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An interdisciplinary intervention is associated with overall improvement of older inpatients in a non-geriatric setting: A retrospective analysis of an observational, longitudinal study with one-year follow up

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Abstract

Older persons often loose independence during hospitalization. This analysis aimed at retrospectively evaluating the effects of a pilot individualized multidimensional intervention (IMI) on the comprehensive geriatric assessment (CGA)-based prognosis of older multimorbid patients in an acute internal medicine setting.

Records from 72 patients aged 65 years and above who received the IMI were compared to those from 403 patients who received standard of care (SOC). All patients had undergone the CGA-based Multidimensional Prognostic Index (MPI) calculation on admission and at discharge. Patients were divided into three risk groups according to MPI score: Low-risk (MPI-1, 0-0.33), medium-risk (MPI-2, 0.34-0.66) and high-risk (MPI-3, 0.67-1).

From admission to discharge, IMI patients showed significant improvements in their MPI score (P=0.014) and subdomains compared to SOC. This was particularly evident in MPI-2 and MPI-3 as well as in patients with poorer functions on MPI admission subdomains.

An early geriatric intervention during hospitalization for disease-specific treatments in internal medicine settings improves overall individual prognosis in older multimorbid patients. Prospective randomized studies are needed to confirm these preliminary retrospective observations.

How this fits in

As society grows older and the individual life expectancy rises, complications like loss of function in older patients during hospitalization are becoming increasingly problematic. To prevent this development, early interventions have become more urgent in daily hospital life. Due to time pressure and limited resources, it is crucial to identify patients who can profit from an early, multidomain intervention and to measure its impact in a time-effective yet accurate way, for which the MPI as a validated prognostic and frailty index is well suited.

Introduction

Among the current public health priorities worldwide such as global warming, pandemics and obesity, population aging represents a unique challenge for health care systems.[1] It is widely known that hospitalization can cause adverse effects on older people such as functional loss, higher risk of rehospitalization and mortality.[2,3] However, hospitalizations trends are dramatically increasing.[4] Once lost, recovering to the function level prior to hospitalization can prove difficult and can require resources and rehabilitation that are more costly and time-consuming than the initial hospital stay.[5] To counteract this development, many approaches have been studied to prevent disability and mortality in older persons after hospital discharge.[5,6]

An interdisciplinary multidimensional intervention (IMI) based on a Comprehensive Geriatric Assessment (CGA) was implemented in 2016 as a pilot project to monitor and prevent functional loss in older patients undergoing acute high-performance medical interventions in an acute medical setting. The CGA was used for goal-oriented treatment and to calculate overall multidimensional prognosis according to the Multidimensional Prognostic Index (MPI), a validated tool used in several thousand older multimorbid patients worldwide.[7-9] The MPI is associated with length of stay, number of geriatric syndromes and resources, grade of care, number of general practitioner visits and mortality in a follow up after 3 months and 1 year.[10-14]

The aim of this analysis was to examine and compare the development of the MPI and its subdomains in patients who received the IMI *versus* standard of care (SOC).

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Materials and Methods

This retrospective study is registered in the DRKS (DRKS00016949) and was approved by the Ethical Committee of the University Hospital of Cologne (EK 16-213).

Data from patients who participated in the prospective study '*Influence of a Geriatric Assessment on hospitalization of older, multimorbid patients*' (MPI-InGAH) between August 2016 and July 2019 was analysed (EK 16-213, DRKS00010606 and DRKS00013791). This study was conducted at the Department II of Internal Medicine - Nephrology, Rheumatology, Diabetology and General Internal Medicine of the University Hospital of Cologne, Germany, where patients were treated for a wide range of diseases, the most common being kidney failure, infection, respiratory and cardiovascular diseases. The criteria of inclusion into MPI-InGAH were: i) being 65 years of age or older; ii) suffering from multimorbidity defined as having two or more illnesses that require long term treatment; and iii) having given their permission themselves or by a proxy to participate in the study.[15] Overall, 475 patients met the criteria and their records were included in the MPI-InGAH study.[12,15]

All patients received a CGA on admission and at discharge based on which the MPI was calculated (see section below). Also, a phone-based follow up after 3, 6 and 12 months was undertaken to disclose patients' living conditions, falls and rehospitalizations.

During the performance of the MPI-InGAH study, an IMI was implemented to prevent hospitalization-related clinical deterioration in older, mainly highly vulnerable nephrological patients undergoing high performance medicine.[16] The latter included necessary therapeutic choices requiring close specialized monitoring. The IMI was instrumented by an interdisciplinary team of physiotherapists, occupational therapists, speech therapists, pharmacists and specialized nurses guided in co-management by a geriatrician and a nephrologist and regularly trained by a geriatrician. Medical students were actively involved in the program to promote age-attuned management of older patients and the acquaintance with challenges and complexity of ageing medicine.[17] Patients judged to be at risk of frailty and loss of independence during a weekly consultation were allocated to IMI. Criteria for allocation included risk for or beginning immobility or instability syndromes, planned length of hospitalization of at least one week as well as ascertained presence of recovery potential, motivation, psychological stability and language comprehension. The IMI's content was a combination of specialized individual and MPI-independent functional therapy that surpassed the amount of therapy patients receive during a normal hospital stay and which focused on intrinsic capacity and individual deficits determined by the CGA and performance tests scores on admission. The SOC collective received the CGA and the CGA-based MPI as part of the MPI-InGAH study as well as the usual care provided in the hospital with no additional focus on mobility or rehabilitation.[12,15]

Datasets were included in the analysis if complete of CGA-MPI scores, IMI features, source of referral, discharge destination, length of educational period and geriatric syndromes and resources [12,15]

Assessments

Between November 2016 and June 2019, 121 patients were included into the IMI program. Forty of the 121 selected patients did not participate in the MPI_InGAH study described above and were therefore excluded as they did not undergo CGA. Of the remaining patients, 4 died during the hospitalization and 5 had incomplete data. Therefore, records from the remaining 72 IMI patients were included in this analysis and compared to those of the 403 SOC patients undergoing admission and discharge CGA-MPI evaluation.

The MPI is calculated through a mathematical algorithm which includes scores from Activities of Daily Living (ADL), Instrumental Activities of Daily Living (IADL), Exton Smith Scale (ESS), Short Form of the Mini Nutritional Assessment (MNA), Short Portable Mental Status Questionnaire (SPMSQ), Cumulative Illness Rating Scale (CIRS), as well as social index and number of medications taken per day, as described before.[15,18] The calculation yields a continuous value between 0 and 1, allowing the identification of three mortality risk groups: low-risk (MPI-1, 0-0.33), intermediate-risk (MPI-2, 0.34-0.66) and high-risk (MPI-3, 0.67-1).

In IMI patients, the Geriatric Depression Scale (GDS - range 0 to 15 points with a score over 6 associated with a higher likelihood of depression),[19] the Montreal Cognitive-Assessment (MoCA - range 0 to 30 points, 30 representing best cognitive performance),[20] the Morton Mobility Test (DEMMI - range 0 to 100 points, 100 representing best mobility),[21] the Timed Up and Go Test (TUG - measured in seconds with 10 seconds or lower indicating intact mobility),[22] the Hand Grip Test (HG - reference values vary according to age, sex and dominating hand),[23] the Mini Mental State Examination (MMSE - range 0 to 30 points, 30 representing best cognitive performance),[24] as well as the Dementia Detection Test (DemTect - range 0 to 18 points, 18 representing best cognitive performance)[25] were collected and used for goal-oriented multidisciplinary therapy. Physiotherapists focused on strength gain through physical exercises in a target-oriented personalized manner that addressed deficits found in the DEMMI, TUG and HG. Occupational therapists supported patients' independent functioning by practicing ADL and by addressing cognitive deficits found in the SPMSQ, MoCa, MMSE or DemTect. Swallowing disorders potentially favoring a low MNA were treated by speech therapists while pharmacists evaluated drug therapies with the goal of reducing polypharmacy. All results and interventions were discussed with the whole interdisciplinary team during weekly rounds.

Statistics

For the presentation of descriptive statistics, absolute numbers and relative frequencies were used to express categorical variables while quantitative variables were depicted by median and quartiles (Q_1, Q_3).

To analyze the effect of the IMI, the two patient collectives were compared in total as well as subdivided into their MPI risk-groups on admission. The x^2-test or Fishers-exact-test were used to analyze frequencies while the Mann-Whitney-U-Test or the Kruskal-Wallis-Test were used to analyze quantitative distributions. To describe the changes of the MPI and its subdomains, the Delta-score was calculated for each domain by subtracting the admissions from the discharge score. A linear regression analysis was performed to analyze the influence of the IMI on the MPI and its domains adjusted for age, sex and MPI on admission. A Cox regression tested for an influence of treatment group on survival rates. Also, a Spearman's correlation and a linear regression adjusted for age, gender, length of hospital stay (LHS), number of therapies and days in the IMI were performed to analyze the correlation between MPI-value on admission and geriatric test results. A P-value of 5% or less was considered significant. All analysis were performed using SPSS (Statistical Package for Social Sciences, SPSS Inc., Chicago, IL, USA, Version 25.0) software.

Results

Demographics

The demographics and clinical conditions by MPI group on admission and by treatment group (SOC and IMI) are shown in Table 1. The IMI collective was distributed according to the MPI classification into MPI-1, MPI-2 and MPI-3 groups (8, 44 and 20 patients, respectively).

Overall, there was no significant difference in gender distribution, years of education, living status, grade of care/nursing needs and number of medications on admission between the IMI and SOC collectives (Table 1). IMI patients were more likely to have been transferred from a different internal ward, while SOC patients tended to be new admissions from outside the hospital (Table 1).

The LHS of IMI patients was more than twice as long (22 days [14.25, 32.75] *vs* 8 days [5, 15]) compared to SOC (P<0.001) (Table 1). The IMI patients remained in the hospital up to 102 days.

There were no differences between groups concerning number of geriatric resources. However, IMI patients were more frequently affected by immobility (61.1% *vs* 36.7%, P>0.001) as well as incoherence/delirium (12.5% *vs* 3.2%, P=0.002) than SOC patients.

The results of the CGA are displayed in Table 2. The median MPI values on admission were significantly higher in the IMI collective (0.56 [0.45, 0.69] *vs* 0.44 [0.25, 0.63], P<0.001) than in the SOC collective. Concerning the subdomains of the MPI, the ADL, IADL, ESS and MNA scores were significantly worse in the IMI collective on admission compared to SOC (Table 2).

Outcomes at discharge

The IMI collective showed significantly worse MPI scores at discharge compared to SOC (0.5 [0.44, 0.63] *vs* 0.44 [0.31, 0.56], P=0.001) (Table 2). This was especially evident in MPI-1 subgroup, while in contrast, IMI patients of MPI-3 showed a significantly better score at discharge than SOC patients of the same group (Table 2). Similarly, the ADL, IADL and CIRS scores were significantly worse in IMI patients compared to SOC at discharge (Table 2). ADL and ESS scores of IMI patients were significantly worse in MPI-1 and better in MPI-3 compared to SOC. IMI patients in MPI-1 showed a significantly higher number of drugs at discharge than SOC patients (Table 1). There was no difference concerning occurrence of polypharmacy (taking six drugs or more) between both collectives.

Overall, while the MPI at discharge was higher in IMI patients than SOC, the IMI

Table 1. Descriptive statistics.

	Total		MPI- 1		MPI- 2		MPI-3	
	SOC N=403 (100%)	IMI N=72 (100%)	SOC N=111 (27.5%)	IMI N=8 (11%)	SOC N=216 (53.5%)	IMI N=44 (61%)	SOC N=76 (19%)	IMI N=20 (28%)
Female, n (%)	157 (39.0)	30 (41.7)	36 (32.4)	5 (62.5)	88 (40.7)	14 (31.8)	33 (43.4)	11 (55)
P-value°	0.695		0.122		0.312		0.451	
Age (years), median (Q_1, Q_3)	77 (73, 81)	78 (74, 82)	75 (71, 79)	79.5 (76.5, 81)	77 (74, 82)	77.5 (74, 82.75)	80 (75.3, 88)	77 (70.3, 84.8)
P-value°	0.304		0.018*		0.597		0.165	
LHS (days), median (Q_1, Q_3)	8 (5, 15)	22 (14.3, 32.8)	7 (4, 13)	27 (13.8, 43)	8 (5, 14)	18.5 (13, 29.5)	12 (7, 19)	28.5 (19.8, 34.8)
P-value°	<0.001*		<0.001*		<0.001*		<0.001*	
Period of education (years), median (Q^1, Q^3)	12 (10.5, 15)	11 (9, 14)	12 (11, 15.25)	11 (10, 14)	11 (10, 15)	12 (11, 15)	11 (9, 13)	11 (8, 11)
P-value°	0.216		0.167		0.461		0.095	
Number of medications on admission, median (Q_1, Q_3)	9 (7, 12)	10 (8, 14)	7 (5, 10)	10 (7, 12.8)	9 (7, 12)	10 (8, 13)	11 (8, 13)	10 (8, 12.8)
P-value°	0.061		0.102		0.301		0.42	
Number of medications at discharge, median (Q_1, Q_3)	10 (7, 12)	11 (9, 13)	8 (6, 11)	13.5 (9, 14.8)	11 (8, 12)	11 (9, 13.3)	10 (8, 13.8)	10.5 (8.3, 12.8)
P-value°	0.002*		0.003*		0.117		0.937	
Polypharmacy, n (%)	336 (83.4)	66 (91.7)	70 (63.1)	7 (87.5)	193 (82.4)	40 (90.9)	72 (96.1)	19 (95.0)
P-value°	0.072		0.257		>0.999		>0.999	
BMI, median (Q_1, Q_3)	25.6 (22.6, 30)	24.4 (22, 30)	26.2 (23, 29.9)	25.28 (23.4, 32)	25.61 (22.8, 30.3)	24.3 (21.9, 30.2)	24.7 (21.9, 29.7)	24.88 (21.7, 25.9)
P-value°	0.146		0.979		0.331		0.493	
Source of referral								
New admission, n (%)	203 (51)	17 (23.6)	69 (63.3)	7 (87.5)	112 (52.8)	8 (18.2)	22 (28.9)	2 (10)
P-value°	<0.001*		0.258		<0.001*		0.144	
External ward, n (%)	76 (19.1)	17 (23.6)	20 (18.3)	1 (12.5)	40 (18.9)	11 (25)	16 (21.1)	5 (25)
P-value°	0.422		>0.999		0.406		0.763	
Internal ward, n (%)	118 (29.7)	38 (52.8)	20 (18.3)	0	60 (28.3)	25 (56.8)	38 (50)	13 (65)
P-value°	0.001*		0.348		0.001*		0.315	
Discharge destination								
Home, n (%)	258 (67.0)	29 (45.3)	93 (85.3)	4 (57.1)	141 (68.1)	18 (43.9)	24 (34.8)	7 (43.8)
P-value°	0.001*		0.085		0.004*		0.569	
Geriatric rehabilitation, n (%)	44 (11.4)	19 (29.7)	5 (4.6)	2 (28.6)	26 (12.6)	15 (36.6)	13 (18.8)	2 (12.5)
P-value°	<0.001*		0.057		0.001*		0.726	

Descriptive statistics, MPI and its subdomains, source of referral and discharge destination for the SOC and IMI collective as well as divided by MPI risk-group on admission. ° Chi-Square or Fishers exact test for frequencies, Mann-Whitney-U-Test for continuous; *significant at 5% SOC, standard of care; IMI, interdisciplinary multidimensional iintervention; Q_1: First Quartile, Q_3: Third Quartile; MPI, Multidimensional Prognostic Index; LHS, Length of hospitalization; BMI, Body Mass Index.

Table 2. Comprehensive geriatric assessment [Median, Q_1, Q_3].

	Total		MPI- 1		MPI- 2		MPI-3	
	SOC N=403	IMI N=72	SOC N=111	IMI N=8	SOC N=216	IMI N=44	SOC N=76	IMI N=20
MPI on admission	0.44 (0.25, 0.63)	0.56 (0.45, 0.69)	0.25 (0.19, 0.31)	0.25 (0.25, 0.31)	0.47 (0.38, 0.56)	0.56 (0.56, 0.56)	0.75 (0.69, 0.82)	0.75 (0.69, 0.75)
P-value°	<0.001*		0.533		0.001*		0.359	
MPI at discharge	0.44 (0.31, 0.56)	0.5 (0.44, 0.63)	0.25 (0.25, 0.31)	0.38 (0.33, 0.38)	0.44 (0.38, 0.56)	0.47 (0.39, 0.56)	0.69 (0.69, 0.75)	0.63 (0.56, 0.73)
P-value°	0.001*		0.001*		0.255		0.002*	
Delta MPI	0 (–0.06, 0.003)	–0.029 (–0.12, 0)	0 (–0.003, 0.06)	0.126 (0.03, 0.18)	0 (–0.06, 0.003)	–0.03 (–0.12, 0)	–0.001 (–0.06, 0.003)	–0.12 (–0.18, 0)
P-value°	0.014*		0.001*		0.038*		0.025*	
ADL on admission	5 (3, 6)	3 (1, 5)	6 (6, 6)	6 (5, 6)	5 (3, 6)	3 (2, 5)	1 (1, 2)	1 (1, 2)
P-value°	<0.001*		0.268		<0.001*		0.798	
ADL at discharge	5 (3, 6)	4 (3, 5)	6 (6, 6)	4.5(2.3,6)	5 (4, 6)	5 (3, 6)	1 (1, 2)	2.5(1.3,4)
P-value°	0.021*		0.002*		0.299		0.006*	
Delta ADL	0 (0, 0)	0 (0, 2)	0 (0, 0)	–0.5 (–2.8, 0)	0 (0, 0)	0 (0, 2)	0 (0, 0)	1.5 (0, 3)
P-value°	<0.001*		<0.001*		0.001*		<0.001*	
IADL on admission	5 (3, 5)	4.5 (2.3, 6)	7 (6, 8)	6 (5.3, 7.8)	5 (3, 7)	5 (4, 7)	2 (1, 3)	2 (1, 4)
P-value°	0.025*		0.094		0.842		0.689	
IADL at discharge	5 (3, 8)	4 (3, 6)	7 (6, 8)	5 (4.3, 7.3)	5 (3, 7)	4.5 (4, 6.8)	2 (1, 3)	3 (1, 4)
P-value°	0.013*		0.013*		0.651		0.165	
Delta IADL	0 (0, 0)	0 (0, 0)	0 (0, 0)	–1 (–1.8,0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 1)
P-value°	0.105		<0.001*		0.130		0.033*	
SPMSQ on admission	1 (0, 2)	1 (1, 2)	1 (0, 1)	1 (0.3, 1.8)	1 (0, 2)	1 (0.3, 2)	2 (1, 4)	2 (1, 4)
P-value°	0.072		0.378		0.377		0.993	
SPMSQ at discharge	1 (0, 2)	1 (0, 2)	1 (0, 1)	1 (0, 1)	1 (0, 2)	1 (0, 2)	2 (1, 4)	1 (1, 3)
P-value°	0.673		0.738		0.859		0.123	
Delta SPMSQMedian (Q_1, Q_3), mean [Minimum; Maximum]	0 (0, 0)–0.05 [–3; 3]	0 (0, 0)–0.48 [–7; 1]	0 (0, 0)–0.05 [–2; 3]	0 (0, 0)–0.25 [–2; 0]	0 (0, 0)–0.0 7 [–2; 2]	0 (0, 0)–0.3 [–4; 1]	0 (0, 0)0 [–3; 3]	0 (–1, 0)–1 [–7; 0]
P-value°	<0.001*		0.535		0.071		<0.001*	
ESS on admission	15 (11, 17)	12.5 (10, 15)	18 (16, 19)	16 (4.5, 16.75)	15 (12, 17)	13 (11, 15)	9.5 (8, 12)	10 (8, 12)
P-value°	<0.001*		0.009*		0.010*		0.634	
ESS at discharge	16 (12, 18)	15.5 (13, 17)	18 (17, 19)	15 (3.5, 17.75)	16 (13, 17)	16 (14, 17)	11.5 (8, 13)	15 (10, 16)
P-value°	0.208		0.007*		0.972		0.002*	
Delta ESS	1 (0, 1)	1 (0, 4)	0 (0, 0)	0 (–0.8, 0.8)	0 (0, 1)	1 (0, 3.8)	0 (0, 1)	4 (0, 6)
P-value°	<0.001*		0.358		<0.001*		0.002*	
MNA on admission	9 (7, 12)	7 (5, 10)	12 (10, -13)	12 (9.5, 13.8)	9 (7, 11)	7 (5, 10)	6 (4.3, 7)	6 (5, 9)
P-value°	0.003*		0.747		0.010*		0.323	
MNA at discharge	9 (6, 12)	8 (5, 10.8)	11 (9, 13)	10.5 (3.8,13.5)	9 (7, 12)	8 (5, 10.8)	5 (3, 8.8)	7.5 (5.3, 9.8)
P-value°	0.064		0.577		0.129		0.052	
Delta MNA	0 (0, 0)	0 (0, 0)	0 (0, 0)	–1 (–5, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (–1, 2)
P-value°	0.435		0.075		0.448		0.529	
CIRS on admission	5 (4, 6)	5.5 (4, 6.8)	4 (3, 5)	5 (4, 6)	5 (4, 6)	6 (4, 7)	6 (5, 6.8)	5 (4.3, 6)
P-value°	0.072		0.133		0.314		0.265	
CIRS at discharge	5 (3, 6)	5 (4,6.8)	4 (2, 5)	5 (3.3, 7)	5 (4, 6)	5 (4,6.8)	6 (5, 6)	5 (4, 6)
P-value°	0.022*		0.085		0.108		0.282	
Delta CIRS	0 (–1, 0)	0 (–1, 0)	0 (–1, 0)	0.5 (0, 1)	0 (–1, 0)	0 (–1, 0)	0 (–1, 0)	0 (–1, 0)
P-value°	0.071		0.040*		0.251		0.834	

MPI and its subdomains, Delta MPI (MPI discharge - MPI admission) as well as the Delta of all its subdomains between discharge and admission for SOC and IMI as well as subdivided by MPI-risk-group on admission. °Chi-Square or Fishers exact test for frequencies, Mann-Whitney-U-Test for continuous; *significant at 5%. SOC, standard of care; IMI, interdisciplinary multidimensional intervention; Q^1: First Quartile, Q_3: Third Quartile, MPI, Multidimensional Prognostic Index; ADL, Activities of Daily Living; IADL, Instrumental Activities of Daily Living; SPMSQ, Short Portable Mental Status Questionnaire; ESS, Exton Smith Scale; MNA, Mini Nutritional Assessment; CIRS, Cumulative Illness Scale.

collective improved significantly in their MPI compared to SOC (P=0.014) (Table 2). According to MPI group on admission, IMI patients in MPI-1 displayed a significant worsening of their score compared to the SOC (P=0.001) while the opposite was the case in MPI-2 (P=0.038) and MPI-3 (P=0.025) (Figure 1).

In the overall patients' collective, there was a larger improvement in the ADL score in patients who underwent the IMI compared to the SOC group (P<0.001) (Table 2). Again, this improvement was evident in MPI-2 and MPI-3, while the IMI patients' ADL score worsened in MPI-1. A similar development could be seen in the IADL, the ESS and the CIRS (Table 2). A linear regression on the influence of the treatment group on the Delta ADL adjusted for age, gender and MPI on admission confirmed a significant improvement of the ADL score in the IMI collective (P<0.001) in MPI-2 and MPI-3 subgroups (regression coefficient 0.705 and 1.191, respectively).

Concerning the SPMSQ, 22.5% of IMI patients improved their score compared to only 8% of SOC patients (P=0.002).

Of the SOC group, 67.0% of the patients were discharged home *vs* 45.3% of IMI patients (P=0.001) (Table 1). IMI patients were more likely to be discharged to geriatric rehabilitation facilities or an external ward than SOC patients.

At follow up, patients of the IMI collective showed an increase in their grade of care /nursing needs at discharge and after three months as well as a higher fall percentage after 3 months and a higher rehospitalization rate after six months compared to SOC (Table 3). A similar observation could be made concerning the development of home care use (Table 3). Furthermore, at different points in follow up the survival rates between IMI and SOC showed significant differences, however patient collectives are small (Table 3). A Cox regression of the influence of IMI or SOC affiliation on survival rate did not reveal a significant connection (P=0.214).

Patients participating in the IMI received median 9 (Q_1 5, Q_3 14, range 2-38) treatments of interdisciplinary therapy during their median IMI duration of 12 days (Q_1 7, Q_3 18, range 2-43 days). There was a significant correlation between MPI on admission and DEMMI-test score (rho= –0.347, P=0.008) confirmed by adjusted linear regression as well as between MPI on admission and the Delta of the Handgrip test between admission and discharge (Right hand: rho= –0.776, P=0.014; Left hand: rho= –0.733, P=0.025).

Analysis of MPI subdomain changes

When investigating which subgroup profited most from the intervention, MPI-2 and MPI-3 patients showed a greater improvement in the MPI (MPI-3 *vs* MPI-1: P<0.001; MPI-2 *vs* MPI-1: P=0.003), ADL (MPI-3 *vs* MPI-1: P=0.002; MPI-2 *vs* MPI-1: P=0.038), IADL (MPI-3 *vs* MPI-1: P=0.002; MPI-2 *vs* MPI-1: P=0.023) and ESS (MPI-3 *vs* MPI-1: P=0.004; MPI-2 *vs* MPI-1: P=0.047) compared to patients in MPI-1. The development of the CIRS, the MNA and the SPMSQ were not influenced by MPI group on admission.

Patients with a high-risk ADL score on admission (ADL ≤2) improved significantly in their MPI compared to low-risk ADL (ADL >4) patients (–0.12 [–0.18, 0] *vs* 0 [0, 0.13] P<0.001) as well as in their ESS (4 [1, 5.5] *vs* 0 [0, 1], P<0.001). High-risk ADL patients also improved in their ADL score compared to low-risk ADL patients (2 [0, 3.5] *vs* 0 [–0.25, 0], P<0.001) and medium-risk ADL (ADL 3-4) patients (2 [0, 3.5] *vs* 0 [–0.5, 1.5], P=0.002).

Gender, number of IMI treatments, number of days in the IMI, amount of days in hospital until inclusion into the IMI, ini-

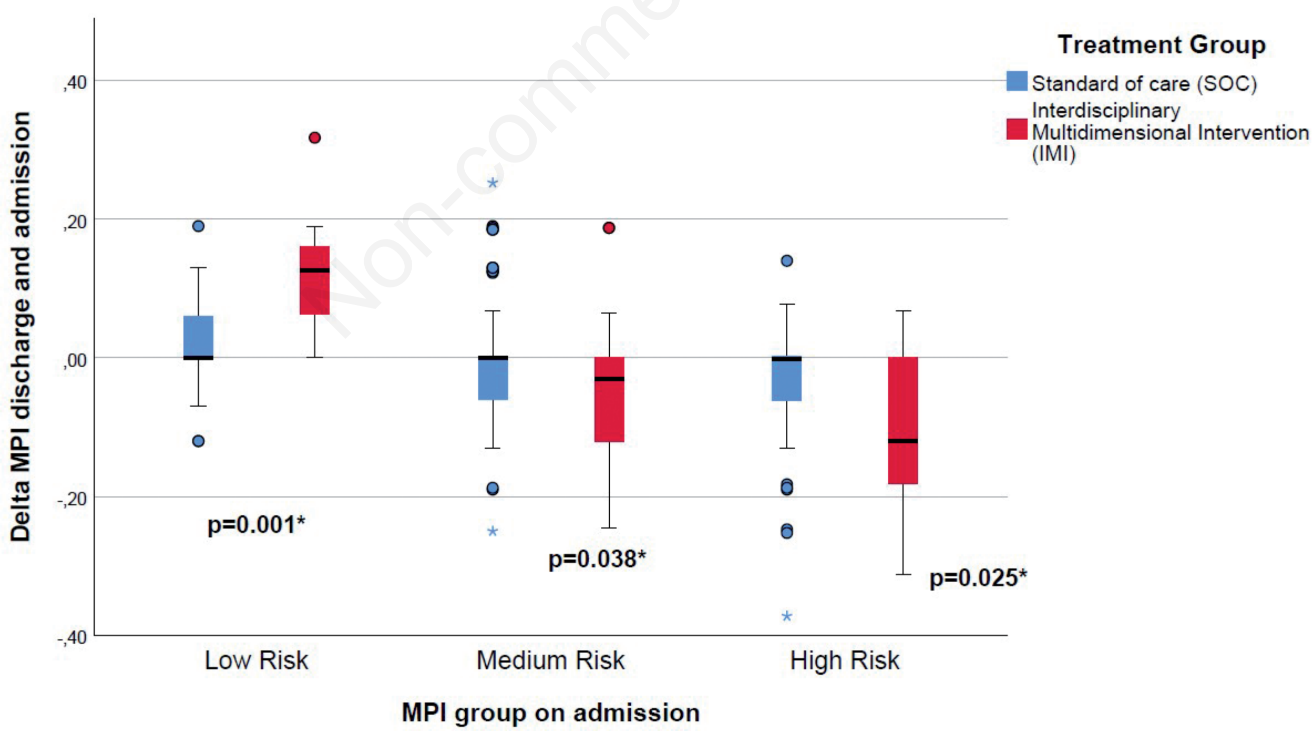

Figure 1. Delta of the Multidimensional Prognostic Index (MPI) divided by MPI group on admission. Delta of the MPI between discharge and admission presented as a Box Plot displayed by MPI risk-group on admission. The interdisciplinary multidisciplinary intervention (IMI) collective is shown in red, the standard of care (SOC) collective in blue. P-values were calculated with the Mann-Whitney-U-Test and were significant at 5%.

tial diagnosis and number of medications had no influence on the Delta MPI and the Delta of its subdomains (P>0.05).

IMI patients between the age of 65 to 74 years (n=22) improved significantly in the MPI (–0.12 [–0.18, 0] *vs* 0 [–0.07, 0.06], P=0.023), the ADL (1.5 [0, 4] *vs* 0 [0, 2], P=0.020) and the ESS (3 [1, 5] *vs* 0 0, 2], P=0.002) compared to patients aged 75 to 84 years (n=39). Patients aged 85 years or older (n=11) also improved in the ESS score (3 [1, 6] *vs* 0 [0, 2], P=0.039) compared to 75 to 84-year old. In accordance with that and compared to SOC patients of the same age group, IMI patients aged between 65 and 74 showed better MPI (–0.12 [–0.18, 0] *vs* 0 [–0.06, 0.005], P<0.001), ADL (1.5 [0, 4] *vs* 0 [0, 0], P<0.001), ESS (3 [1, 5] *vs* 0 [0, 1], P<0.001) and MNA developments (0 [0, 1.25] *vs* 0 [0, 0], P=0.042) at discharge compared to admission. The same could be observed for IMI patients aged 85 and older, who improved in MPI (–0.06 [–0.13, 0] *vs* 0 [-0.06, 0.005], P=0.007), ADL (0 [0, 2] *vs* 0 [0, 0], P=0.008) and ESS scores (3 [1, 6] *vs* 0 [0, 1], P=0.001) compared to SOC. IMI patients aged between 75 and 84 displayed no significant developments compared to SOC except for a worsening in their IADL (0 [–1, 0] *vs* 0 [0, 0], P<0.001).

Discussion

This analysis showed significant improvements from admission to discharge in multidimensional prognosis measured by a highly valid tool like the MPI in older adults undergoing interdisciplinary intervention during acute medical treatment in a non-geriatric setting. Despite the clear limitations described below and due to the retrospective nature of the analysis, such improvement was not detectable in the datasets belonging to usual care patients. As the MPI-related improvement was evident in patients with medium- or high-risk prognosis on admission, one could argue that the observation is likely related to the poorer admission prognosis of the IMI compared to that of SOC patients. However, the within-group delta MPI from admission to discharge showed an improvement in prognosis in the IMI but not in the SOC group. The development of the scores of the ADL, ESS and IADL is similar, although interpretation of improvements in those domains in IMI patients should be done cautiously due to the below described limitations of the patient collective. To disclose the effects of the IMI, further studies are needed which randomly allocate a larger patient collective

Table 3. Follow up data [n/n patients surveyed in follow up (% of patients in follow up, % of whole patient collective].

	Total		MPI-1		MPI-2		MPI-3	
	SOC N=403	IMI N=72	SOC N=111	IMI N=8	SOC N=216	IMI N=44	SOC N=76	IMI N=20
Follow up at discharge								
Grade of care need	16/385 (4.2, 4)	10/70 (14.3, 13.9)	2/109 (1.8, 1.8)	1/8 (12.5, 12.5)	12/212 (5.7, 5.6)	6/42 (14.3, 13.6)	2/64 (3.1, 2.6)	3/20 (15, 15)
P-value°	P=0.001*		0.193		0.090		0.085	
Home care need	22/385 (5.7, 5.5)	10/70 (14.3, 13.9)	4/109 (3.7, 3.6)	0/8	13/212 (6.1, 6)	7/42 (16.7, 15.9)	5/64 (7.8, 6.6)	3/20 (15, 15)
P-value°	0.019*		>0.999		0.030*		0.388	
Admission to long-term care after 3/20 discharge	6/385 (1.6, 1.5)	2/70 (2.9, 2.8)	1/109 (0.9, 0.9)	0/8	1/212 (0.5, 0.05)	1/42 (2.4, 2.3)	4/64 (6.3, 5.3)	1/20 (5, 5)
P-value°	0.355		>0.999		0.304		>0.999	
Falls during hospitalization	16/385 (4.2, 4)	5/70 (7.1, 6.9)	4/109 (3.7, 3.6)	0/8	11/212 (5.2, 4.9)	3/42 (7.1, 6.8)	1/64 (1.6, 1.3)	2/20 (10, 10)
P-value°	0.346		>0.999		0.709		0.14	
3 months								
Patients alive	283/355 (79.7, 70.2)	49/66 (74.2, 68.1)	97/105 (92.4, 87.4)	6/7 (85.7, 75)	163/194 (84, 75.5)	30/40 (75, 68.2)	23/56 (41.1, 29.5)	13/19 (68.4, 0.65)
P-value°	0.317		0.453		0.172		0.062	
Increase in grade of care /nursing needs	48/210 (22.9, 11.9)	15/38 (39.5, 20.8)	9/68 (13.2, 8.1)	3/4 (75, 37.5)	37/122 (30.3, 17.1)	7/23 (30.4, 15.9)	2/20 (10, 2.6)	5/11 (45.5, 25)
P-value°	0.042*		0.013*		0.992		0.067	
Home care use	53/266 (19.9, 13.2)	13/49 (19.7, 18.1)	6/93 (6.5, 5.4)	2/6 (33.3, 25)	40/151 (26.5, 18.5)	6/30 (20, 13.6)	7/22 (31.8, 9)	5/13 (38.5, 25)
P-value°	0.399		0.073		0.456		0.726	
Admission to long-term care	14/272 (5.1,3.5)	0/49 (0, 0)	0/95	0/6	7/155 (4.5,3.2)	0/30	7/22 (31.8, 9)	0/13
P-value°	0.139		>0.999		0.601		0.031*	
Rehospitalization	155/276 (56.2, 38.5)	37/53 (69.8, 51.4)	45/97 (46.4, 40.5)	4/6 (66.7, 50)	93/157 (59.2, 43.1)	23/33 (69.7, 52.3)	17/22 (77.3, 21.8)	10/14 (71.4, 50)
P-value°	0.065		0.420		0.263		0.712	
Falls in the last 3 months	39/263 (14.8, 9.7)	13/49 (26.5, 18.1)	9/91 (9.9, 8.1)	3/6 (50, 37.5)	27/151 (17.9, 12.5)	7/30 (23.3, 15.9)	3/21 (14.3, 3.8)	3/13 (23.1, 15)
P-value°	0.044*		0.024*		0.454		0.653	

To be continued on next page

with similar MPI values on admission to IMI or to SOC. While there have been studies measuring the effect of multidisciplinary interventions on scores like the ADL,[26] there are no randomized studies to date which used a prognostic index like the MPI to monitor the effects of individualized multidisciplinary strategies in geriatric or in non-geriatric settings, despite the large amount of evidence showing the beneficial effects of CGA-based personalized interventions.[27]

The observations presented here deserve attention for the high potential carried by geriatric multidomain interventions particularly when conducted simultaneously with intensive though necessary disease-centered treatments in internal medicine settings like in urgent medicine and surgical care.[28-30]

Of note, patients with a low-risk MPI on admission worsened in their prognosis as well as in their functionality after receiving the IMI, showing a worse MPI at discharge as well as a worse Delta MPI. This is surprising, as one would not expect a treatment like the IMI to lead to adverse effects. However, with a MPI-1 IMI patient collective only numbering 8, the significance of this subgroup-analysis is limited. A possible explanation for this development could be the long LHS known to negatively influence functions in older multimorbid patients.[2,3,31] The hospitalization-related functional loss in the IMI group, indeed, might also be reflected by the higher num-

Table 3. Continued from previous page.

	Total		MPI-1		MPI-2		MPI-3	
	SOC N=403	IMI N=72	SOC N=111	IMI N=8	SOC N=216	IMI N=44	SOC N=76	IMI N=20
6 months								
Patients alive	253/342 (74, 62.8)	38/64 (59.4, 52.8)	91/101 (90.1, 82)	6/8 (75, 75)	142/185 (76.8, 66.2)	21/38 (55.3, 47.8)	20/56 (35.7, 25.6)	11/18 (61.1, 55)
P-value°	0.017*		0.214		0.007*		0.057	
Increase in grade of care /nursing needs	34/194 (17.5, 8.4)	5/32 (15.6, 6.9)	11/68 (16.2, 10)	1/5 (20, 12.5)	19/111 (17.1, 8.8)	3/16 (18.8, 6.8)	4/15 (26.7, 5.1)	1/11 (9.1, 5)
P-value°	0.792		>0.999		>0.999		0.365	
Home care use	42/238 (17.6, 10.4)	13/40 (32.5, 18.1)	6/88 (6.8, 54)	2/7 (28.6, 25)	32/133 (24.1, 14.8)	6/21 (28.6, 13.6)	4/17 (23.5, 5.1)	5/12 (41.7, 25)
P-value°	0.004*		0.106		0.656		0.233	
Admission to long-term care	15/244 (78.9, 3.7)	4/41 (9.8, 5.6)	1/89 (1.1, 0.9)	1/7 (14.3, 12.5)	7/137 (5.1, 3.2)	1/22 (4.5, 2.3)	7/18 (38.9, 9)	2/12 (16.7, 10)
P-value°	0.494		0.141		>0.999		0.249	
Rehospitalization	93/244 (38.1, 23.1)	18/39 (46.2, 25)	33/90 (36.7, 29.7)	2/6 (33.3, 25)	49/136 (36, 22.7)	9/22 (40.9, 20.5)	11/18 (61.1, 14.1)	7/11 (63.6, 35)
P-value°	0.024*		>0.999		0.037*		>0.999	
Falls in the last three months	39 (16.7, 9.7)	4/40 (10, 5.6)	9/88 (10.2, 8.1)	2/7 (28.6, 25)	28/130 (21.5, 13)	1/21 (4.8, 2.3)	2/16 (12.5, 2.6)	1/12 (8.3, 5)
P-value°	0.353		0.185		0.079		>0.999	
12 months								
Patients alive	190/309 (61.5, 47.1)	33/61 (54.1, 45.8)	71/94 (75.5, 63.9)	6/8 (75, 75)	105/160 (65.6, 48.6)	18/36 (50, 40.9)	14/55 (25.5, 17.9)	9/17 (52.9, 45)
P-value°	0.281		>0.999		0.080		0.034*	
Increase in grade of care/nursing needs	15/155 (9.7, 3.7)	5/31 (16.1, 6.9)	3/56 (5.4, 2.7)	2/6 (33.3, 25)	9/85 (10.6, 4.2)	1/16 (6.3, 2.3)	3/14 (21.4, 3.8)	2/9 (22.2, 10)
P-value°	0.338		0.069		>0.999		>0.999	
Home care use	27/185 (14.6, 6.7)	11/33 (33.3, 15.3)	4/72 (5.6, 3.6)	1/6 (16.7, 12.5)	22/100 (22, 10.2)	4/18 (22.2, 9.1)	1/13 (7.7, 1.3)	6/9 (66.7, 30)
P-value°	0.009*		0.337		>0.999		0.007*	
Admission to long-term care	10/189 (5.3, 2.5)	3/33 (9.1, 4.2)	1/72 (1.4, 0.9)	1/6 (16.7, 12.5)	6/102 (5.9, 2.8)	1/18 (5.6, 2.3)	3/15 (20, 3.8)	1/9 (11.1, 5)
P-value°	0.638		0.149		0.913		>0.999	
Rehospitalization	79/191 (41.4, 19.6)	15//33 (45.5, 20.8)	26/74 (35.1, 23.4)	2/6 (33.3, 25)	46/102 (45.1, 21.3)	8/18 (44.4, 18.2)	7/15 (46.7, 9)	4/9 (55.6, 20)
P-value°	0.841		>0.999		0.911		>0.999	
Falls in the last 6 months	27/185 (14.6, 6.7)	10/33 (30.3, 13.9)	9/71 (12.7, 8.1)	1/6 (16.7, 12.5)	17/100 (84.7, 7.9)	5/18 (27.8, 11.4)	1/14 (7.1, 1.3)	4/9 (44.4, 20)
P-value°	0.081		0.579		0.519		0.056	

Follow up at discharge, after 3, 6 and 12 months for SOC and IMI and divided by MPI risk-group on admission. °Chi-Square or Fishers exact test for frequencies; *significant at 5%. SOC, standard of care; IMI, interdisciplinary multidimensional intervention; Q_1: First Quartile, Q^3: Third Quartile; MPI, Multidimensional Prognostic Index.

ber of falls within 3 months after discharge compared to the SOC group (Table 3).

Previous studies have underlined the influence of discharge planning on prognosis with patients being discharged home as an indicator for better survival.[2] In the present study, SOC patients were more likely to be discharged home while IMI patients more often transitioned into a geriatric rehabilitation facility. However, as admission to long-term care or rehospitalization rates did not differ consistently in follow up data, it appears that transition through a rehabilitation facility was not disadvantageous was not disadvantageous for IMI patients in the long-term. Concerning mortality, differences in survival rates were not consistent during follow up, therefore further longitudinal research is necessary.

Despite the below described limitations of the study, some hints on criteria for patients' allocation to multidisciplinary interventions might be discussed here. Firstly, IMI patients with a low functionality at baseline improved more in their prognosis compared to IMI patients with a higher level of functionality on admission, which is supported by previous studies that also found that low ADL scores on admission coincide with a higher functionality improvement after an intervention.[6,32] A similar development can be seen in patients in MPI-2 or MPI-3 on admission, although this is to be expected as patients of MPI-1 have a better MPI to begin with and therefore less possibilities to improve. Secondly, concerning the age of patients, it seems that the young-old patients (65 to 74 years) as well as the oldest-old (85+ years) profit the most, which is partly supported by previous studies that identified older patients as benefiting the most from a multidimensional intervention.[32]

The present analysis has several limitations. First of all, the retrospective nature limits its conclusions. However, the MPI_InGAH-study, in which all patients of this study participated, is of prospective nature and its data has been collected homogeneously, thus raising the quality of the measures analysed. Second, the IMI collective was relatively small with SOC patients outnumbering IMI patients by more than five to one, thus limiting the representativeness of older inpatient undergoing high-performance medicine as well as limiting comparability between both collectives. This limited comparability is enhanced by several statistically significant differences between both groups, such as initial MPI values, LHS and source of referral. However, the intra-IMI group results deserve a good deal of attention for their potential of encouraging the collection of data regarding the effects of comanagement between geriatricians and internists in older patients in need of high-tech organ medicine.

Finally and importantly, there is a selection bias between groups, as participants of the study were not randomly assigned to the intervention or control group but chosen according to clinicians' perspective as described above. However, despite this lack of randomization, the differences in Delta-MPI in IMI but not in the SOC group is highly suggestive of an IMI-related overall improvement of patients.

Conclusions

The overall health condition and multidimensional prognosis of older multimorbid patients in acute care appear to be beneficially impacted by a personalized multidisciplinary intervention. The effect appears more prominent for patients with poor multidimensional prognosis on admission and an age range characterizing the young-old and the oldest-old patient. In order to establish an intervention program that helps each individual patient and that targets individual deficits, a structured intervention beginning on the first day of hospitalization and with equal priority to conventional medicine should be implemented and evaluated in a randomized fashion.

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