 0.002**
Vitality domain impairment	64 (50%)	72 (70%)	***p* = 0.002**	55 (89%)	***p* = 0.001**	11 (41%)	34 (54%)	$p = 0.35$	146 (72%)	***p* = 0.002**	47 (56%)	108 (69%)	$p = 0.06$	36 (68%)	$p = 0.22$	33 (28%)	113 (88%)	***p* < 0.001**	45 (100%)	***p* < 0.001**
Pneumonia (yes)	28 (22%)	21 (20%)	$p = 0.80$	6 (10%)	$p = 0.04$	4 (15%)	54 (86%)	***p* < 0.001**	42 (21%)	$p = 0.65$	9 (11%)	29 (18%)	$p = 0.16$	17 (32%)	***p* = 0.003**	18 (15%)	27 (21%)	$p = 0.29$	10 (22%)	$p = 0.38$
Charlson Comorbidities Index																				
0	41 (32%)	16 (16%)	***p* = 0.006**	6 (10%)	***p* = 0.002**	2 (8%)	17 (27%)	$p = 0.07$	44 (22%)	$p = 0.14$	15 (18%)	30 (19%)	$p = 0.94$	18 (34%)	***p* = 0.05**	26 (21%)	27 (21%)	$p > 0.9$	10 (22%)	$p > 0.9$
2-Jan	37 (28%)	45 (44%)	***p* = 0.02**	22 (35%)	$p = 0.43$	15 (56%)	19 (30%)	***p* = 0.04**	70 (34%)	***p* = 0.05**	32 (38%)	55 (35%)	$p = 0.74$	17 (32%)	$p = 0.59$	44 (37%)	43 (33%)	$p = 0.87$	17 (38%)	$p > 0.9$
4-Mar	9 (7%)	2 (2%)	$p = 0.13$	5 (8%)	$p > 0.9$	10 (37%)	3 (5%)	***p* < 0.001**	13 (6%)	***p* < 0.001**	4 (5%)	8 (5%)	$p > 0.9$	4 (8%)	$p = 0.76$	8 (7%)	4 (3%)	$p = 0.30$	4 (9%)	$p = 0.87$
> 5	42 (33%)	40 (39%)	$p = 0.39$	29 (47%)	***p* = 0.08**	0 (0%)	24 (38%)	***p* = 0.004**	77 (38%)	***p* < 0.001**	33 (39%)	64 (41%)	$p = 0.93$	14 (26%)	$p = 0.17$	42 (35%)	55 (43%)	$p = 0.26$	14 (31%)	$p = 0.77$

Table 1 (continued)

	Cognitive domain					Locomotion domain					Psychological domain					Vitality domain				
Baseline characteristics	**Group 1**	**Group 2**		**Group 3**		**Group 1**	**Group 2**		**Group 3**		**Group 1**	**Group 2**		**Group 3**		**Group 1**	**Group 2**		**Group 3**	
N	**129**	**103**		**62**		**27**	**63**		**204**		**84**	**157**		**53**		**120**	**129**		**45**	
Polypharmacy (yes)	99 (77%)	72 (70%)	$p = 0.30$	48 (75%)	$p > 0.9$	17 (63%)	48 (76%)	$p = 0.30$	154 (75%)	$p = 0.24$	67 (80%)	113 (72%)	$p = 0.24$	39 (74%)	$p = 0.52$	100 (83%)	91 (71%)	$\mathbf{p = 0.02}$	28 (62%)	$\mathbf{p = 0.007}$
Comordidity, mean (SD)	4.93 (2.85)	4.96 (2.53)	$p = 0.84$	4.82 (2.58)	$p = 0.95$	4.11 (2.43)	4.39 (1.98)	$p = 0.38$	5.18 (2.86)	$p = 0.06$	4.67 (2.64)	4.87 (2.78)	$p = 0.80$	5.41 (2.40)	$\mathbf{p = 0.04}$	4.78 (2.38)	5.01 (2.94)	$p = 0.82$	5 (2.68)	$p = 0.55$
GIR (N, %)																				
2	41 (32%)	38 (37%)	$p = 0.49$	45 (72%)	$\mathbf{p < 0.001}$	7 (26%)	18 (29%)	$p > 0.9$	99 (48%)	$\mathbf{p = 0.04}$	26 (31%)	74 (47%)	$\mathbf{p = 0.02}$	24 (45%)	$p = 0.12$	30 (25%)	66 (51%)	$\mathbf{p < 0.001}$	28 (62%)	$\mathbf{p < 0.001}$
3	26 (20%)	38 (37%)	$\mathbf{p = 0.007}$	10 (16%)	$p = 0.63$	7 (26%)	10 (16%)	$p = 0.41$	57 (28%)	$p > 0.9$	25 (30%)	39 (25%)	$p = 0.50$	10 (19%)	$p = 0.22$	33 (28%)	30 (23%)	$p = 0.53$	11 (24%)	$p = 0.84$
4	49 (38%)	26 (25%)	$\mathbf{p = 0.05}$	6 (10%)	$\mathbf{p = 0.001}$	8 (30%)	30 (48%)	$p = 0.17$	43 (21%)	$p = 0.44$	27 (32%)	37 (24%)	$p = 0.19$	17 (32%)	$p > 0.9$	47 (39%)	29 (22%)	$\mathbf{p = 0.006}$	5 (11%)	$\mathbf{p = 0.001}$
5	11 (8%)	1 (1%)	$\mathbf{p = 0.02}$	1 (2%)	$p = 0.12$	5 (18%)	5 (7%)	$p = 0.27$	3 (1%)	$\mathbf{p < 0.001}$	5 (6%)	6 (4%)	$p = 0.66$	2 (4%)	$p = 0.86$	10 (8%)	3 (2%)	$p = 0.06$	0 (0%)	$p = 0.10$

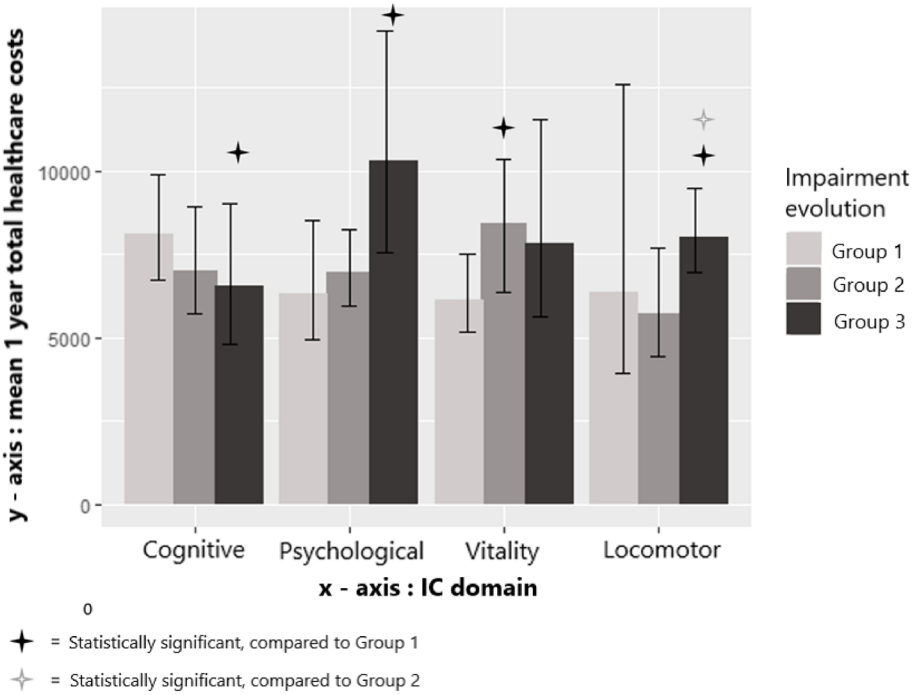

Fig. 2 Total healthcare costs by group for each IC domain impairment evolution

[22–24]. An economic study conducted in community-dwellers and NH residents shows an annual cost increase of 11,000€ after a fall reflecting a mobility impairment [25]. Another study, conducted in community-dwelling older people shows an increase of healthcare cost in relation with functional recovery after hospitalization in older adults [26]. In our study, cost increase related to locomotion domain is mainly driven by paramedic care and inpatients stays, reflecting dependency and more comorbid conditions. A 2019 systematic literature review shows that between 10 and 67% of NH residents with a physical impairment use physiotherapist services [27].

The cost increase for the group 3 in comparison with group 1 for the psychological domain observed in our study is consistent with the French study that found a cost increase of 33% related to deficit on psychological domain in community-dwellers [6]. An observational economic study identified a cost increase with depressive syndrome and severe depression in comparison with no depression [28]. Another study shows that costs increase is not linked with psychiatric care suggesting that care for these residents are in relation with other comorbidities. In our results, people with deficit on psychological domain have a greater number of health conditions (e.g. as pain) and more pneumonia occurrence than others [29].

The study conducted by Pagès et al. in community dwelling older people found no effect of cognitive impairment on healthcare costs [6]. Other studies show that dementia decrease the probability of being hospitalized and that people with dementia in NH present 41% costs decrease than people without dementia [30, 31]. In our study, costs decrease for the IC cognitive domain is mainly driven by medication and people in group 3 have a fewer number of medications at baseline than other groups. This result is in relation with the fact that cognitive impairment increases the risk of medication related adverse events [32]. A Swedish study shows an increase in the resource use inside the NH (e.g. Staff time) that can explain the reduction of outpatient and inpatient care use in this specific population [33]. In community-dwellers, the sense of the association between healthcare costs and cognitive impairment is controversial and mainly depends of the inclusion of informal care in the costs analysis [34–37].

A Dutch study shows that malnutrition in NH increase annual cost from the NH perspective from 8000€ to 10 000€ while our study shows a cost increase between 1710€ and 2030€ from the healthcare insurance perspective [38]. Moreover, studies have shown that malnutrition increase hospitalization after NH admission [39, 40]. A literature review performed in 2022 shows a statistically significant association between polypharmacy and malnutrition in older people that may explain medication cost decrease for the severe annual impairment evolution group [41].

More globally, we observe a reduction in medication costs for all IC domains from group 1 to group 3. This

Table 2 Costs components by group for each IC domain impairment profile

	Group 1	Group 2	*p*-value *	Group 3	*p*-value *
Cognitive domain	*n* = 129	*n* = 103		*n* = 62	
Hospitalizations	3847.13 [2560.92—5133.35]	3575.07 [2130.97—5019.17]	*p* = 0.98	3704.59 [1802.97—5606.20]	*p* = 0.50
Consultations	383.64 [330.98—436.30]	373.88 [316.34—431.41]	*p* = 0.58	340.40 [274.30—406.49]	*p* = 0.32
Paramedic care	920.70 [648.26—1193.14]	851.02 [577.45—1124.60]	*p* = 0.85	791.66 [462.43—1120.88]	*p* = 0.92
Medical Acts	288.75 [224.06—353.44]	233.65 [180.14—287.16]	*p* = 0.53	**156.76 [106.13—207.40]**	***p* = 0.02**
Medical Devices & Medications	1814.71 [1340.21—2289.22]	**1357.39 [1033.92—1680.85]**	***p* = 0.04**	**1121.49 [898.87—1344.11]**	***p* = 0.05**
Transportation	732.08 [563.09—901.07]	490.17 [378.92—601.42]	*p* = 0.37	**328.29 [234.95—421.63]**	***p* = 0.01**
Total cost	8110.20 [6518.95—9701.45]	6986.89 [5412.54—8561.24]	*p* = 0.33	**6559.43 [4427.37—8691.49]**	***p* = *0.07***
Locomotion domain	*n* = 27	*n* = 63		*n* = 204	
Hospitalizations	3535.08 [329.83—6741.76]	2625.45 [1216.41—4034.49]	*p* = 0.50	4084.94 [3013.92—5155.95]	*p* = 0.65
Consultations	387.31 [245.76—528.86]	362.64 [302.09—423.19]	*p* = 0.86	371.57 [330.66—412.47]	*p* = 0.88
Paramedic care	411.17 [41.88—780.46]	549.18 [272.52—825.84]	*p* = 0.55	**1028.47 [811.52—1245.43]**	***p* = 0.03**
Medical Acts	163.28 [100.83—225.72]	279.19 [197.77—360.61]	*p* = 0.37	240.37 [195.89—284.86]	*p* = 0.54
Medical Devices & Medications	1359.76 [794.06—1925.46]	1422.24 [1023.74—1820.74]	*p* = 0.70	1554.54 [1234.70—1874.39]	*p* = 0.73
Transportation	412.74 [198.01—627.46]	390.06 [255.75—524.38]	*p* = 0.83	635.11 [520.25—749.97]	*p* = 0.17
Total cost	6364.05 [2571.17—10156.92]	5736.61 [4120.16—7353.07]	*p* = 0.80	8035.85 [6791.51—9280.20]	***p* = *0.07***
	Group 1	Group 2	*p*-value *	Group 3	*p*-value *
Psychological domain	*n* = 84	*n* = 157		*n* = 53	
Hospitalizations	2969.11 [1547.96—4390.27]	3433.39 [2441.88—4424.91]	*p* = 0.42	5768.83 [2818.58—8719.09]	*p* = 0.51
Consultations	305.72 [250.33—361.10]	**403.34 [56.95—449.72]**	***p* = 0.01**	379.23 [291.17—467.30]	*p* = 0.26
Paramedic care	717.67 [446.93—988.41]	863.17 [630.82—1095.53]	*p* = 0.45	1126.52 [670.03—1583.01]	*p* = 0.17
Medical Acts	216.84 [147.60—286.09]	238.89 [189.91—287.86]	*p* = 0.14	288.94 [205.35—372.53]	*p* = 0.67
Medical Devices & Medications	1814.71 [1340.21—2289.22]	1409.67 [1140.60—1678.75]	*p* = 0.10	**1660.70 [1209.46—2111.94]**	***p* = 0.03**
Transportation	433.72 [296.96—570.48]	496.13 [404.01—588.25]	*p* = 0.14	**961.43 [635.67—1287.19]**	***p* = 0.01**
Total cost	6335.92 [4554.47—8117.37]	6972.59 [5851.30—8093.89]	*p* = 0.09	**10 295.01 [6947.35—13642.66]**	***p* = 0.05**
Vitality domain	*n* = 120	*n* = 129		*n* = 45	
Hospitalizations	2418.12 [1645.37—3190.88]	4508.67 [2968.57—6048.76]	*p* = 0.19	4942.31 [2285.27—7599.34]	*p* = 0.11
Consultations	336.13 [288.27—383.99]	404.69 [350.77—458.61]	*p* = 0.10	368.06 [279.21—456.92]	*p* = 0.53
Paramedic care	781.66 [516.69—1046.63]	960.63 [695.65—1225.61]	*p* = 0.35	839.74 [482.28—1197.19]	*p* = 0.21
Medical Acts	265.52 [198.77—332.26]	245.02 [196.41—293.62]	*p* = 0.55	168.10 [104.72—231.48]	*p* = 0.21
Medical Devices & Medications	1689.57 [1165.26—2213.88]	1555.20 [1309.42—1800.98]	*p* = 0.30	**890.50 [677.10—1103.89]**	***p* = 0.01**
Transportation	518.72 [369.12—668.32]	627.30 [497.23—757.37]	*p* = 0.09	491.39 [312.94—669.83]	*p* = 0.51
Total cost	6117.72 [4960.69—7274.74]	**8420.21 [6706.06—10134.36]**	***p* = *0.07***	7827.04 [4921.29—10732.81]	*p* = 0.35

*compared to Group 1

may be due to the optimization of medication prescription in NH to avoid adverse events and drug-drug interactions correlated to the polypharmacy [42]. Moreover, pneumonia seems to have a larger effect than all IC domains on healthcare costs because it has a direct impact on inpatient and outpatient care costs while IC limitations mobilized NH staff and resources [5].

Our study has some limitations. First, 43% of the initial INCUR population have economic data available. This is because the insurance database includes data of people enrolled in the general scheme and in the Midi-Pyrénées Region while the initial sample was composed of people also living in another region in France and enrolled in others healthcare insurance schemes. Nevertheless, we performed comparison of baseline characteristics between the INCUR population without complete economic data (N = 506) and our population (N = 345) and no difference was found except that more people experience polypharmacy in our sample than in the population without complete economic data. We assume that the mean effect of polypharmacy has no impact on the results. As in other studies conducted on the INCUR sample, we cannot guarantee the generalizability of our results given the partial representativeness of our sample [43]. Nevertheless, few studies on older people living in NH are available and our study provides economic information relative to IC based on robust

Table 3 Analysis of total annual cost predictors

	Unadjusted [$]				Adjusted [$1]				Adjusted [$2] *				Adjusted [$3] **			
Cognitive capacity																
Group 1	ref	-			ref	-			ref	-			ref	-		
Group 2		0.85	0.56, 1.16	0.3		0.84	0.52, 1.15	0.3		0.83	0.61, 1.15	0.3		0.85	0.59, 1.22	0.3
Group 3		0.80	0.63, 1.16	0.2		0.77	0.61, 1.15	0.2		0.79	0.52, 1.20	0.2		0.94	0.60, 1.49	0.8
Locomotion capacity																
Group 1	ref	-			ref	-			ref	-			ref	-		
Group 2		0.99	0.57, 1.66	> 0.9		1.16	0.67, 1.95	0.6		1.13	0.65, 1.91	0.6		1.05	0.57, 1.90	0.9
Group 3		1.29	0.78, 2.03	0.3		1.31	0.80, 2.04	0.3		1.35	0.82, 2.14	0.2		1.39	0.79, 2.10	0.2
Psychological capacity																
Group 1	ref	-			ref	-			ref	-			ref	-		
Group 2		1.14	0.84, 1.34	0.4		1.06	0.77, 1.45	0.7		1.11	0.80, 1.52	0.5		1.17	0.82, 1.66	0.3
Group 3		**1.6**	**1.09, 2.39**	**0.01**		1.28	0.82, 2.01	0.3		1.34	0.85, 2.13	0.2		1.27	0.78, 2.10	0.3
Vitality																
Group 1	ref	-			ref	-			ref	-			ref	-		
Group 2		**1.38**	**1.04, 1.82**	**0.02**		**1.32**	**0.95, 1.83**	**0.08**		1.29	0.92, 1.81	0.11		**1.35**	**0.94, 1.96**	**0.08**
Group 3		1.33	0.91, 2.00	0.2		1.35	0.87, 2.11	0.2		1.36	0.88, 2.14	0.2		1.29	0.78, 2.17	0.3
Pneumonia																
No			/				/				/		ref	-		
Yes			/				/				/			**1.75**	**1.18, 2.65**	**0.006**

[$]: adjusted on Age [61–84] | [85–90] | [91–103], Sex; [$1]: adjusted on Age [61–84] | [85–90] | [91–103], Sex, other intrinsic capacity domain deficits; [$2]: Age [61–84] | [85–90] | [91–103], Sex, Charlson comorbidity 2016 index groups (0 point, 1–4 points, ≥ 5 points), pneumonia O/N, ADL baseline score (≤ 2 |> 2), other intrinsic capacity domain deficits; [$3]: Age [61–84] | [85–90] | [91–103], Sex, Charlson comorbidity 2016 index groups (0 point, 1–4 points, ≥ 5 points), pneumonia Y/N, polypharmacy Y/N, ADL baseline score (≤ 2 |> 2), other intrinsic capacity domain deficits

*About age, *p*-value 0.08 for age range [91—103] years, with exp(coef): = 0.74

**About polypharmacy, *p*-value = = 0.01 with exp(coef): = 1.68

data from the French health insurance database. Data used in our study are a decade old because the INCUR study was conducted from 2013 to 2016. To deal with this limitation, we adjust costs to euro 2021 and assume that global care management of people in NH and particularly regarding the prevention of IC limitations as not evolved since 2013 because IC is a relatively new concept. This highlight the need to conduct new research on this topic to confirm and update our results. NH charges were estimated between 67 160€ and 68 620€ annually per resident with dementia [44]. We were not able to record this data. Few economic studies are conducted in NH and more are conducted on community-dwelling individuals, from the healthcare payer or the patient's perspective that limit the comparison of our results with those in the literature. The integration of NH charges will highlight the specific burden of IC domains deficit for the staff in NH and will allow the optimal dimension of human resources in NH to improve care for residents. Moreover, it is difficult to dissociate the impact of each IC domain impairment on healthcare costs because residents can present impairment on several IC domains. A study shows that psychological and cognitive domains deficits have a greater impact on healthcare costs than the effect of either condition alone [45].

Conclusion and implication

Our study is the first to estimate the association between deficits in IC domains and healthcare costs in NH residents. We used accurate and robust economic data from the healthcare insurance database, which also helps avoid missing data in the follow-up of residents. The implementation of clusterization highlights resident profiles through a data-driven process, whereas other studies have used a priori cluster definitions that do not allow for optimal cluster formation. The findings emphasize the need for systematic monitoring of intrinsic capacity in older adults to tailor individualized care strategies in nursing homes. Incorporating IC assessments into routine practice could enhance intervention effectiveness, reduce functional decline, and ultimately improve residents'health outcomes. The development of impairment trajectories for each IC domain provides valuable insights to support reflections on personalized preventive strategies, ensuring that resources are allocated efficiently. This would provide policymakers with more information on the effectiveness of care pathways through the optimization of NH care management [46, 47]..

Abbreviations

AMTS	Abbreviated Mental Test Score
CCI	Charlson Comorbidity Index
CI	Confidence Intervals
IC	Intrinsic Capacity
ICOPE	Integrated Care for Older People
INCUR	INcidence of pneumonia and related ConseqUences in Resident
FSHI	French Social Health Insurance
GDS	Geriatric Depression Scale
GLM	Generalized Linear Model
KmL	K-means Longitunial
MNA-SF	Short-Form Mini-Nutritional Assessment
NH	Nursing Home
ORIG	Observatoire du Risque Infectieux en Gériatrie (Observatory of Infectious Risk in Geriatrics)
SPPB	Short Physical Performance Battery
WHO	World Health Organization

Supplementary Information

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Supplementary Material 1.

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To design and develop the INCUR study, the principles of the Declaration of Helsinki have been followed and ethical standards complied. The Ethics Committee of the Centre Hospitalier Universitaire de Toulouse and the Consultative Committee for the Treatment of Research Information on Health (CNIL) approved the entire study protocol. The manuscript was reread by an English native person.

Authors' contributions
- Study concept and design: All authors. -Acquisition of data: CN, MC, RY. -Analysis and interpretation of data: All authors. -Drafting of the manuscript: CN, GE, MC, RY. -Critical revision of the manuscript for important intellectual content: All authors.

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Data availability
Due to the nature of this research, coming from claims database, we cannot share individual's data publicly. Upon acceptable request, we can investigate and share aggregate data.

Declarations

Ethics approval and consent to participate
The INCUR study was conducted in accordance with the amended Declaration of Helsinki. Both the Ethics Committee of the "[Blinded for review]" University Hospital and the Consultative Committee for the Treatment of Research Information on Health (CNIL) approved the study protocol (approval number: "[DR- 2012 - 291."]"). The requirement for informed consent was waived by the Ethics Committee of (Committee for the protection of People (CPP)) because of the retrospective nature of the study. All patients (or their representatives) received written information about the study prior to inclusion and could decline participation.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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