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The effect of an interdisciplinary multidimensional intervention on the prognosis of older inpatients in a non-geriatric setting

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Franziska Maria Müller
aus Kassel

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Dekan: Universitätsprofessor Dr. med. G. R. Fink
1. Gutachterin: Universitätsprofessorin Dr. med. C. Polidori Nelles
2. Gutachterin: Privatdozentin Dr. med. G. Röhrig-Herzog

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List of abbreviations

ADL	Activities of Daily Living
AUDIT-C	Alcohol Use Disorder Identification Test
BI	Barthel Index
CIRS	Cumulative Illness Rating Scale
CGA	Comprehensive Geriatric Assessment
DEMMI	De Morton Mobility Index
DemTect	Dementia Detection Test
DOSS	Delirium Observation Screening Scale
DRG	Diagnosis-related groups
EFAS	Essener Fragebogen Alter und Schläfrigkeit
ESS	Exton Smith Scale
GCT	Geriatric Complex Treatment
GDS	Geriatric Depression Scale
GEMU, GEM	Geriatric Evaluation and Management Unit
GEU	Geriatric Evaluation Unit
GW	Geriatric ward
HG	Hand Grip Test
IADL	Instrumental Activities of Daily Living
IMI	Interdisciplinary multidimensional intervention
LHS	Length of hospital stay
MMSE	Mini Mental State Examination
MNA	Mini Nutritional Assessment
MOCA	Montreal Cognitive Assessment
MPI	Multidimensional Prognostic Index
OPS	Operationen- und Prozedurenschlüssel

RCT	Randomized Controlled Trial
SOC	Standard of Care
SPMSQ	Short Portable Mental Status Questionnaire
TUG	Timed Up and Go Test
VA	Veterans Administration

1. Zusammenfassung

Weltweit zeichnet sich ein zunehmendes Bevölkerungsaltern ab.[1] Dies vollzieht sich in Deutschland größtenteils auf der Basis von drei Entwicklungen: Dem Altern der *Baby Boomer Generation,*[2] der sinkenden Geburtenrate,[3] sowie stetig wachsendem medizinischen Fortschritt mit damit einhergehender höherer Lebenserwartung.[4] Dies bringt vielfältige Herausforderungen an das Gesundheitssystem mit sich, da diese Patienten nicht nur einen höheren Pflegebedarf aufweisen als jüngere Patienten,[5] sie machen ebenfalls einen Großteil der Hospitalisationen aus (**2.2. The ageing society as the challenge of modern healthcare**).[6] Die Behandlung geriatrischer Patienten unterscheidet sich grundlegend von der jüngerer Patienten, da ältere Menschen sehr oft zahlreiche Komorbiditäten aufweisen, oft unter *Gebrechlichtkeit (frailty)* leiden und weniger Ressourcen bieten können, um eine akute Krankheit zu bekämpfen (**2.3. Geriatric medicine and geriatric patients**).[7] Daher ist das Risiko von schlechten medizinischen Resultaten in geriatrischen Patienten besonders hoch und muss bei der Behandlung bedacht werden.[8] Zusätzlich zeigen Studien, dass ältere Patienten sich während der Hospitalisierung regelmäßig in ihrer Funktionalität verschlechtern und nach dem Krankenhausaufenthalt weniger selbstständig sind als zuvor.[9] Dies geht dementsprechend einher mit einer schlechteren Prognose und höherer Morbidität (**2.5.1. The hospitalized geriatric patient**).[10] Angesichts dieser Problematik hat sich ein ganzheitlicher Ansatz in der Behandlung geriatrischer Patienten bewährt.[11] So wird sichergestellt, dass nicht nur die individuelle Akutkrankheit, welche die Hospitalisation auslöste, behandelt wird, sondern sämtliche geriatrische Syndrome und Probleme identifiziert und adressiert werden.[12] Hierbei sollte, wenn möglich, auf zuvor identifizierte geriatrische Ressourcen zurückgegriffen werden.

Dieses ganzheitliche Konzept wird in dem *Geriatrischen Assessment* (*Comprehensive Geriatric Assessment*, CGA – **2.4. The Comprehensive Geriatric Assessment as basis for prognosis in older patients**) vertreten.[13] Das CGA dient der ganzheitlichen Einschätzung eines Patienten mit der anschließenden Behandlung der im CGA diagnostizierten Defizite, welche oft zuvor unerkannt waren.[14,15] Dementsprechend führt das CGA oft zur Diagnose bisher unerkannter Probleme und zum Erkennen eines schleichenden, potentiell ohne CGA nicht erkennbaren Verlustes der Funktionalität.[15]

Um die Ergebnisse eines CGAs in einem einzelnen repräsentativen und prognostisch aussagekräftigen Index zusammenzufassen, wurde der *Multidimensionale Prognostische Index* (MPI – **2.4.1. The Multidimensional Prognostik Index**) entwickelt.

Das dem MPI zugrundeliegende CGA setzt sich aus den folgenden Komponenten zusammen: Den Aktivitäten des täglichen Lebens (Activities of Daily Living – ADL)[16], den Instrumentellen Aktivitäten des täglichen Lebens (Instrumental Activities of Daily Living – IADL)[17], der Exton Smith Skala (Exton Smith Scale – ESS)[18], dem Mini Nutritional Assessment

(MNA)[19], dem Short Portable Mental Status Questionnaire (SPMSQ)[20], der Cumulative Illness Rating Scale (CIRS)[21], der täglichen Medikamentenanzahl sowie der häuslichen Lebenssituation.[22] Aus diesen Domänen wird ein Wert zwischen 0 und 1 berechnet, wobei ein höherer Wert mit einer schlechteren Prognose assoziiert ist.[22] Es werden folgende drei Risikogruppen voneinander unterschieden: Geringes Risiko (MPI-1, 0-0.33), mittleres Risiko (MPI-2, 0.34-0.66) und hohes Risiko (MPI-3, 0.67-1).[22]

Dieser Index wurde bereits vielfach sowohl im ambulanten als auch im stationären Setting validiert.[23] Er ist unter anderem assoziiert mit der Hospitalisierungsdauer,[24] der Anzahl geriatrischer Syndrome und Ressourcen,[25] dem Pflegegrad,[26] der Lebensqualität,[27] der Mortalität[28] und der Entlassdestination.[26]

Um den speziellen Bedürfnissen geriatrischer Patienten während eines stationären Aufenthaltes zu begegnen, haben sich zwei Konzepte der spezialisierten multidimensionalen geriatrischen Versorgung entwickelt: Geriatrische Stationen und mobile geriatrische Teams (**2.5.3. Geriatric interventions in an acute medical setting**). Bei beiden Formen wird die Behandlung überwiegend durch ein speziell geschultes Team aus verschiedenen Disziplinen gestaltet.[29]

Insgesamt haben sich geriatrische Stationen als erfolgreicher bezüglich unter anderem der Entwicklung der Mortalität, Funktionalität sowie Prävention von Heimplatzierung gezeigt.[30] In diesem Setting werden geriatrische Patienten in einem kontrollierten Umfeld mit einem interdisziplinären Team mit regelmäßigen Behandlungseinheiten betreut. Der Standard dieser Behandlung in Deutschland ist die *Geriatrische Komplexbehandlung* (GCT), bei der Patienten 14 Tage hospitalisiert bleiben und währenddessen zusätzlich zur akutmedizinischen Behandlung Physiotherapie, Ergotherapie und je nach Bedarf Logopädie, Diätberatung und soziale Unterstützung bekommen.[31,32]

Im Gegensatz dazu stehen geriatrische Interventionen, die nicht einer festen Station zugeordnet sind, sondern auf mobilen Teams basierend im gesamten Krankenhaus einsetzbar sind. In vergangenen Studien konnte jedoch nicht regelmäßig ein Vorteil gegenüber der Standardbehandlung dieser Art der Intervention gezeigt werden.[33,34]

Diese Arbeit widmet sich der Frage, ob ein Pilotprojekt in Form einer interdisziplinären multidimensionalen Behandlung (Interdisciplinary multidimensional intervention, IMI) auf einer internistischen Akutstation eine prognostische und/oder funktionelle Verbesserung in geriatrischen Patienten, gemessen anhand des MPIs und verglichen mit der Standardbehandlung (standard of care, SOC) erzielen kann.[35] Hierzu wurden retrospektiv die Daten von insgesamt 475 Patienten analysiert, welche zwischen August 2016 und Juli 2019 in der Klinik II für Innere Medizin – Nephrologie, Rheumatologie, Diabetologie und allgemeine

Innere Medizin der Universitätsklinik Köln, Deutschland, hospitalisiert waren.[35] Diese Patienten partizipierten alle in der prospektiven Studie „Influence of a Geriatric Assessment on hospitalization of older, multimorbid patients“ (MPI-InGAH) (**2.6. The Multidimensional Prognostic Index in an acute medical setting [MPI-InGAH]**).

Die Einschlusskriterien der MPI-InGAH-Studie waren ein Alter über 65 Jahren, Multimorbidität und die Zustimmung einer Teilnahme. Alle Patienten erhielten ein CGA sowohl bei Aufnahme als auch bei Entlassung sowie eine MPI-Kalkulation zu diesen Zeitpunkten. Außerdem wurde bei allen Patienten ein telefonisches Follow up nach 3, 6 und 12 Monaten durchgeführt, welches die aktuelle Lebenssituation, etwaige Stürze und Rehospitalisationen erfasste. Diese Studie zeigte eine Assoziation des MPI mit der Hospitalisierungsdauer, dem Pflegegrad, dem Vorhandensein von geriatrischen Syndromen und Ressourcen sowie der Entlassdestination.[26]

Das Pilotprojekt der IMI wurde 2016 etabliert (**2.7. The Interdisciplinary multidimensional intervention [MPI-Rehab]**). Das Ziel der IMI war die Prävention des Krankenhaus-assoziierten funktionellen Verlusts bei älteren Patienten. Um dies zu erzielen, wurde ein interdisziplinäres Team aus geriatrisch geschulten Pflegekräften, Physiotherapeut*innen, Ergotherapeut*innen, Logopäd*innen, Sozialarbeiter*innen und Apotheker*innen zusammengestellt, welches unter der Leitung von Geriater*innen und Ärzt*innen anderer Fachrichtungen gemäß der individuellen Therapieziele und Defizite der Patienten einen Behandlungsplan erstellte und umsetzte. Eine wöchentliche Teamsitzung sollte eine ständige Reevaluation des Therapieerfolgs und der Therapieziele gewährleisten.

Patienten wurden für die IMI ausgewählt, wenn sie einen drohenden Verlust der Selbstständigkeit und zunehmende Immobilität aufwiesen oder als *gebrechlich (frail)* kategorisiert wurden. Außerdem wurden Patienten ausgewählt, welche eine geschätzte Hospitalisierungsdauer von mindestens einer Woche hatten sowie das Potential und den Willen einer Verbesserung aufwiesen.[35] Außerdem musste die Fähigkeit der Kommunikation in der deutschen Sprache vorhanden sein sowie die mentalen Fähigkeiten, Anweisungen der Therapeuten zu verstehen und umzusetzen. Die IMI selbst bestand aus einer Kombination aus Physiotherapie und Ergotherapie, welche den Umfang der normalen funktionellen Therapie im Krankenhaus überschritt.[35] Hierbei war eine tägliche Therapieeinheit von 30 bis 45 Minuten Dauer das Ziel. Physiotherapeut*innen fokussierten sich auf eine Verbesserung der Mobilität durch Übungen für die Rumpfstabilität, die Lagetransfers sowie Sitz- und Gehtraining. Ergotherapeut*innen ergänzten dies mit weiteren Laufübungen und Ausdauerverbesserung sowie ADL- und Gedächtnistraining.[35] Bei Bedarf wurde die Behandlung um Logopädie, soziale Beratung sowie Optimierung der Medikation durch Apotheker*innen erweitert. Zur Einschätzung der individuellen Defizite lag den Therapeut*innen der bei Aufnahme erhobene

MPI mit seinen Subdomänen vor. Zusätzlich erfolgte die Erhebung zahlreicher geriatrischer Tests, welche die Basis für die weitere Therapie lieferten. Hierzu zählten die Geriatrische Depressionsskala (Geriatric Depression Scale, GDS)[36], der Timed Up and Go Test (TUG)[37], der Mini Mental State Examination Test (MMSE)[38], der Dementia Detection Test (DemTect)[39], der HandGrip Test (HG)[40], das Montreal Cognitive Assessment (MoCa)[41] sowie der de Morton Mobility Test (DEMMI)[42].

Der Datensatz der Patientenkollektive SOC und IMI wurde durch ein weiteres Kollektiv vervollständigt, welches auf einer geriatrischen Station des St. Marienhospitals Köln hospitalisiert war (*Geriatric ward,* GW – **2.8. The Multidimensional Prognostic Index in a geriatric unit [MPI-AGE]**). Dieses Kollektiv ist Teil einer großen internationalen prospektiv ausgerichteten Studie, deren Ziel es ist, den Nutzen einer CGA-basierten MPI Berechnung für ältere Patienten auf einer geriatrischen Station zu ergründen.[43] Die Patienten erhielten alle eine GCT sowie eine MPI-Kalkulation bei Aufnahme und bei Entlassung.

Die Analyse der hier zugrundeliegenden Daten zeigte eine positive Entwicklung des IMI Kollektivs im Vergleich zu SOC Patienten bezüglich MPI-Prognose und Funktionalität, gemessen an den Variablen MPI und ADL. Diese positive Entwicklung zeigte sich vor allem in MPI-2 und MPI-3 Subkollektiven, während sich die IMI Patienten in MPI-1 im Vergleich zu SOC in MPI und ADL verschlechterten. Dies ist überraschend, da es nicht zu erwarten war, dass eine Behandlung wie die IMI mit einer Verschlechterung der Prognose assoziiert sein könnte. Es ist jedoch zu bedenken, dass IMI Patienten eine deutliche längere Verweildauer vorwiesen als SOC Patienten. Es lässt sich daher diskutieren, ob Patienten mit einer verhältnismäßig guten Prognose entsprechend MPI-1 durch eine längere Verweildauer mit den damit verbundenen Komplikationen trotz intensivierter funktioneller Behandlung eher Nachteile erfahren im Vergleich zu Patienten mit einer schlechteren Prognose bei Aufnahme.[44]

Die Ergebnisse der Follow up-Analyse ließen keine klare Aussage bezüglich der Mortalitätsentwicklung zu, da sowohl IMI als auch SOC Patienten je nach Subkollektiv einen Vorteil in der Mortalität aufwiesen. Eine Cox Regression zeigte keine Auswirkung der Kollektivzugehörigkeit auf die Mortalität. Daher sind weitere Studien notwendig, um eine sichere Aussage bezüglich eines etwaigen Einflusses der IMI auf die Mortalität der Patienten zu treffen.

Vergangene Studien haben gezeigt, dass geriatrische Behandlungen einen protektiven Effekt auf die Entlassdestination haben können.[45] Der Vergleich unserer Kollektive ergab jedoch, dass SOC Patienten mit höherer Wahrscheinlichkeit nach Hause entlassen wurden, während IMI Patienten öfter in einer geriatrischen Rehabilitationseinrichtung platziert wurden.

Die Rehospitalisationsraten und Heimplatzierungsraten unterschieden sich allerdings nicht signifkant, weshalb keine sichere Aussage bezüglich der Auswirkung der IMI auf die Entlassdestination getroffen werden kann.

Es zeigte sich außerdem, dass sich IMI Patienten der Risikogruppen MPI-2 und MPI-3 sich in ihrem MPI und einigen seiner Subdomänen im Vergleich zu IMI Patienten der Gruppe MPI-1 verbesserten (**4.2. Patient selection**). Da der MPI bereits in seiner Identifikation von *frailty* validiert wurde und *frailty* und *pre-frailty* mit den Risikogruppen MPI-2 und MPI-3 korreliert,[23,46] kann man dementsprechend vermuten, dass gebrechliche Patienten und Vorstufen hiervon eher von einer IMI profitieren. Eine ähnliche Entwicklung konnte in den Untergruppen ADL-2 und ADL-3 gesehen werden, da IMI Patientin dieser Risikogruppen sich verbesserten im Vergleich zu IMI Patienten mit geringerer funktioneller Einschränkung entsprechend ADL-1. Außerdem schienen die Patienten der Altersgruppe der über 85-Jährigen sowie der 65 bis 74-Jährigen besonders von der Behandlung zu profitieren.

Es konnte kein Zusammenhang der Prognose oder der Funktionalität mit der Anzahl der Therapien oder der Dauer der IMI festgestellt werden.

Es müssen einige Limitationen der vorliegenden Studie bedacht werden. Zum einen handelt es sich um kleine Patientenkollektive, vor allem wenn man das Gesamtkollektiv nach MPI-Risikogruppen aufteilt. Dementsprechend sind weitere Studien mit einer ausreichenden Patientenanzahl notwendig.

Zum anderen liegt eine Auswahlverzerrung vor, da die Patientin nicht in die jeweiligen Behandlungsgruppen randomisiert wurden, sondern von dem interdisziplinären Team anhand der oben aufgelisteten Kriterien zugeteilt wurden. Dies spiegelt sich in den signifikanten Unterschieden zwischen den Kollektiven bei Aufnahme wider (**3.1. Published Original Results**). Die Vergleichbarkeit ist daher eingeschränkt.

Außerdem handelte es sich bei dieser Studie um eine retrospektive Datenanalyse, welches die Aussagekraft der Daten allein aufgrund der Studienart reduziert. Hierzu muss ergänzt werden, dass bereits während der IMI-Laufzeit eine randomisierte, prospektive Studie eingeleitet wurde, welche diese Limitationen nicht aufweist (*„Vun nix kütt nix“,* **5. Outlook**).

Im Vergleich der SOC und IMI Patienten mit dem GW Kollektiv zeigte sich, dass GW Patienten insgesamt eine schlechtere Prognose gemessen am MPI aufzeigten als IMI und SOC Patienten. Bezogen auf die Entwicklung des MPIs konnte gezeigt werden, dass GW Patienten aus der Subgruppe MPI-1 sich signifikant im Vergleich zu IMI verbesserten, während IMI Patienten aus MPi-2 und MPI-3 den GW Patienten überlegen (**4.4. Geriatric interventions in an acute geriatric setting**). Dies steht im Kontrast zu dem aktuellen wissenschaftlichen Stand, welcher eine Überlegenheit von geriatrischen Stationen gegenüber geriatrischer

Behandlung auf Normalstationen besagt.[33] Hierbei muss man allerdings erwähnen, dass die Vergleichbarkeit dieser drei Kollektive ebenfalls eingeschränkt ist, da die Behandlungen in verschiedenen Krankenhäusern stattfanden und keine Randomisierung erfolgte. Daher sind Schlüsse aus diesen Ergebnissen mit Vorsicht zu ziehen.

Sowohl IMI als auch GW Patienten zeigten eine funktionelle Verbesserung gemessen am ADL-Wert im Vergleich zu SOC Patienten, jedoch waren sie bei Aufnahme in ihrer Funktionalität deutlich eingeschränkter, sodass womöglich mehr Potential zur Verbesserung bestand als bei SOC Patienten.

Zusammenfassend kann man aufgrund der hier vorliegenden Studie sagen, dass sich eine positive Entwicklung der IMI Patienten im Vergleich zu SOC Patienten abzeichnet, vor allem in den Subgruppen MPI-2 und MPI-3 sowie bei Patienten mit einer stark eingeschränkten Funktionalität bei Aufnahme. Bei diesen Subgruppen konnte im IMI Kollektiv eine signifikante Verbesserung der Prognose sowie der Funktionalität verglichen mit der Standardbehandlung erzielt werden. Angesichts der oben aufgeführten Limitationen sind diese Schlüsse mit Vorsicht zu ziehen, da es sich vor allem um ein kleines Patientenkollektiv mit Auswahlverzerrung und fehlender Randomisierung handelt. Eine klare Aussage bezüglich des Vergleichs der IMI Patienten mit Patienten auf einer geriatrischen Station lässt sich ebenfalls nur vorsichtig treffen. Die vorliegenden Daten suggerieren einen vorteilhafte Entwicklung der IMI Patienten gegenüber GW Patienten, welches angesichts des aktuellen Forschungsstands allerdings durch weitere Studien untersucht werden müsste.

Bisherige Studien konnten nicht durchgehend einen vorteilhaften Effekt der Behandlung durch mobile geriatrische Teams auf Normalstationen zeigen.[47,48] Vor allem verglichen mit der multidimensionalen Behandlung auf geriatrischen Stationen war Letztere den Teams meistens überlegen. Die vorliegende Studie ist nach unserem Wissen die Erste, die den Effekt einer solchen Behandlung an einem multidimensionalen Index wie dem MPI misst. Die vielversprechenden Resultate unserer Studie sowie der Fakt, dass nicht alle geriatrischen Patienten, die von einer Behandlung wie der IMI oder einer geriatrischen Komplexbehandlung profitieren könnten, diese auf einer geriatrischen Station erhalten können, zeigt die Wichtigkeit weiterer Studien bezüglich mobiler geriatrischer Teams auf. Unsere Studie legt nahe, dass vor allem Patienten mit schlechter initialer Prognose sowie schlechter Funktionalität bei Aufnahme eine Verbesserung durch die IMI erfahren können. Dies könnte in Zukunft bei der Auswahl von Patienten und der damit verbundenen bestmöglichen Ressourcennutzung helfen. Weitere Studien vor allem auch mit der konsequenten Durchführung der Therapien sowie geriatrischer Tests zur Identifizierung von Problemen und zur Verlaufskontrolle sind notwendig, um bestmögliche Aussagen bezüglich der idealen Zusammensetzung und der Zielsetzung eines solchen Teams sowie der Patientenauswahl zu treffen.

Um den Effekt einer geriatrischen multidimensionalen Behandlung ohne die oben aufgeführten Limitationen zu untersuchen, wurde an der Universitätsklinik Köln bereits die nächste Studie ins Leben gerufen. *„Vun nix kütt nix“*, kölscher Dialekt für „Von nichts kommt nichts“, ist eine Studie auf einer neu eingerichteten geriatrischen Station der Universitätsklinik. Hier erfolgt eine Behandlung ähnlich zu der der IMI, nur unter kontrollierten Bedingungen und mit gleichem Stellenwert der geriatrischen Interventionen zu medizinischen Behandlungen und Untersuchungen. Außerdem erfolgt bei Einschluss der Patienten eine Randomisierung, sodass die meisten Limitationen unserer Studie beseitigt werden konnten. Die Ergebnisse dieser Studie werden mit Spannung erwartet, denn sollten die vorliegenden Ergebnisse reproduziert werden können, kann der MPI als valides Messinstrument für den therapeutischen Erfolg einer geriatrischen Behandlung gebraucht werden und es kann weiter an dem bestmöglichen Behandlungsstandard für geriatrische Patienten gearbeitet werden.

2. Introduction

The past two years have been shaped by remarkable scientific research. Since the WHO officially declared the outbreak of Sars-CoV-2 as a pandemic on March 11th 2020,[49] and as the whole world suffers from the effects of the global Sars-CoV-2-pandemic, every country turns to its virologists, epidemiologists and other scientific researchers for answers, innovations and solutions. One of the population groups which has suffered most from the situation is undoubtedly the older population, as they must fear the virus more than others due to their high risk of severe COVID-19 symptoms, hospitalization and death.[50–52] Current research suggests that amongst other factors, frailty and biological age are leading indicators of potential adverse outcomes in COVID-19 affecting older people and not chronological age.[52–54] Taking into account the high prevalence of frailty among older adults, this results in a large group of patients with a high mortality risk.[52,53] By the beginning of January 2022, Germany had recorded roughly 113.000 COVID-19-associated deaths.[55] Of these deaths, more than 95.000 were of patients aged 70 years and above.[55] Life expectancy in Germany, for the first time since 2007, did not rise in 2020 due to the increased death rates of Sars-CoV-2 infected people.[56] The life expectancy for people aged over 65 did not change either.[56]

In addition to higher mortality rates, long-term health problems often referred to as *Long COVID* are not uncommon in patients hospitalized for the illness.[57] Furthermore, many more older people suffer from social isolation as nursing homes banned or strictly limited visitors and social activities were shut down.[58] This coincides with its own problems, like functional and mental decline, higher prevalence of frailty as well as a higher morbidity and mortality.[59–61]

In the current situation where older people are at high risk due to infection and hospitalization, it is even more important to continue upholding the best possible medical care for geriatric patients in an inpatient as well as outpatient setting.[62] Therefore, in the face of global challenges like the pandemic combined with worldwide population ageing, continuing research into methods that result in the best possible prognosis of geriatric patients and limit hospital-associated risk factors should be continued as much as possible in present times. We are happy to contribute new findings to the emerging field of Geriatrics.

2.1. History of Geriatrics

Look at the patient lying long in bed

What a pathetic picture he makes.

The blood clotting in his veins,

The lime draining from his bones,

The scybola stacking up in his colon,

The flesh rotting from his seat,

The urine leaking from his distended bladder,

And the spirit evaporating from his soul.

Teach us to live that

We may dread unnecessary time in bed.

Get people up and we may save

Patients from an early grave.[63]

This poem, which was composed by British physician Dr Richard Asher in 1942, stems from a time that most consider the beginning of modern geriatric medicine. Up to the early 1930s, geriatric patients would, when hospitalized, simply lie in bed and be destined for institutionalization after treatment of acute illness.[64] This changed when Dr Marjory Warren, also a British physician and today considered the mother of geriatric medicine, recognized the hazardous effects bedrest, immobility and depression, amongst others, can have on the development and prognosis of older patients.[65,66] She criticized the existing management of older hospitalized patients, who were often seen as merely a burden and who were not properly diagnosed and treated and therefore remained disabled after hospitalization.[15] Furthermore, she campaigned for specialized wards to be implemented for the treatment of geriatric patients. These wards were to be then staffed by interdisciplinary teams bringing “optimism and hope”[65] in addition to individual treatment to patients, thereby setting the groundwork for modern geriatric medicine and geriatric rehabilitation.[64]

Dr Warren’s methods were characterized by a multidimensional approach to the evaluation and treatment of a geriatric patient: the assessment of the medical, psychological and social status as well as the rehabilitation potential in addition to the acute medical problem that led to hospitalization.[67] These proceedings often led to the diagnosis of already existing and treatable medical problems that had been overlooked by standard care. The following treatment of these problems resulted in beneficial health outcomes compared to standard care, which laid the groundwork for geriatric rehabilitation facilities and for the establishment of a geriatric assessment.[68] Over time, Dr Warren's approach was incorporated into standard geriatric practice in Britain, and included a program known as *progressive geriatric care*, which assessed every geriatric patient in a specialized ward unless the patient had been admitted into intensive care. After concluding that acute care was necessary, and if the patient was not ready to be discharged home, the aim was to transfer patients to a geriatric rehabilitation ward or facility for further treatment and rehabilitation.[69,70]

Dr Warren was one of the first who stipulated that Geriatrics was a specialized field.[65] Over time, support for this opinion grew as physicians realized the full difficulty of giving older patients the specialized care they deserved without the appropriate basic surroundings.[71] First used by Ignatz Leo Nasher in 1909 with the plea for a more specific approach to treating older patients, the term G*eriatrics* derives from a combination of the Greek words for old age *(geras)* and medical *(iatrikos)*.[63,72] Throughout the 20th century, geriatric medicine was established in Great Britain and consequently as a subspecialty worldwide, leading to the foundation of, for example, *The American Geriatrics Society* in 1942, among others, and the publication of first editions of presently renowned geriatric journals.[63] Later, Dr Warren's model geriatric clinics and programs were established in the United States of America, with a driving force being the *Veterans Administration (VA)*.[63] The VA recognized the need for improved geriatric care for its ageing veterans and, as a consequence, implemented teaching and fellowship programs at universities and shaped the concept of interdisciplinary teams, assessments and geriatric units.[63,73]

At that time, only a few individuals delved into the new concept of Geriatrics in Germany. Max Bürger founded the *Deutsche Gesellschaft für Altersforschung* in 1938, which laid the groundwork for the founding of the first chairs for Gerontology and Geriatrics in the cites of Leipzig in 1969 and Erlangen in 1970, the development of the *Deutsche Gesellschaft für Gerontologie* in the former East and West Germany and finally the *Deutsche Gesellschaft für Gerontologie und Geriatrie* in 1991.[74]

Since the 1970s, when the subject first reached clinical relevance in Germany, progress in the establishment of Geriatrics as an essential part of clinical care has been slow.[75] As Geriatrics is characterized by its interdisciplinary nature and its lack of lucrative machine-based diagnostic, it has been a long, difficult and ongoing progress for the subject to take root in Germany.

Today, geriatric care in Germany can be distinguished in two ways: firstly by the manner of care – i.e., acute care and rehabilitative care, and, secondly, the method of care setting – i.e. inpatient, partly inpatient or outpatient.[76]

The subject of Geriatrics is not represented as an individual department in all medical schools in Germany. In 2021, there were 14 chairs for Geriatrics and two university clinics for Geriatrics in Germany.[77] Overall, geriatric treatment accounts for over 17,500 hospital beds in Germany, distributed into 309 departments for acute geriatric care, as well as more than 8,000 beds in 161 departments for geriatric rehabilitation.[78,79] However, many patients that are characterized as geriatric are not hospitalized in geriatric wards, but in wards of other specialties according to the dominating illness that led to hospitalization. Foremost among these are the medical fields of neurology, internal medicine, general surgery and trauma surgery.[76] This highlights the need for an interdisciplinary approach to geriatric treatment which, in the best case, is led and supported by specially trained geriatric personnel.

As of 2020, about 2.900 physicians had undergone the necessary training in order to receive the title of *geriatrician*, which was an increase of 7.6% compared to the previous year.[80] In three German states, Geriatrics is recognized as a subspecialty of internal medicine, and geriatricians can receive the title of *Facharzt für Innere Medizin und Geriatrie* if they choose to complete their training in both subjects - internal medicine and Geriatrics.[81] In the other thirteen states, Geriatrics is only a supplementary field and not a specialty in itself.[82]

However, even though the absolute number of geriatricians and other specially trained personnel is rising, it is not doing so at a rate which reflects the number of patients in need of geriatric care.[83] Overall, there are still very few geriatricians compared to the increasing number of patients who are reaching the age of 65 and above. Morley showed that the number of geriatricians per 10,000 people aged over 65 ranged somewhere between a half to two in developed countries, with countries like France and the UK faring the best with about two geriatricians per 10,000 people over the age of 65.[83] This shortage of trained geriatric personnel means that many geriatric patients are still treated singularly by medical professionals who have not been specifically trained to deal with the accumulating challenges a geriatric patient poses, which results in sub-optimal care.[84]

Today, Geriatrics has been able to establish itself as an important and emerging field of medicine and research worldwide, and it is continuously growing. When searching *PubMed*, the term G*eriatrics* yields over 19.000 results published in the year 2021 – that is more than five times the number of manuscripts published per year at the beginning of the century. This shows that the growing field of Geriatrics in an ageing society of the 21st century is just as present and important as it was for Dr Asher and Dr Warren 80 years ago.

2.2. The ageing society as the challenge of modern healthcare

Population ageing is a worldwide phenomenon that has shaped the 20th century and is rising steadily in the 21st century, with countries like Japan, Australia and Italy showing the highest trend of ageing demographics.[1,85] In 2015, 8.5% of the world's population was aged over 65 years. By 2030, it is assumed that that number will increase by over 50%, meaning that over one billion people will be aged 65 and above.[86] This number will rise to approximately 1.5 billion in 2050.[87]

An ageing society is also the trend in Germany. In 2019 the average age of a German citizen was 45.6 years, 1.3 years more than in 2010.[88] A girl born in Germany today can expect to live to the age of 83.6 years and a boy to the age of 78.9 years, which is more than 14 years longer than children born in 1950.[89] This trend is expected to continue to some degree, as forecasts predict a rise of life expectancy in Germany for both genders by more than four years until 2060.[89]

This demographic change is largely the result of three developments: Firstly, the so-called *baby boomer generation*, those born between 1946 and 1964, is reaching retirement age. The percentage of citizens over the age of 65 has risen from 15% in 1991 to 22% in 2019 – in a European comparison, only Italy shows a higher percentage of over 65-year-olds.[6] Notably, the age group of the *oldest-old* (85 years or older) doubled during that time frame up to 2.4 million German citizens in 2019.[2] This makes the age group of the oldest-old the fastest growing population subgroup.[90] By 2030, it is estimated that a larger part of the labour force will be made up of 64 to 75-year-olds than of workers under the age of 20.[91]

Secondly, a declining birth rate has led to fewer children in relation to the growing older population. The birth rate in Germany dropped to an all-time low of 1.24 children per woman in 1994, although it has stabilized at about 1.5 children per woman in the last few years.[3] By comparison, the worldwide average birth rate is 2.41 children per woman, with Germany in place 206 from 227 nations worldwide.[92] Between 1975 and 2015, the German *Statistische Bundesamt* observed a change in demographics: people under 15 had, until then, always outnumbered the generations above 65 years of age. Since 2015, however, this ratio has reversed, with the number of seniors over 65 outnumbering children under 15 years of age in Germany.[6] This development has been observed in several countries worldwide.[93]

Finally, pioneering research in every field of medicine in the last century has led to the discovery of new disease and treatment options. This has resulted in a drastically increased life expectancy worldwide, which is mostly because of decreased mortality in younger years in developing nations and in increased life expectancy in richer nations.[4] Today, according to the German *Statistische Bundesamt*, a person of the age of 60 still has a remaining life expectancy of over 21 (men) and over 25 (women) years, which is about double the life expectancy at that age compared to 1880 and more than three years longer than in the 1990s.[6,94] The life expectancy of people over 80 years of age has also increased by two years.[95]

This trend of population ageing presents a big challenge for health care systems worldwide as the growing age groups are those that are most likely to suffer from multimorbidity and/or disability. The prevalence of certain chronic diseases is growing due to increased life expectancy, although the diseases themselves are often no longer as disabling as they were in the past.[96,97] This is due to an improved diagnostic process, better treatment options and socioeconomic changes.[1,98] Therefore, the years lived with moderate health issues have increased for many patients compared to the years lived with severe health issues.[99,100] Despite this trend, the number of years overall that people spend with disease and disability is high due to the increased life expectancy and the higher number of older people, which leads to higher costs for the health care system.[97,101]

While the quality of life that geriatric patients spend towards the end of their lifespan might have improved due to the developments listed above, the often chronic and non-communicable diseases that geriatric patients display are the cause of a high percentage of health care costs.[102] Cardiovascular diseases alone are the cause of about 20% of all health care costs for patients over the age of 65.[102] Furthermore, high obesity rates in all age-groups in the 21st century pose a new danger to healthy ageing.[103] It is expected that the global burden of disease will continue to increase, which is mostly due to the worldwide increased life expectancy.[104] Today, 23% of the worldwide health burden is caused by people over the age of 60.[5] In particular, the increase of the population of the oldest-old, who are more likely to suffer from disabling diseases and require higher nursing needs, has contributed to this rising disease burden.[5,105] The overall number of people in need of nursing has also risen steadily since the early 21st century, with the increase getting higher each year. In Germany, the number of people in need of care rose from 2.5% in 2003 to 3.3% in 2013.[6] According to the German *Statistische Bundesamt*, while only 8% of people aged between 70 and 75 years are in need of care, that number is as high as 76% for over 90-year-olds.[106] In 2019, the *Statistische Bundesamt* determined that 80% of all patients in need of care were over 65 years of age.[106] Furthermore, 34% of patients in need of care were over 85 years of age, and this number is expected to increase to 50% by 2030.[106,107] As nursing homes cannot accommodate the rising number of people in need of care, more people are being cared for at home by relatives, live-in care providers or outpatient care services.[106] A survey showed that 56% of people in need of care were cared for at home by relatives.[106,108] However, higher mobility in the 21st century has meant that children often do not live in the vicinity of their parents when the latter reach an age when they require assistance, making them dependent on professional care.[107] The number of people being cared for in permanent nursing homes increased by 24.5% from 2005 to 2019, and outpatient nursing services increased by as much as 108%.[109]

Furthermore, patients over the age of 65 made up 43% of all hospitalized patients in Germany in the year 2014.[6] In that same year, a survey by the German *Robert-Koch-Institut* determined that almost 26% of patients over 65 years of age had been hospitalized in the previous twelve months, which was an increase of more than 2.5% in five years.[110] The most common causes of hospitalization of the over 65s are cardiovascular problems, followed by tumours and gastrointestinal problems in men, musculoskeletal problems in women and problems caused by external factors like poison and injury.[6] With more people of geriatric age groups in society, the number of hospital days for those age groups is projected to increase.[111] This increase in hospitalization and nursing needs, particularly in the oldest-old, as well as a higher prevalence of multimorbidity and frailty (see 2.2.) in the growing age group of older people, has resulted in a large financial burden on the health care system.[87,102,112–114]

The health care system in Germany is based on the welfare state principle, with all citizens socially insured in either a public or private health insurance.[101] With 73.3 million members, the public health insurance is responsible for health care for the vast majority of German citizens.[115] The insurance contribution that each insured citizen has to pay is calculated as a certain percentage of his or her income up to a certain threshold above which the costs cease to rise.[101] This is also the case for retired people, who pay a certain percentage of their pension into the public health insurance of their choice unless they are members of a private health insurance.[116] However, as the statutory pension levels tend to be low, the insurance contribution of retired persons is comparably low when considering that people over 65 years of age are responsible for a large part of the expenses of public health insurance. Therefore, younger working people subsidize the health expenses of older people through their own insurance contributions.[101] As the baby boomers retire and the birth rate continues to remain low, this poses a problem: there are fewer younger people to stem the increasing costs of an ageing society.[101]

In conclusion, population ageing is a worldwide phenomenon that is shaping demographics, medicine, and health care systems worldwide and will continue to do so in years to come. The trend of an ageing society coincides with more people in need of nursing, hospital care and other support, which puts a burden both on the individual as well as society as a whole.

2.3. Geriatric medicine and geriatric patients

For a long time, the treatment of older patients not considered to be a specialty. Consequently, elderly patients were treated in the same wards and according to the same principles as their younger counterparts.[72,83,117] However, a geriatric patient is not characterized merely by his chronological age: one 75-year-old patient could still be able to live on his own and be completely independent in everyday life, while another 70-year-old patient might require extensive treatment, a rehabilitation plan as well as home care.[118] A geriatric patient, therefore, is characterized by a combination of different multidimensional factors and deficits rather than chronological age.[119] There are several distinct attributes in which a geriatric patient differs from younger patients who might be hospitalized for the same illness. For instance, Abraham et al. compared geriatric patients and non-geriatric patients hospitalized for myocardial infarction and determined that the geriatric patients required a significantly higher length of hospital stay (LHS), had a higher complication rate and needed more nursing and therapeutic resources than the younger patients.[119] The risk of adverse health outcomes is higher in old age, as a higher prevalence of frailty, multimorbidity and disability cause problem patterns that are not found in younger patients and which coincide with reduced physiological repair functions in response to stress and illness.[7,8] Furthermore, diseases present themselves with different symptoms in older patients than in younger ones, increasing the challenge of the diagnostic process.[86,120] The fact that older people are often excluded from clinical studies because of their age makes it even more difficult to treat geriatric patients in alignment with best evidence-based medicine.[121,122]

According to Marengoni et al., the percentage of multimorbidity, i.e., the presence of two or more diseases, in older people over the age of 65 is between 55% and 98% worldwide.[123] Van den Bussche et al. determined that 73% of Germans of that age group are multimorbid.[124] Multimorbidity is strongly associated with a high dependency, a low quality of life and bad health in general.[114,125] The diagnostic process is often complicated as typical disease-specific symptoms are frequently absent in older people and are replaced by a decline in cognitive status or functionality that may lead to falls, delirium or simply fatigue, or weight loss.[14] Consequently, diseases and problems in older patients are often underdiagnosed.

Diseases in geriatric patients often present themselves in so called "patterns", meaning certain diseases regularly coincide with one another.[126] This is worth noting, as the sum of harm done by individual diseases can be outweighed by the harm that is done by the simultaneous occurrence of those diseases.[126] Currently, modern health systems are largely based on the diagnosis and subsequent treatment of individual diseases. Due to the high prevalence of multimorbidity in older patients, this principle is not ideal in geriatric medicine, as a multidimensional and holistic approach is needed.[12]

In addition to the increase of multimorbidity, it is also important to mention frailty and disability. Frailty describes a status of increased vulnerability to stressors due to an accumulation of reduced function of body systems and a lack of reserves in old age.[127] Cregg et al. describe frailty as "a consequence of age-related decline in many physiological systems, which collectively results in vulnerability to sudden health status changes triggered by minor stressor events".[127] Several models have been proposed to assess frailty more specifically. Linda Fried’s model proposed a *phenotype* for frailty consisting of the presence of weight loss, weakness, fatigue, reduced walking speed and low activity.[128] Rockwood et al. proposed a so-called *deficit accumulation model* to assess frailty, in which a frailty index is calculated by including the presence or absence of diseases, symptoms and other “deficits” into the calculation.[129]

The terms multimorbidity, disability and frailty are often used synonymously - however, they describe different phenomenons.[7] Multimorbidity is defined as the presence or absence of diseases and does not necessarily have to be used in a geriatric setting. Disability describes the state where a person can no longer perform necessary tasks in everyday life.[128] By contrast, frailty is mostly a geriatric term that describes a patient in a more comprehensive, multidimensional way, looking past the diagnosed diseases at the person as a whole.[130] Therefore, multimorbidity can be a precursor of frailty, while disability is a potential result of frailty.[128] Furthermore, certain combinations of simultaneously occurring diseases and multimorbidity patterns are associated with a higher frailty prevalence than others.[131]

According to Dent et al., frailty is the leading cause of high morbidity and early death in older patients.[132] It is associated with a higher likelihood of falls,[133] lower gait speed,[134] higher and premature mortality,[133] lower quality of life,[135] loss of Activities of Daily Living (ADL),[133] loss of physical function[133] and increased number of hospitalizations,[133] to mention a few.[127,128,130,136] Assessing frailty can help identify older patients in need of further geriatric care by implementing a holistic approach to a geriatric patient.[5,137] This is especially important when considering that, as the number of older geriatric patients increases, not all of them are in need of specialized geriatric treatment.

In Germany, Santos-Eggimann et al. determined that 12.1% of community-dwelling adults aged 65 and above were frail and 34.6% were prefrail,[138] which is supported by other studies.[139] Women seem to be more likely to be frail while displaying a lower in-hospital mortality than men, and the prevalence of frailty increases with higher age.[138–140] Frailty prevalence tends to also be higher in hospitals, with the prevalence measuring between 24.7% and 80%.[141–143] However, as there is still no standardized way of assessing frailty, specification on the prevalence of frailty in different settings still varies a lot from study to study.[138,144]

The importance of determining frailty in older patients has increased since the COVID-19 pandemic has spread worldwide. Current studies suggest that frailty increases the risk of severe COVID-19.[52,54]

Over time, these individual characteristics of geriatric patients were identified and ways to address them were implemented. Consequently, the key components of the field of Geriatrics have developed as follows:[11]

- *Comprehensive Geriatric Assessment* (CGA, see 2.4.). This is defined as “the identification and documentation of medical, physical, social and psychological problems”[145] of a geriatric patient with subsequent targeted treatment.[15,33,145] The CGA is based mainly on the pioneering work of Rubenstein and colleagues, who found that CGA-based treatment in specialized wards with individually targeted geriatric medicine can improve health outcomes such as functionality, discharge destination and diagnostic accuracy.[30,146]
- Individual multidimensional and interdisciplinary interventions (see 2.5.). These address the deficits found in a CGA.[11]
- Input at point of care by a specially trained interdisciplinary team working closely together.[11]

In conclusion, Geriatrics is still an emerging field of medicine in Germany, with ever growing scientific insights. A patient should not be defined as geriatric simply because of chronological age. Many different factors determine whether a patient should be considered *geriatric* and in need of further geriatric consultation and treatment. The main characteristics of geriatric patients are the high prevalence of multimorbidity, disability and geriatric syndromes like frailty and the limitations in everyday life that these entail. Treating separate diseases does not suffice when it comes to geriatric medicine, as the patient must be seen as a whole and not only as a co-existence of diseases. This focus on a multidimensional and holistic approach is indicative for geriatric medicine and should be included in every aspect of its implementation. The following chapter addresses one of the main instruments with which such an approach is possible, namely the Comprehensive Geriatric Assessment.

2.4. The Comprehensive Geriatric Assessment as basis for prognosis in older patients

As described above, frail older patients often suffer from numerous problems simultaneously, resulting in a complex situation that makes the appraisal of the patients' overall status and the diagnosis of all underlying diseases difficult even for trained geriatric personnel.[147] However, many problems for which geriatric patients are hospitalized, such as mental decline or repeated falls, often have specific causes that might be addressed through targeted individual treatment.[146]

A multidimensional approach that includes many different domains in the form of a geriatric assessment can, therefore, help provide an adequate overview of a patient's problems and help discover hazardous developments like functional deterioration.[148] The most common and established form today is the CGA, the idea of which is based on the philosophy of Marjory Warren described above. It has developed into a worldwide used diagnostic and therapeutic tool in the treatment of older patients that provides the multidimensional aspect needed in Geriatrics.[14,33,149]

The individual deficits determined in the assessment can consequently be addressed in a treatment plan based on the said deficits, thereby adding a therapeutic aspect to the CGA in addition to its diagnostic aspect.[15,33,145] The use of standardized and validated assessment tools makes the CGA easy to implement and teach.[150] It also facilitates the understanding of a patient's status by medical professionals who may not have been involved in the original CGA themselves, as instruments are used that are universal, reliable and well known.[151] The German guideline for a geriatric assessment stipulates the following domains that can be assessed:

- Functionality and independence, evaluated, for example, by the Activities of Daily Living (ADL), the Barthel Index (BI) and/or the Instrumental Activities of Daily Living (IADL)[152]
- Mobility, measured by mobility scores like, for example, the Timed Up and Go Test (TUG) or the de Morton Mobility Index (DEMMI)[152]
- Cognitive function, assessed by scores like the Mini Mental State Examination (MMSE) or Dementia Detection Test (DemTect)[152]
- Likelihood of delirium, assessed by scores like the Delirium Observation Screening Scale (DOSS)[152]
- Presence of depression, measured, for example, by the Geriatric Depression Scale (GDS)[152]
- Social situation and living situation[67,152]

- Presence of pain according to pain measurement instruments[152]
- Nutritional status, assessed by, for example, the Mini Nutritional Assessment (MNA)[152]
- Sleep patterns, assessed by, for example, the Essener Fragebogen Alter und Schläfrigkeit (EFAS)[152]
- Substance addiction, assessed by the Alcohol Use Disorder Identification Test (AUDIT-C) or the CAGE-Questionnaire,[152] the name of which is an acronym for its four questions.

The tests and assessments of importance for this study are described in detail at a later point.

The CGA's systematic approach to a patient often leads to the diagnosis of so far unnoticed and untreated diseases and often reveals inadequacies in the patient's medication.[15] It can also call attention to gradual functional decline that older patients often suffer from but which is underdiagnosed due to its slow progress.[153] An early detection by a CGA can help identify and possibly treat the underlying cause of the decline.[153]

The goals of the CGA-based treatment plan should be set in collaboration with the patient with a focus on his individual aims, and subsequent therapy can serve to control success.[145,154] The CGA is usually implemented by an interdisciplinary team of specially trained professionals that is typically made up of physicians, nurses and social workers and according to need and availability is complemented by occupational and physical therapists, psychologists, pharmacists, dietetics, dentists and audiologists.[67,145]

Laurence Rubenstein and his colleagues, in particular, pioneered the development and validation of the CGA in the United States of America by establishing what was to be known as *Geriatric Evaluation Units* (GEUs), or *Geriatric Evaluation and Management Units* (GEMs or GEMUs) in *Veterans Administration* (VA) hospitals throughout the United States.[155] In the first randomized controlled trial (RCT) on this subject, they analysed the effect of the CGA in a GEU compared to standard care and established its benefits which included a reduction of mortality rates, improved functionality, an accelerated discharge and reduced medication.[30,146,156,157] Some of these benefits were shown to persist for at least two years.[156] In 1985, a geriatric unit performing CGA on patients in acute care could be found in more than half of American medical schools.[158] However, due to the high costs of establishing such a GEU, it took several decades until GEUs were established outside of the VA hospitals despite their proven benefits.[159]

Since the early trials, the CGA has been repeatedly validated. In a first meta-analysis, Stuck et al. determined that a CGA has beneficial effects in reducing mortality compared to standard care, especially when conducted in specialized wards with ensuing rehabilitation.[149] Systematic reviews by Ellis et al. found that a CGA performed in specialized wards reduced mortality and increased the likelihood of being discharged home and living at home after one year.[13,29] Another meta-analysis of randomized controlled trials confirmed this while failing to show the benefits of a CGA performed by mobile geriatric teams.[33]

The first German geriatric assessment was published in 1995.[160] In the 21st century, the CGA has evolved into a central and unanimously accepted element in the care for geriatric patients worldwide in inpatient, outpatient as well as rehabilitative settings.[13,33,147,161,162]

With the growing prevalence of frailty in ageing populations, a standardized way of assessing and treating frailty during hospitalization for acute illness is receiving more attention. An RCT performed by Clegg et al. showed that undergoing a CGA during hospitalization is associated with benefits for frail patients, for instance, less functional decline and lower mortality. However, this was shown in specialized wards and not in a general acute medical setting.[127] Other studies supported these findings.[163–165]

Turner and Clegg went as far as to call the CGA the "gold standard" for caring for frail older people.[147,166] A CGA can help the treating physicians determine which of the assessed domains might be a contributor to the frail phenotype of the patient and whether or not it is reversible.[167] This is especially helpful in settings where personnel not specially trained in the field of Geriatrics have to make treatment decisions and assess a patient’s status. A standardized assessment, like the CGA, can be immensely helpful and can aid untrained personnel in identifying possible domains that show potential for improvement.[130]

There are different approaches to the implementation of the CGA during acute medical care in the hospitals that have been studied in several RCTs and meta-analyseis. These include specialised wards, mobile multidimensional teams who are deployed where they are needed throughout the hospital,[33,67,168–170] and outpatient programs after discharge.[67,170]

Specialized geriatric wards performing CGA have been shown to improve physical functionality, reduce mortality and facilitate discharge compared to standard care and are generally accepted as being beneficial.[163–165,170] The benefits of mobile geriatric consultation teams, on the other hand, could not be consistently proved.[170,171] An early RCT by Thomas et al. from 1993 showed that a geriatric consultation team that implemented CGA and made subsequent treatment recommendations could improve a patient's longevity and functionality.[172] However, since then, numerous studies and meta-analysis have failed to identify a significant effect of a mobile geriatric CGA team on outcomes like mortality, functionality or discharge.[13,14,29,33,149,173]

To conclude, the CGA has developed into a standard instrument in the care of geriatric patients. Its holistic approach and multidimensional nature help combat many of the problems described above that arise in the treatment of geriatric patients. The implementation of the CGA has proven to be beneficial for patients, especially in the context of geriatric wards.

2.4.1. The Multidimensional Prognostic Index

As established above, the CGA is a useful tool in the treatment and care of geriatric patients. It provides much information concerning the different domains of a patient. However, although its results may give hints concerning the prognosis of a patient, it does not provide prognostic evidence in a direct way. Although the treatment of individual diseases still dominates medical thinking, considering the prognosis of a patient plays a major role in the treatment planning of older patients.[174,175] The potential benefits of a treatment or diagnostic process may be outweighed by the stress and strain such interventions can cause in an older patient whose health status is already vulnerable. Furthermore, a limited life expectancy could mean that the patient will not likely survive long enough to reap the benefits of a treatment. Therefore, prognosis should influence all decisions in the individual care planning of older patients, and physicians are confronted with the prognosis process daily.[176,177] However, a survey by Christakis et al. suggested that many physicians find it very difficult to present a patient with a specific prognosis and therefore prefer to remain vague.[177]

In an effort to merge the information gained by a CGA into a single tool that has prognostic significance and is easy to apply, Pilotto et al. developed the *Multidimensional Prognostic Index (MPI)*. This prognostic index is calculated by an algorithm that includes the following eight scales assessed by a standardized CGA:

- Activities of Daily Living (ADL)[16]: This scale measures functionality and mobility by assessing a patients' capabilities in daily functions, like getting in and out of bed, dressing oneself, using the toilet, bathing, eating and walking. Each category provides a score of 0 or 1, which added together yields a total score between 0 and 6, with 6 indicating the highest level of independence in the activities measured.[16] A risk stratification into low risk (ADL score 5 to 6), medium risk (ADL score 3 to 4) and high risk (ADL score 0 to 2) is possible.
- Instrumental Activities of Daily Living (IADL): The IADL measures a person's ability to perform necessary daily tasks like using the telephone, shopping, cooking, cleaning, washing, taking one's medication, managing money and using transportation. Similarly to the ADL, each category is valued with a score of 1 or 0 and yields an accumulated score between 0 and 8.[17] The following risk groups can

be set: low risk (score between 6 and 8), medium risk (score of 4 or 5) or high risk (scores between 0 and 3).

- Exton Smith Scale (ESS): This score reflects the risk of developing bedsores and is calculated by giving between 1 and 4 points each for bodily and cognitive status, activity, mobility and incontinence[18] One can, therefore, determine a low risk (score 16-20), a medium risk (score 10-15) and a high risk (score 5-9) of developing bedsores.
- Short Form of the Mini Nutritional Assessment (MNA): This score includes the body mass index (BMI), weight loss, mobility, food intake, comorbidities and psychological status.[178] It yields a score between 0 and 14, with a score lower than 7 indicating a high risk of malnutrition, a score between 8 and 11 a medium risk, and a score above 12 indicatig a low risk of malnutrition.
- Short Portable Mental Status Questionnaire (SPMSQ): The SPMSQ consists of 10 questions that assess patients' cognitive status and orientation to location, time, and self. Each wrongly answered question yields 1 point.[20] A score between 8 and 10 indicates a high cognitive impairment, a score between 4 and 7 a medium and a score between 0 and 3 a low cognitive impairment.
- Cumulative Illness Rating Scale (CIRS): This scale indicates the severity of multimorbidity a patient suffers from. Every organ system, for example heart, respiratory system, kidney, and metabolism, to name a few, is awarded points between 0 (no comorbidity) and 4 (extremely severe comorbidity).[21] A score higher than 3 equals a high burden of multimorbidity, a score of 1 and 2 a medium burden and a score of 0 a low burden of multimorbidity and severity of illnesses.
- Number of medications taken per day: The number of medications is divided into low risk (0 to 3 medications per day), medium risk (4 to 6 medications per day) and high risk (more than 7 medications per day).
- Living condition: It is assessed whether a patient lives with family (low risk), lives in care (medium risk), or alone (high risk).

The result is a continuous figure between 0 and 1 with a higher number being associated with a higher likelihood of adverse health outcomes and with a higher mortality risk.[22,24,43] Pilotto and colleagues then formed three mortality risk groups in ascending order: low risk (MPI-1, 0-0.33), intermediate risk (MPI-2, 0.34-0.66) and high risk (MPI-3, 0.67-1).[22]

Since its development in 2008, the MPI has been validated in over 56,000 patients of hospital-based as well as population-based cohorts with more than 180 studies conducted worldwide.[179,180] In hospitalized patients, the MPI is proven to be associated with the number of geriatric syndromes and resources,[25] LHS,[24,26,181] grade of care,[26] quality of life,[27] and discharge destination.[26] In a community setting, patients with a higher MPI were found to have a higher likelihood of hospitalization,[43] as well as a higher likelihood of serious health incidents and more visits to the general practitioner in the next year.[182] In comparison to other prognostic indices, the MPI is characterized by its high validity and high accuracy in predicting mortality in a hospital setting according to a systematic review by Yourman and collegues.[183]

A higher MPI value has also been shown to be associated with worse outcomes and higher mortality rates in patients who suffer from acute myocardial infarction,[184] chronic kidney disease,[185,186] transient ischemic attack,[19] cancer,[187] pneumonia,[28] heart failure[188] and dementia.[189] In an ongoing prospective observational study, Custodero et al. are assessing whether the MPI can be used to predict the likelihood of ICU treatment and in-hospital complications as well as mortality rates in patients hospitalized because of COVID-19.[190]

In addition to facilitating prognosis, the CGA-based MPI can determine frailty and age-associated decline much better than monodimensional tools.[191] Therefore, gradual decline that often escapes the notice of treating physicians can be identified and, if possible, counteracted, thus lending assistance to physicians in judging a patients' status independent of chronological age.[192] Warnier et al. showed in their systematic review that the MPI is among the most sensitive instruments for identifying frailty.[46] Pilotto et al. also determined that among established frailty indices, the MPI stands out as the index with the best record for reducing mortality.[193] Veronese et al. conducted a recent meta-analysis concerning the prevalence of frailty by assessing it via the MPI, postulating that a multidimensional assessment is superior in assessing frailty.[23] They found that frailty, defined as a MPI score in the range of MPI-3, is more prevalent in nursing homes than in communities, with the overall prevalence measuring at about 27%. Concerning pre-frailty (defined as MPI-2), the prevalence was highest in hospitals followed by nursing homes.[23]

In summary, the MPI is a validated prognostic tool that can help identify gradual functional decline through its foundation on a broad CGA and is associated with a large number of clinical parameters like mortality, LHS, and more. Its prognostic significance can be a valuable tool in the clinical evaluation and treatment of older patients.

2.5. Acute hospitalization of a geriatric patient: problems and solution approaches

2.5.1. The hospitalized geriatric patient

Older patients often do not have enough reserves and resilience to adapt to the change of scenery and stress during hospitalization for acute illness, which can lead to the deterioration of functionality.[9,194] This functional loss is often difficult to reverse and can make rehabilitative treatment necessary long after the successful treatment of the initial disease that warranted hospitalization.[195] While the disease itself can be disabling, and higher severity of disease can lead to high functional impairment, this hospital-associated functional decline can occur independently of the illness that led to hospital admission.[195]

Some aspects of disease treatment that lead to hospitalization are associated with a high risk of functional decline, such as high-performance iatrogenic treatments or adverse medication side effects.[195] However, there are many different hospital-related risk factors, which have been identified as being associated with in-hospital functional decline and subsequent adverse health outcomes, that are independent of the hospitalization-causing disease and its treatment. Among these risk factors, low mobility is probably the most prominent, as sick older patients are often confined to their beds during a hospital stay, either as a result the illness itself or because of the lack of assistance by understaffed personnel in an unfamiliar environment.[196] While bed rest is proven to lead to adverse effects in young as well as in old people, the latter are much less likely to recover their individual baseline.[197] The lack of mobility results in accelerated muscle loss that again prevents geriatric patients from being independent in their ADLs.[195] This explains why the level of functionality on admission does not protect against the adverse outcomes of low mobility – patients with low risk functional impairment on admission suffer from the same low mobility and muscle loss as patients with a high risk functional impairment.[196] Furthermore, it has been shown that malnutrition,[198] dehydration,[195] disrupted sleep patterns and alien sensory environment,[195] not ideal continence care,[195] social isolation[195] and psychological problems like depression[199] during hospitalization all lead to a higher functional decline in hospitalized older patients.

The decline in functional status and a failure to recover the baseline prior to discharge are associated with the following adverse effects: a lower likelihood of functional recovery post-discharge, higher mortality as well as higher morbidity, a higher likelihood of infection as well as readmission and admission to long-term care and, finally, a faster decline in cognitive functions.[10,114,200–203] A decline in functionality can be quantified by scales like the ADL and/or the IADL but can also present itself in a multitude of different clinical problems, such as delirium, depression, malnutrition or dehydration.[9,195,204]

Patients especially at risk from functional deterioration often present themselves with polypharmacy, weight loss, multimorbidity, as well as a history of home care or falls on admission.[205] Studies put the percentage of geriatric patients who undergo functional decline during hospitalization between 17% and 65%,[9,44,194,196,206,207] with the subgroup of the oldest-old most likely to experience hospital-associated functional decline.[9] A recent meta-analysis puts the percentage of hospital-associated decline in ADL at 30%.[208]

In light of these scientific findings, it is crucial to eliminate the hospital-associated risk factors for functional decline as much as possible in order to provide geriatric patients with the best possible care. In contrast to prolonged bed rest, the benefits of regular exercise are undisputed.[209,210] Numerous studies that examine some kind of in-hospital physical or mobility program show improvements in the functionality and mobility of patients.[10,211–213] Consequently, exercise is a key component of programs that focus on early rehabilitation with the goal of reducing hospital-associated functional decline (See 2.5.2.).[214]

Another important factor to consider in the hospitalization of older patients is the transitions of care after hospital discharge. Many older people cannot be discharged home after their hospital stay. This could be due to a continued need of rehabilitation or the need for transition into short- or long-term care facilities. In order for the transition of care to be ideal, a multidisciplinary team has to include the patient's status and wishes as well as the opinion of family caregivers.[215] Early and regular communication is elementary in this process.[215] When executed thoroughly and in collaboration with both patient and relatives, an adequate discharge plan can lead to fewer readmissions and a higher likelihood of the patient being able to live at home.[215,216]

To conclude, hospitalization is associated with adverse outcomes in older patients who lack the reserves to adapt to a stressful and changed environment. A major danger for the hospitalized older patient is functional decline independent of acute disease. Therefore, in the following chapters, different forms of rehabilitation and intervention are described that aim at negating the hazardous effects of hospitalization.

2.5.2. Geriatric rehabilitation

The World Health Organization defines rehabilitation as "a set of interventions designed to optimize functioning and reduce disability in individuals with health conditions in interaction with their environment",[217] with the goal of unlimited participation in everyday life.[218] Patients of all age groups can be in need of rehabilitation after a stressor like a high-performance medical treatment or surgical procedures. In these settings, rehabilitation is often necessary to prevent complications or functional decline and, therefore, to fulfil the full potential of the treatment.[219,220]

Geriatric rehabilitation specifically is the attempt to support older patients in drawing from their resources and improving functional disabilities or their perception of their own functional abilities.[75,221] Cameron and Kurrle described the goal of geriatric rehabilitation in the following way: "The major goal of rehabilitation programs for older people is to assist them to manage personal activities of daily living without the assistance of another person. If this is not possible, the goal is to minimize the need for external assistance through the use of adaptive techniques and equipment."[222] Stressors leading to rehabilitation needs in older people are often events like fractures, strokes or the exacerbation of existing chronic diseases.[222] In order to be eligible for geriatric rehabilitation, a patient has to show deficits after an acute stressor event that might be addressed by rehabilitation, and he has to be medically capable of participating in the rehabilitation process.[223] Cognitive impairment or chronological age should not determine eligibility for geriatric rehabilitation.[221,224] The benefits of an assessment like the CGA in the evaluation of rehabilitation potential have been described.[225] Following a holistic assessment, rehabilitation goals should be evaluated and adjusted for and in collaboration with each individual patient, with the overall aim being, if possible, the improvement of functional, social and psychological status.[221] However, it has to be considered that not every patient can regain the level of functionality he or she had before the event that caused the disability.[226] The unique characteristics of geriatric patients in need of rehabilitation, i.e. frailty, multimorbidity, geriatric syndromes and the special need for discharge planning, have to be considered during this process.[221] Furthermore, chronic conditions and weakening factors like anemia should be controlled as much as possible in order to facilitate positive rehabilitation.[222]

The team implementing a geriatric rehabilitation should be led by a specially trained physician, ideally a geriatrician, and should otherwise consist of a multidimensional team including geriatric nurses, physical and occupational therapists as well as a social worker.[222,224] The team can be complemented, according to requirements by dietitians, pharmacists, speech therapists or psychologists and should conduct weekly meetings to discuss treatment plans and progress.[221,222] Geriatric rehabilitation should begin at the earliest possible time and should proceed even through a change of circumstance like a discharge to another institution.[224] Using standardized approaches like a CGA can enable an unbroken chain of rehabilitation through inpatient and outpatient care.[75,224]

Due to demographic change, the demand for rehabilitation has increased and, according to predictions, will continue to do so.[219] However, although the principle of geriatric rehabilitation is recognized in most European countries, there are still great differences in its implementation and facilities. Overall, it is evident that geriatric rehabilitation lacks resources and funding compared to other forms of rehabilitation.[227] Geriatric rehabilitation in Germany can be divided roughly into three forms: inpatient post-acute rehabilitation in specialized facilities, outpatient rehabilitation, and early rehabilitation during acute hospitalization.[228] Most geriatric rehabilitation resources in Germany are focused on the early rehabilitation process during acute care, which accounts for 83% of performed geriatric rehabilitation.[228]

The awareness of the possible complications older patients can suffer from during acute hospitalization has risen (see 2.5.1.), and different approaches have been made to support those patients during their hospital stay. Early rehabilitation describes the concept of rehabilitation and acute medical treatment taking place simultaneously. According to the *Deutsche Sozialgesetzbuch*, rehabilitation should be implemented at the earliest time possible,[229] and should address deficits in body and in function that are noticeable during hospitalization.[230] The immediate goals are to prevent functional decline, maintain independence as much as possible, and provide continuous rehabilitative care for patients eligible for post-hospitalization rehabilitation.[230,231] In the long term, the goals of early rehabilitation include a reduction in nursing needs and disability.[230,231] By achieving these goals, early rehabilitation can lead to a reduction in overall health care costs of a patient, as the costs of early rehabilitation are much smaller than repeated hospitalizations or institutionalization. Similar to other processes of rehabilitation, early rehabilitation should strive to be interdisciplinary and target individual problems and goals.[218,230]

The benefits of early rehabilitation have been clearly researched in literature. A systematic review by Kosse et al. determined that early rehabilitation programs that include an exercise program improve functionality compared to standard care when performed on a normal or acute geriatric ward during acute hospitalization.[214] In their systematic review of randomized controlled trials, Martínez-Velilla et al. examined a variety of exercise and early rehabilitation programs.[232] Overall, they came to the conclusion that early rehabilitation in the form of exercise and multidimensional interventions can have benefits concerning LHS, in-hospital functional decline, post-discharge institutionalizations and mortality.[232]

There are many different forms of early rehabilitative interventions in hospitalized older adults. The following chapter presents an overview of the different kinds of interventions implemented today.

2.5.3. Geriatric interventions in an acute medical setting

Many different forms of interventions and programs are described in literature as having the goal of preventing hospital-associated adverse health effects in older people. Most of these interventions differ greatly in their implementation form, extent, goal setting and measurement of outcomes. One can generally differentiate between geriatric wards and geriatric teams as well as multi- or monodimensional interventions.

Monodimensional interventions that focus on a single goal must be distinguished from multidimensional programs. The most prominent examples of monodimensional interventions are exercise programs that focus singularly on the mobility of patients and have been shown to be beneficial for preventing hospital-associated immobility and functional decline.[214,233] However, a systematic review conducted by Dedeyne et al. concluded that multidomain interventions are superior compared to single domain interventions improving outcomes such as frailty status and physical capabilities. They also determined that physical exercise is a key part of multidimensional interventions.[234]

Furthermore, in the implementation strategy of geriatric interventions, one can differentiate between mobile geriatric teams and specialized geriatric wards, i.e., non-geriatric versus geriatric settings. Both forms of treatment are most often based on an interdisciplinary team of at least one experienced geriatrician who is supported by a geriatric nurse and optionally by social workers, physiotherapists, pharmacists and others.[33] The treatment implemented varies according to the approach and conceptual framework of the project.[235] It can consist of following the recommendations of the treating physicians, different kinds of therapies and assessments like a CGA performed by the team or geriatric co-management, as well as conventional medicine. Different programs combine these components in individual ways.

Geriatric wards are one approach in the treatment of geriatric patients during acute hospitalization that aims at limiting the influence of hospital-associated risk factors on the prognosis of those patients. Often, geriatric wards are specially designed according to the needs of older patients, i.e., without tripping hazards, with clear paths to the bathroom and other areas, as well as common areas for socialization. They require a lot of manpower and resources but have been validated in numerous different studies.[164] A first RCT by Rubenstein et al. concerning treatment in a Geriatric Evaluation Unit in a VA hospital showed that treatment in the unit was associated with lower mortality, higher functionality and fewer admissions to long-term care.[30] These findings have been replicated since then, with geriatric wards being associated with improved functionality,[236–238] fewer admissions to long-term care,[237,239,240] and lower mortality.[30,241] A meta-analysis of RCTs performed by van Craen et al. found that being treated in a geriatric ward was associated with better functionality as well as a lower likelihood of being institutionalized after one year.[242] Similarly, CGA wards have also been found to be effective when an individualized geriatric intervention follows a thorough CGA, improving functionality compared to standard care.[163]

Geriatric patients hospitalized in geriatric wards in Germany often have the possibility of undergoing a so-called geriatric complex treatment (GCT). This treatment is part of early rehabilitative specialized geriatric care, with the goal of reinstating or upholding a patient's functionality and rehabilitative eligibility.[31] An ensuing rehabilitation program is often only possible after early rehabilitative GCT during hospitalization.[31,243]

The GCT is the only form of early rehabilitative treatment, in addition to the usual amount of physiotherapy, occupational therapy etc. during hospitalization, which can be billed to the patient's health insurance by a hospital in Germany. However, in order to receive compensation for a GCT, a program must meet the following requirements according to the German Operationen- und Prozedurenschlüssel (OPS): 1) The therapy provided is made up of physiotherapy, occupational therapy, speech therapy (two of which have to be included) and/or psychotherapy. 2) The team must be interdisciplinary and be led by a resident physician qualified in Geriatrics. 3) Specially trained geriatric nurses with at least six months' experience in the field must provide the nursing care. 4) Weekly interdisciplinary team meetings must take place. 5) A CGA should be performed on admission (covering the fields of self-sufficiency, emotion, mobility, and cognitive status) as well as at discharge (covering at least the areas of self-sufficiency and mobility). 6) The social status of a patient has to be assessed with a focus on living situation, nursing needs, social support and social activities.[32] The GCT has to be made up of at least 10 therapy sessions over the course of seven days.[32] Hospitals are recompensated for the GCT-performance according to the German DRG and OPS systems if they fulfil the criteria mentioned above. The DRG-system (diagnosis-related groups) is the way hospitals bill for patients' hospital stays. Patients are clustered into certain groups according to diagnosis, age, comorbidities and interventions needed, among others, and hospitals receive the according compensation for the patient.[244] The foundation for billing of intervention and procedures during a hospital stay is laid by the OPS system, with which the interventions are documented and later billed accordingly.[245]

The GCT-billing is categorized into three subgroups according to the duration of the GCT: 1) 10 therapy sessions within at least seven days (OPS 8-550.0); 2) 20 therapy sessions within at least 14 days (OPS 8-550.1) and 3) 30 therapy sessions within at least 21 days (OPS 8-550.2).[31,32] An analysis of a central German dataset for geriatric patients showed that the coding of OPS 8-550.0 increased in the subgroups of older patients, while OPS 8-550.2 was used least in the higher age-subgroups.[246] The most often implemented standard in all age groups was OPS 8-550.1. However, it could be shown that extending the treatment and the number of treatment sessions improved functionality, independent of age, multimorbidity and LHS.[246] The benefits of a GCT are widely agreed on, particularly in the care for geriatric trauma patients.[247,248] While there are some projects that have initiated a GCT in a non-geriatric setting implemented by a geriatric team, the GCT is mostly implemented in acute geriatric wards.[249]

Contrasting the concept of geriatric wards is that of mobile geriatric teams. These include specialized geriatric medical personnel who are deployed throughout a hospital in non-geriatric wards. They provide necessary geriatric expertise because medical professionals in non-geriatric wards often have not undergone enough specific training concerning the special needs and treatment of older patients. This results in a lower quality of care in those wards.[84,235] In most cases, the team assesses a patient and makes suggestions for treatment and care planning to the physicians in charge, as well as possibly implementing some form of treatment themselves. The benefits of this kind of geriatric service are fairly obvious: they require fewer financial resources than geriatric wards and can supply consultation in all wards of the hospital, reaching patients in all departments.[168] As some hospitals, especially in rural areas, may be too small to warrant a geriatric ward, a geriatric team can provide the necessary expertise in treating older patients.[250] Furthermore, geriatric teams can be deployed quickly without having to wait for a ward to be established or a transferral to a geriatric ward to take place.[168] A geriatric team that visits older patients in acute wards during hospitalization can therefore provide the benefits that have been proven in specialized geriatric wards while minimizing costs and maximizing flexibility.[251] The range of care provided by a mobile geriatric team varies between recommendations to the treating physicians,[252] co-management, i.e., inclusion in decision-making process,[253] and intervention in the form of discharge planning, exercise and assessment programs or combinations of all these components.[33,34] While the different approaches of geriatric teams are discussed in Chapter 4.3., one can say that while geriatric teams have been found to be beneficial in several cases, the overall consensus, at this point, is that results of geriatric wards have been more consistently promising.[33,254]

In summary, a multitude of geriatric interventions have been researched and recorded in literature. Geriatric wards have been proven to be more consistently beneficial than geriatric teams. However, they are not so flexible and cannot be established everywhere. At this point in time, there is no unanimous agreement on how geriatric intervention should be structured, and which patients should be targeted in order to reach the highest level of efficacy, although geriatric wards seem to be more beneficial for patients than geriatric teams. The GCT is the only form of geriatric intervention that is billable in Germany, but it is often limited to geriatric wards due to its high level of requirements. In the next chapters, the patient collectives, intervention forms and study designs of this analysis are presented.

2.6. The Multidimensional Prognostic Index in an acute medical setting (MPI-InGAH)

In August of 2016, the Department II of Internal Medicine – Nephrology, Rheumatology, Diabetology and General Internal Medicine of the University Hospital of Cologne, Germany, introduced a prospective study called the "Influence of a Geriatric Assessment on hospitalization of older, multimorbid patients" (MPI-InGAH, EK 16-213, DRKS00010606 and DRKS00013791) with the goal of determining prognosis trajectories during older patients' hospital stay as well as new associations of the MPI.[25,26]

All patients hospitalized in the aforementioned ward were screened according to the following criteria of inclusion: 1) The patients should be 70 years of age or older, although, after two years, this was reduced to 65. 2) Every patient included should be suffering from two or more diseases that require long-term treatment, thereby fulfilling the criteria of multimorbidity. 3) A permission to participate in the study in form of a signature of the consent form had to be given by either the patient or his proxy.[26]

Between August 2016 and July 2019, all patients in the qualifying age group were screened for inclusion into the study. Of these patients, 475 met all the inclusion criteria and were included.[25,26] All patients received a CGA on admission and at discharge from which the MPI was calculated. Also, a phone-based follow up after three, six and twelve months was undertaken to record patients' living conditions, falls, admissions to long-term care, use of home care and rehospitalizations.[35]

This study showed that the MPI during acute hospitalization is associated with LHS, grade of care as well as discharge destination.[26] Furthermore, a higher MPI was associated with a higher prevalence of geriatric syndromes and a lower prevalence of geriatric resources.[25] Furthermore, Pickert et al. showed that determining the MPI not only on admission and at discharge but also in the intermediate time during hospitalization can provide information concerning the momentum of health development in the patient and provide necessary information for individual interventions to optimize a patient's health status.[255]

2.7. The interdisciplinary multidimensional intervention (MPI-Rehab)

The interdisciplinary multidimensional intervention (IMI) is part of a pilot project of the Department II of Internal Medicine – Nephrology, Rheumatology, Diabetology and General Internal Medicine of the University Hospital of Cologne, Germany. It was introduced in November 2016 with the goal of preventing hospital-associated multidimensional decline in older patients by improving individual deficits found in a CGA and in various geriatric tests.[35]

The IMI was implemented and developed by an interdisciplinary team of medical professionals that included a geriatrician, a nephrologist, treating physicians, specially trained geriatric nurses, physiotherapists, occupational therapists and a case manager. Medical students were included in the assessment-process and were able to make suggestions for patients eligible to be included in the IMI.[256] If required, the team could be expanded by a pharmacist or a speech therapist. The team was led by a geriatrician who coached the team regularly. Weekly rounds ensured the involvement of the patient in the planning process of further therapies as well as in setting individual goals for the intervention. Weekly team meetings by the whole team evaluated the patient's progress and discussed further treatment as well as discharge options to ensure smooth transitions of care.

All patients admitted to the department described above were screened for inclusion in the IMI-project. The inclusion criteria were as follows:

- The patient had to be 65 years of age or older to be considered for the IMI.
- The patient was judged to be frail or in danger of becoming frail and in danger of functional loss.
- Patients included had to display sufficient mental capacity to participate in the IMI treatments and to follow directions from the therapists. Therefore, patients who suffered from diagnosed dementia were excluded from the IMI.
- The patient had to be able to communicate in German.
- The predicted LHS was expected to be one week or more in order to achieve a certain continuity of treatment over a significant amount of time.
- Finally, the general requirements for rehabilitation – i.e. motivation, capability and need – had to be present. According to these requirements, a patient had to demonstrate a certain willingness to take part in the IMI sessions as this was considered a prerequisite for ensuring beneficial effects. He also had to be resilient enough to be able to partake in the treatments. Furthermore, there had to be potential for improvement, meaning there was an evident or self-reported decline in the cognitive, emotional, or functional status of the patient before or during the early stages of hospitalization.

The pilot project entailed the simultaneous treatment of two patients within the framework of the IMI. After discharge or at the end of treatment plan for one patient, the team made a joint decision on which patient to include next from the patients hospitalized in the ward described above.

The IMI provided functional treatment that went beyond the amount of treatment patients usually receive during hospitalization. During the course of the IMI, the treatment plan included daily physiotherapy and occupational therapy sessions of 30 to 45 minutes each. If treatment slots happened to coincide, the individual therapists worked together in the design of the treatment session. The goal of the IMI was individualized for each patient at the beginning of the treatment, during the first sessions with therapists and during the weekly rounds with the whole IMI team. Physiotherapists focused on giving patients more control and stability in their movements, with particular attention given to torso stability. Furthermore, the transfer from bed to chair as well as walking stability and training were focal points of physiotherapy sessions. The occupational therapists also supported patients in improving their gait speed and security as well as their overall physical constitution. In addition, they assessed the ADL of patients and worked on improving deficits they found there. They also advised patients on the correct usage of walking aids and other everyday aids that could be of use. Concerning the mental status of patients, they trained memory capabilities as well as specializing in addressing personal worries and problems about the current situation. When the patients were mobile enough, they trained the patients' stair-climbing abilities.

The concept of the IMI also included a number of geriatric tests conducted at the beginning and at the end of the treatment with the goal of both discerning deficits that could be addressed in the treatment as well as measuring the effect the intervention might have on a patient's test results. The deficits were used as a basis for establishing an individual treatment plan that was set in collaboration with the whole team as well as reflecting the patient's goals and wishes. The following table shows the different tests that were performed during the IMI, the respective domain assessed, and the possible stratifications of the results.

Test	Domain	Description
Timed Up and Go Test (TUG)	Mobility	The TUG was developed by Podsiadlo and Richardson in 1991 and is a simple test to measure mobility and gait speed.[37] As a starting position, the patient sits upright in a chair. Then, at a given signal, they get up, walk three meters, turn around and sit back in the chair.[37] The time is stopped when the sitting position is reached again. The time is measured in seconds. Walking aids are permitted. A score of 10 seconds or lower is considered normal, a score between 11 and 20 seconds indicates slightly restricted mobility, and a score between 21 and 30 seconds indicates highly restricted mobility. A high TUG is associated with cognitive impairments,[257] admissions to long-term care,[258] a higher risk of falls,[259] and has predictive value concerning the development of ADL and IADL disability.[260]
De Morton Mobility Index (DEMMI):	Mobility	The DEMMI is a commonly used mobility assessment tool. It was developed by Natalie de Morton et al. in 2008,[42] and was translated into German in 2014.[261,262] The test includes domains of getting out of bed or out of a chair, balance while standing or walking as well as walking stability. The score yields a value between 0 and 100, with 100 representing optimal mobility. Lower DEMMI scores are associated with longer LHS[263] and lower functionality.[264]
Handgrip Strength (HG)	Mobility	With the Handgrip Test, it is possible to have a representative idea of the muscle mass and strength of the whole body. It is measured by dynamometry and different values are expected regarding the dominant and non-dominant hand. A lower than average HG score is associated with high mortality, a high prevalence of frailty, low mobility and a higher LHS.[40,265,266] A low HG strength is also associated with a poor nutritional status.[267]

Geriatric Depression Scale (GDS)	Emotion, Cognition	This test was developed by Yesavage et al. in 1983 with the goal of having a validated and simple tool that can screen for the presence of depression in a geriatric patient.[36] This is important as depression is not uncommon in geriatric patients. Riedel-Heller et al. put the number of older patients suffering from depression between 7% and 17%. It is often mistaken for dementia and, therefore, often underdiagnosed.[36,268] The GDS consists of 15 yes or no questions that relate to the cognitive and emotional state of a patient.[269] A score between 0 and 5 indicates a low risk of depression, while a score of 6 to 10 points equals a moderate depression, and a score of 11 to 15 indicates severe depression.[270]
Montreal Cognitive Assessment (MoCa)	Cognition	The MoCa was developed in 2004 by Nasreddine et al. and is a validated assessment tool for detecting mild cognitive impairment.[41] It yields a score between 0 and 30, with 30 representing optimal cognitive performance. The test assesses a variety of cognitive functions, including memory, repetition, simple calculations, drawing of a clock and a cube, and orientation to date and location. An extra point is given for absolved periods of education over 12 years.
Dementia Detection Test (DemTect)	Cognition	This test was developed in order to assess mild cognitive impairment and early dementia.[39] It provides a result based on a scale between 0 and 18 points, with a score between 13 and 18 indicating adequate cognitive status, a score between 9 and 12 indicating mild cognitive impairment and a score of 8 and below indicating the presence of dementia.
Mini Mental State Examination (MMSE)	Cognition	The MMSE is another cognitive assessment tool developed by Folstein et al. in 1974.[38] Like the MoCa, it is designed to be simple in implementation and has been proven to be valid in detecting mild cognitive impairment. [271,272]

2.8. The Multidimensional Prognostic Index in a geriatric ward (MPI-AGE)

While the MPI-InGAH study described above examines the MPI in an acute non-geriatric setting, the MPI-AGE study does so in a geriatric setting. It is a multicentre and multinational project devised by Alberto Pilotto and colleagues titled "Using the Multidimensional Prognostic Index to improve cost-effectiveness of interventions in multimorbid, frail older persons".[192] Its goal is determining whether patients hospitalized in a geriatric unit profit from the CGA-based MPI and whether the MPI facilitates clinical patient-specific decision making.[43] The MPI-AGE study was of a prospective observational design and included 11 recruitment centres in 10 countries and a total of 1.140 patients. One recruitment centre was located in Cologne, Germany and contributed the data of 188 patients. Inclusion criteria were being at least 65 years of age or older, being hospitalized for acute disease or suffering from the exacerbation of a chronic disease in a geriatric unit and written consent to participate in the study. The patients were included in statistical analyses if they met the criteria above and if they had undergone a standardized CGA on admission and at discharge.[43] The main goal of the study was to identify patients who could profit from geriatric assessment and to develop cost-effective interventions based on the individual patient's risk profile.[192,273]

After analysing the data from all recruitment centres, Cruz-Jentoft et al. found that the MPI could predict in-hospital mortality, as well as mortality in the year following hospitalization.[192] In addition, Pilotto et al. determined that a higher MPI score correlated with increased institutionalization, rehospitalization and increased the need for home assistance in older patients admitted to a geriatric unit. This all helps the physicians responsible for treatment to make decisions based on the patient's needs according to the individual's risk profile.[274]

The German-based cohort was recruited in the geriatric unit of the *St. Marien-Hospital* in Cologne. The *St. Marien-Hospital* provides 122 beds for acute geriatric care and early rehabilitation, 40 beds for geriatric rehabilitation as well as 20 beds for geriatric day care.[275] Patients were recruited to the MPI-AGE study from the ward for acute geriatric care. As part of standard care in this ward, all patients who suffered from an acute disease while also needing rehabilitative care received a GCT (see 2.8.) during their stay in the geriatric ward.[276] Over a three month period between May and August of 2015, 188 patients were recruited. All of these patients were over 65 years of age and had received a CGA-based MPI-calculation on admission and at discharge. Primary endpoints of the study were to record mortality during and one year after hospitalization as well as to determine the interaction of MPI-prognosis and metabolic signature.[273,277]

The results of the German-based MPI-AGE cohort have been described in two previous dissertations. Dirk Hoffmann found that laboratory values such as albumin, C-reactive protein and urea increase the MPI's predictive accuracy concerning one-year mortality and therefore can provide helpful information for physicians in their decision making.[277] Petra Nicole Arenz determined that there was little MPI-trajectory during the hospitalization of patients in the geriatric ward in question. Furthermore, the MPI-subdomain CIRS was strongly associated with higher mortality.[273]

2.9. Underlying problem and aim of the study

In the first quarter of the 21st century, the population is ageing at an unprecedented level. This is due to a combination of decreased child mortality, the effective treatment of infectious diseases and increased life expectancy. As countries like Germany approach the point where the most populous birth cohorts reach old age, the importance of focusing on reducing disability and improving the quality of life for the eldery is increasing.[278] While a certain age-associated decline in functions is normal and unavoidable in the process of ageing, geriatric syndromes like immobility, instability, and incontinence should be actively diagnosed and treated, as they can lead to accelerated decline in many different domains if they remain undiagnosed. This has implications for the individual in the form of higher dependency, as well as for the health care system as a whole, due to higher nursing costs. Therefore, geriatric research should continue to focus on how to uphold functionality, self-sufficiency and quality of life as long as possible into old age and how to keep geriatric syndromes at bay.[279] Accordingly, successful ageing as defined by the WHO is not about disease-free ageing but of securing an ageing process where functionality and self-sufficiency are upheld for as long as possible. [280]

It is widely known that hospitalization has adverse effects on geriatric patients, who by nature lack the resources to deal with acute disease, high-performance medical treatments as well as the change of scenery that hospitalization involves. Therefore, older patients regularly leave the hospital in a worse functional state than they displayed before the onset of disease. Currently, while there are projects like the GCT in geriatric wards in Germany, and physiotherapy for older hospitalized patients if they show specific needs for it, not every geriatric patient in hospital receives specialized geriatric treatment. This is because not every patient in the qualifying age group automatically profits from treatment like the IMI or the GCT. Some patients might be resourceful and independent enough to not require the treatment, despite acute hospitalization, and would, therefore, “waste” resources other patients could use better. Furthermore, other patients might be too ill, both physically and mentally, and suffer from diseases too far progressed, for any kind of additional geriatric treatment to be beneficial.

However, although the number of geriatric wards for acute care is rising, not every patient who may profit from a geriatric treatment can be hospitalized in a specialized ward, both because of a lack of capacity as well as a need for specialized medical treatment that can only be provided in non-geriatric wards.[76] As a result, many patients do not receive geriatric attention. This shows the importance of not only improving care in geriatric wards but also of developing a team-based program aimed at geriatric patients in non-geriatric care.

As described in Chapter 2.5.3., there have been many different approaches to geriatric treatment during acute care, both in geriatric and non-geriatric settings. However, identifying key elements that can be melded into a universal approach with team-based interventions has been proven difficult due to the heterogeneity of the interventions as well as a frequent lack of detailed information concerning the form of intervention. Furthermore, many studies use different outcomes of interest and measure success in different ways, thereby limiting the comparability of the results.

In this context, the CGA-based prognostic index, as well as the concept of multidimensional intervention, are well-timed projects, as they shift the focus from a sole disease diagnostic and treatment process to a multidimensional approach that includes functionality and patient-centred goals.[281] In addition, measuring the success of the intervention in the form of the CGA-based MPI yields a holistic statement about the development of the patient compared to monodimensional outcome measures, which also provides a valid basis for comparison for future studies using the MPI as an outcome of interest.

The goal of this study was to determine whether an interdisciplinary multidimensional intervention like the IMI could improve a patient's multidimensional prognosis, measured by the MPI, compared to standard of care.[35] To our knowledge, there have been no studies so far that have examined the effect of a geriatric intervention team in an acute medical ward on a CGA-based prognostic index. With the change in the MPI as our primary outcome, we hope to incorporate a potential multidimensional effect of an intervention like the IMI into our interpretation of the results. Furthermore, by comparing the impact of the IMI on a cohort of patients hospitalized in a geriatric unit and undergoing GCT within the framework of the MPI-AGE study, we aim at comparing the team-based IMI with the ward-based GCT.

3. Results

3.1. Published original results

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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

Franziska M. Müller,[1] Anna M. Meyer,[1] Lena Pickert,[1] Annika Heeß,[1] Ingrid Becker,[2] Thomas Benzing,[1,3] M. Cristina Polidori[1,3]

[1]Ageing Clinical Research, Department II of Internal Medicine and Center for Molecular Medicine Cologne, Faculty of Medicine and University Hospital Cologne; [2]Institute of Medical Statistics and Computational Biology, Faculty of Medicine and University Hospital of Cologne; [3]Cologne Excellence Cluster on Cellular Stress- Responses in Aging-Associated Diseases (CECAD), Faculty of Medicine and University Hospital Cologne, Cologne, Germany

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).

Correspondence: M. Cristina Polidori, Ageing Clinical Research Department II of Internal Medicine and Center of Molecular Medicine Cologne Faculty of Medicine and University Hospital of Cologne, Herderstraße 52, 50937 Cologne, Germany.
Tel.: +49.22147832753.
Fax: +49.22147886710.
E-mail: maria.polidori-nelles@uk-koeln.de

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Contributions: FMM, AMM, LP, MCP, conceived and designed the retrospective study; FMM, IB, analyzed the data; FMM, MCP, wrote the paper; FMM, AMM, LP, MCP, ID, IB, conception of the manuscript; FMM, AMM, LP, AH, IB, TB, MCP, critical revisions.

Conflict of interests: the authors declare no potential conflict of interests.

Availability of data and materials: all our datasets are available.

Ethical approval and consent to participate: Local ethical committee approved the studies (EK 16-213, see page 1, column 3, Materials and Methods, paragraph 1).

Conference presentation: the results were presented in part at the German Geriatric Society (DGG) Conference in Frankfurt, Germany, September 2019 as a poster presentation (Müller *et al.*: *Einfluss einer multidimensionalen, altersmedizinischen Behandlung auf die Prognose älterer, multimorbider Patienten auf internistischer Akutstation*).

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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-

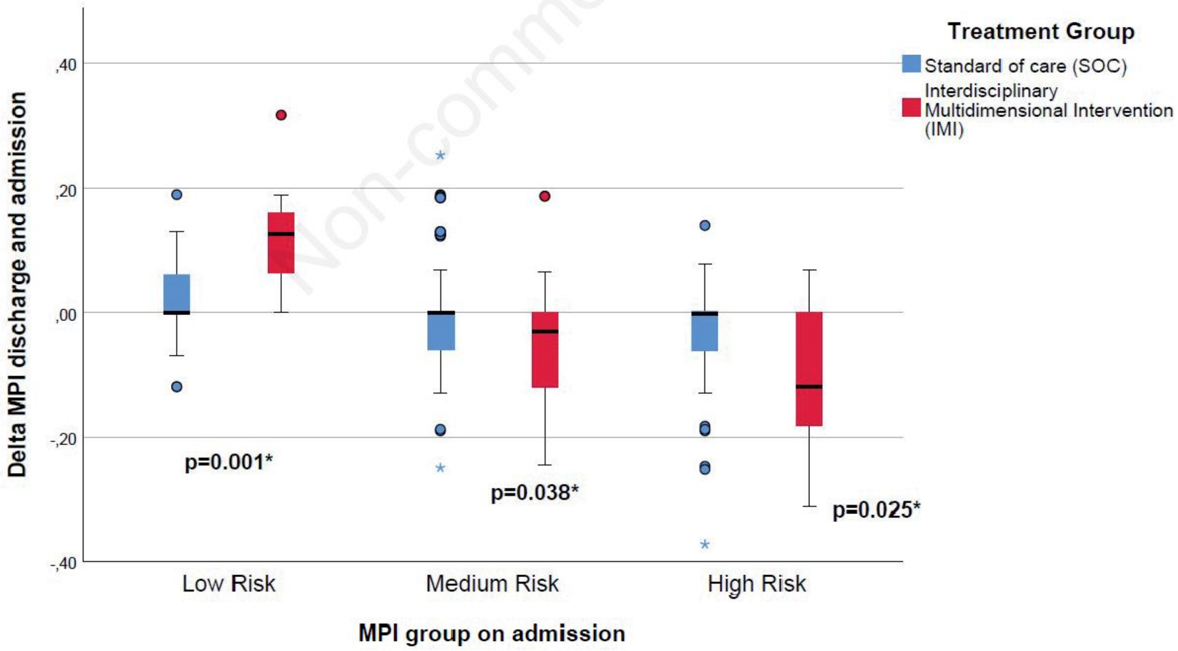

Figure 1. Delta of the Multidimensional Prognostic Index (MPI) divided by MPI group on admission. Delta of the MPI between discharge and admission presented as a Box Plot displayed by MPI risk-group on admission. The interdisciplinary multidisciplinary intervention (IMI) collective is shown in red, the 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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3.2. Unpublished Results

3.2.1. Comparison of the SOC and IMI collectives

Table 1: Presence of geriatric syndromes in SOC and IMI collectives [n, %]

	SOC N=403	IMI N=72	*p-value*†
Incontinence	162 (40.2)	34 (47.2)	0.299
Instability	257 (63.8)	53 (73.6)	0.139
Immobility	148 (36.7)	44 (61.1)	***<0.001****
Cognitive Impairment	39 (9.7)	8 (11.1)	0.671
Chronic Pain	174 (43.2)	35 (48.6)	0.440
Polypharmacy	336 (83.4)	66 (91.7)	0.072
Irritability or (reactive) Depression	70 (17.4)	16 (22.2)	0.322
Sensorial Impairment	237 (58.8)	48 (66.7)	0.241
Insomnia	192 (47.6)	42 (58.3)	0.098
Irritable Colon	169 (41.9)	28 (38.9)	0.697
Iatrogenic Disease	28 (6.9)	7 (9.7)	0.460
Incoherence/ Delirium	13 (3.2)	9 (12.5)	***0.002****
Impoverishment	25 (6.2)	5 (6.9)	0.793
Isolation	31 (7.7)	6 (8.3)	0.813
Fluid/ Electrolyte Problems	128 (31.8)	20 (27.8)	0.581
Swallowing Disorder	61 (15.1)	15 (20.8)	0.225
Inanition	115 (28.5)	21 (29.2)	0.888

Descriptive statistics, presence of geriatric syndromes in SOC and IMI collectives
† Chi-Square for frequencies
* significant at 5%
Abbreviations: SOC, standard of care; IMI, interdisciplinary multidimensional intervention

Table 2: Presence of geriatric resources in SOC and IMI collectives [n, %]

	SOC N=403	IMI N=72	*p-value*†
Physical	213 (53)	31 (43.1)	0.126
Living Condition	289 (71.9)	48 (66.7)	0.398
Social	347 (86.3)	63 (87.5)	>0.999
Financial	248 (61.7)	47 (65.3)	0.6
Spiritual	171 (42.5)	36 (50)	0.248
Motivational	255 (63.4)	45 (62.5)	0.895
Emotional/ Feelings	289 (71.9)	49 (68.1)	0.572
Mnestic/ Memory	193 (48)	30 (54.2)	0.371
Competence-Related/ Hobbies	213 (53)	39 (54.2)	0.898
Intellectual	207 (51.5)	37 (51.4)	>0.999

Descriptive statistics, presence of reriatric resources in SOC and IMI collectives
† Chi-Square for frequencies
* significant at 5%
Abbreviations: SOC, standard of care; IMI, interdisciplinary multidimensional intervention

Tables 1 and 2 show the presence of geriatric syndromes and resources in IMI and SOC patients. There are no differences between collectives concerning geriatric resources. However, IMI patients were more likely to present themselves with the geriatric syndromes of immobility (p<0.001) and incoherence/ delirium (p=0.002).

Table 3: Delta MPI and Delta of its subdomains according to age group [Median, Q1, Q3]

	Young-old (65-74 years)		Middle-old (75-84 years)		Oldest-old (85+ years)	
	SOC N=129	**IMI** N=22	**SOC** N=235	**IMI** N=39	**SOC** N=39	**IMI** N=11
Delta MPI	0 (-0.06, 0.005)	-0.12 (-0.12, 0)	0 (-0.06, 0)	0 (-0.065, 0.063)	0 (-0.058, 0.005)	-0.06 (-0.125, 0)
p-value†	***<0.001****		0.433		***0.007****	
Delta ADL	0 (0, 0)	1.5 (0, 4)	0 (0, 0)	0 (0, 2)	0 (0, 0)	0 (0, 2)
p-value†	***<0.001****		0.195		***0.008****	
Delta IADL [Minimum, Maximum]	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (-1, 0)	0 (0, 0) [-3, 0]	0 (0, 0) [-2, 2]
p-value†	0.719		***<0.001****		***0.049****	
Delta ESS	0 (0, 1)	3 (1, 5)	0 (0, 1)	0 (0, 2)	0 (0, 1)	3 (1, 6)
p-value†	***<0.001****		0.366		***0.001****	
Delta CIRS	0 (-1, 0)	0 (-1, 1)	0 (-1, 0)	0 (0, 0)	0 (-1, 0)	-1 (-1, 0)
p-value†	0.309		***0.017****		0.135	
Delta MNA	0 (0, 0)	0 (0, 1.25)	0 (0, 0)	0 (-1, 0)	0 (0, 0)	0 (0, 1)
p-value†	***0.042****		0.304		0.163	
Delta SPMSQ	0 (0, 0)	0 (-1, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (-1, 0)
p-value†	***<0.001****		0.227		0.103	

Delta MPI (MPI at discharge – MPI on admission) as well as the Delta of all its subdomains between discharge and admission for the SOC and IMI collectives subdivided by age group on admission
† Mann-Whitney-U-Test for continuous
* significant at 5%
Abbreviations: 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 Rating Scale

Table 3 shows the Delta MPI and the Delta of its subdomains of SOC and IMI patients according to age group on admission. IMI patients of the age group young-old showed significant improvements in their MPI (p<0.001), their ADL (p<0.001), their ESS (p<0.001), their MNA (p=0.042) and their SPMSQ (p<0.001) compared to SOC. The oldest-old showed improved results in their MPI (p=0.007), their ADL (p=0.008), their IADL (p=0.049) and their ESS (p=0.001) compared to SOC as well. There was little difference between SOC and IMI in the middle-old age group, where SOC patients showed a better development of their IADL (p<0.001) and CIRS score (p=0.017) than IMI.

Table 4: Delta MPI and Delta of its subdomains according to ADL risk group on admission [Median, Q1, Q3]

	ADL-1 (Low risk >4)		**ADL-2 (Medium risk 3-4)**		**ADL-3 (High risk 0-2)**	
	SOC N=231	**IMI** N=22	**SOC** N=82	**IMI** N=17	**SOC** N=90	**IMI** N=33
Delta MPI	0 (-0.003, 0.003)	0 (0, 0.125)	-0.001 (-0.06, 0.005)	-0.06 (-0.12, 0.034)	0 (-0.06, 0.006)	-0.12 (-0.183, 0)
p-value†	0.096		0.576		***0.001****	
Delta ADL	0 (0, 0)	0 (-0.25, 0)	0 (0, 1)	0 (-0.5, 1.5)	0 (0, 0.25)	2 (0, 3.5)
p-value†	***0.039****		0.979		***<0.001****	
Delta IADL [Minimum, Maximum]	0 (0, 0)	0 (-1, 0)	0 (0, 0)	0 (-0.5, 0)	0 (0, 0) [-5, 1]	0 (0, 0) [-2, 2]
p-value†	***<0.001****		***0.046****		***0.025****	
Delta ESS	0 (0, 1)	0 (0, 1)	0 (0, 1)	1 (1, 3.5)	0 (0, 1)	4 (1, 5.5)
p-value†	0.502		***0.043****		***<0.001****	
Delta CIRS	0 (-1, 0)	0 (-1, 0)	0 (-1, 0)	0 (0, 1)	0 (-1, 0)	0 (-1, 0)
p-value†	0.144		***0.011****		0.280	
Delta MNA	0 (0, 0)	0 (-0.5, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 1.5)
p-value†	0.239		0.796		0.105	
Delta SPMSQ	0 (0, 0)	0 (-0.25, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (-0.75, 0)
p-value†	***0.011****		0.938		***0.001****	

Delta MPI (MPI at discharge – MPI on admission) as well as the Delta of all its subdomains between discharge and admission for the SOC and IMI collectives subdivided by ADL risk group on admission
† Mann-Whitney-U-Test for continuous
* significant at 5%,
Abbreviations: 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 Rating Scale

In Table 4, the Delta of the MPI and its subdomains is compared in the IMI and SOC collectives according to ADL risk group on admission. IMI patients with high functionality, i.e., low risk ADL group on admission, worsened significantly in both the Delta ADL as well as the Delta IADL while improving in the SPMSQ compared to SOC. In ADL-2, IMI patients worsened in the Delta IADL (p=0.046) and Delta CIRS (p=0.011) and improved in the Delta ESS (p=0.043). IMI patients with a low functionality on admission (ADL-3) improved the most compared to SOC: IMI patients improved significantly in their Delta MPI (p=0.001), their Delta ADL (p<0.001), their Delta IADL (p=0.025), their Delta ESS (p<0.001) and their Delta SPMSQ (p=0.001).

Table 5: Linear regression on influence of treatment group on Delta MPI

Overall			
Variable	Coefficient	Standard error	p-value*
Constant	-0.041	0.048	0.401
Treatment group	-0.014	0.010	0.147
Gender	-0.001	0.007	0.916
Age	0.001	0.001	***0.019****
MPI on admission	-0.148	0.020	***<0.001****
MPI-1			
Variable	Coefficient	Standard error	p-value*
Constant	-0.73	0.080	0.363
Treatment group	0.116	0.022	***<0.001****
Gender	0.001	0.011	0.918
Age	-0.0002	0.001	0.958
MPI on admission	-0.109	0.080	0.177
MPI-2			
Variable	Coefficient	Standard error	p-value*
Constant	-0.025	0.071	0.725
Treatment group	-0.022	0.013	0.079
Gender	-0.009	0.009	0.339
Age	0.001	0.001	0.175
MPI on admission	-0.098	0..056	0.079
MPI-3			
Variable	Coefficient	Standard error	p-value*
Constant	0.002	0.150	0.989
Treatment group	-0.059	0.022	***0.010****
Gender	0.007	0.018	0.710
Age	0.002	0.001	0.126
MPI on admission	-0.215	0.127	0.095

Linear regression on the influence of the treatment group on Delta MPI (MPI at discharge – MPI on admission) adjusted for gender, age and MPI on admission for the whole collective as well as according to MPI risk group on admission.
Values for Treatment group: SOC=1, IMI=2; Value for gender: Male=1, Female =2
* significant at 5%
Abbreviations: SOC, standard of care; IMI, interdisciplinary multidimensional intervention; MPI, Multidimensional Prognostic Index

Table 6: Linear regression on influence of treatment group on Delta ADL

Overall			
Variable	Coefficient	Standard error	p-value*
Constant	0.936	0.623	0.133
Treatment group	0.653	0.125	***<0.001****
Gender	-0.039	0.091	0.670
Age	-0.027	0.008	***0.001****
MPI on admission	1.438	0.254	***<0.001****
MPI-1			
Variable	Coefficient	Standard error	p-value*
Constant	1.237	0.763	0.108
Treatment group	-1.109	-0.459	***<0.001****
Gender	0.112	0.088	0,301
Age	-0.006	-0.047	0.585
MPI on admission	0.405	0.045	0.598
MPI-2			
Variable	Coefficient	Standard error	p-value*
Constant	1.025	0.962	0.740
Treatment group	0.705	0,250	***<0.001****
Gender	-0.029	-0.013	0.824
Age	-0.023	-0.118	***0.048****
MPI on admission	1.979	0.159	***0.009****

MPI-3			
Variable	Coefficient	Standard error	p-value*
Constant	3.549	2.943	0.228
Treatment group	1.191	0.394	***<0.001****
Gender	-0.164	-0.066	0.483
Age	-0.033	-0.175	0.068
MPI on admission	-0.447	-0.026	0.787

Linear regression on the influence of the treatment group on Delta ADL (ADL at discharge – ADL on admission) adjusted for gender, age and MPI on admission for the whole collective as well as according to MPI risk group on admission.
Values for Treatment group: SOC=1, IMI=2; Value for gender: Male=1, Female =2
* significant at 5%
Abbreviations: SOC, standard of care; IMI, interdisciplinary multidimensional intervention; MPI, Multidimensional Prognostic Index; ADL, Activities of Daily Living

Table 7: Linear regression on influence of treatment group on Delta IADL

Overall			
Variable	Coefficient	Standard error	p-value*
Constant	0.112	0.322	0.728
Treatment group	-0.110	0.065	0.091
Gender	-0.023	0.047	0.629
Age	-0.001	0.004	0.805
MPI on admission	0.120	0.131	0.361
MPI-1			
Variable	Coefficient	Standard error	p-value*
Constant	1.256	0.392	***0.002****
Treatment group	-0.859	0.106	***<0.001****
Gender	0.126	0.055	***0.024****
Age	-0.010	0.005	0.069
MPI on admission	0.479	0.393	0.225
MPI-2			
Variable	Coefficient	Standard error	p-value*
Constant	-0.012	0.435	0.978
Treatment group	-0.139	0.077	0.074
Gender	-0.083	0.058	0.156
Age	<0.001	0.005	0.926
MPI on admission	0.383	0.342	0.263
MPI-3			
Variable	Coefficient	Standard error	p-value*
Constant	-1.052	1.245	0.400
Treatment group	0.278	0.185	0.136
Gender	-0.015	0.149	0.922
Age	0.012	0.011	0.315
MPI on admission	-0.308	1.058	0.771

Linear regression on the influence of the treatment group on Delta IADL (IADL at discharge – IADL on admission) adjusted for gender, age and MPI on admission for the whole collective as well as according to MPI risk group on admission.
Values for Treatment group: SOC=1, IMI=2; Value for gender: Male=1, Female =2
* significant at 5%
Abbreviations: SOC, standard of care; IMI, interdisciplinary multidimensional intervention; MPI, Multidimensional Prognostic Index, IADL, Instrumental Activities of Daily Living

Table 8: Linear regression on influence of treatment group on Delta ESS

Variable	Coefficient	Standard error	p-value*
Overall			
Variable	Coefficient	Standard error	p-value*
Constant	0.051	0.996	0.959
Treatment group	1.295	0.201	***<0.001****
Gender	0.073	0.146	0.615
Age	-0.024	0.013	0.056
MPI on admission	2.129	0.406	***<0.001****
MPI-1			
Variable	Coefficient	Standard error	p-value*
Constant	0.158	1.178	0.894
Treatment group	-0.773	0.320	***0.017****
Gender	-0.125	0.166	0.451
Age	0.011	0.016	0.476
MPI on admission	0.774	1.183	0.514
MPI-2			
Variable	Coefficient	Standard error	p-value*
Constant	0.835	1.304	0.522
Treatment group	1.279	0.232	***<0.001****
Gender	0.423	0.175	***0.016****
Age	-0.039	0.016	***0.014****
MPI on admission	1.925	1.024	0.061
MPI-3			
Variable	Coefficient	Standard error	p-value*
Constant	-1.182	4.018	0.769
Treatment group	2.451	0.595	***<0.001****
Gender	-0.528	0.481	0.275
Age	-0.001	0.037	0.976
MPI on admission	0.658	3.413	0.848

Linear regression on the influence of the treatment group on Delta ESS (ESS at discharge – ESS on admission) adjusted for gender, age and MPI on admission for the whole collective as well as according to MPI risk-group on admission.
Values for Treatment group: SOC=1, IMI=2; Value for gender: Male=1, Female =2
* significant at 5%
Abbreviations: SOC, standard of care; IMI, interdisciplinary multidimensional intervention; MPI, Multidimensional Prognostic Index, ESS, Exton Smith Scale

Table 9: Linear regression on influence of treatment group on Delta MNA

Variable	Coefficient	Standard error	p-value*
Overall			
Variable	Coefficient	Standard error	p-value*
Constant	-1.904	1.767	0.282
Treatment group	0.200	0.356	0.575
Gender	1.415	0.258	***<0.001****
Age	-0.020	0.023	0.385
MPI on admission	1.663	0.721	***0.021****
MPI-1			
Variable	Coefficient	Standard error	p-value*
Constant	4.058	4.276	0.345
Treatment group	-1.783	1.162	0.128
Gender	1.443	0.601	***0.018****
Age	-0.088	0.057	0.123
MPI on admission	5.811	4.291	0.178
MPI-2			
Variable	Coefficient	Standard error	p-value*
Constant	-3.842	2.584	0.138
Treatment group	0.488	0.460	0.290
Gender	1.622	0.346	***<0.001****
Age	0.002	0.031	0.944
MPI on admission	1.190	2.030	0.558

MPI-3			
Variable	Coefficient	Standard error	p-value*
Constant	-0.320	4.054	0.937
Treatment group	0.533	0.601	0.377
Gender	0.995	0.485	***0.043****
Age	-0.001	0.037	0.969
MPI on admission	-2.348	3.444	0.497

Linear regression on the influence of the treatment group on Delta MNA (MNA at discharge – MNA on admission) adjusted for gender, age and MPI on admission for the whole collective as well as according to MPI risk group on admission.
Values for Treatment group: SOC=1, IMI=2; Value for gender: Male=1, Female =2
* significant at 5%
Abbreviations: SOC, standard of care; IMI, interdisciplinary multidimensional intervention; MPI, Multidimensional Prognostic Index, MNA, Mini Nutritional Assessment

Tables 5 to 9 show the results of linear regressions examining the influence of the treatment group on the Delta MPI and Delta of its subdomains adjusted for gender, age and MPI on admission. Concerning the Delta MPI, the linear regression showed that the IMI was associated with a worsening in the MPI in MPI-1 (p<0.001) and an improvement in MPI-3 (p=0.010), both adjusted for gender, age and MPI on admission. The IMI was furthermore associated with improvement in the Delta ADL in MPI-2 (p<0.001) and MPI-3 (p<0.001) and with a worsening in MPI-1 (p<0.001). Overall, being in the IMI, lower age at recruitment as well as higher MPI risk group on admission were associated with ADL improvement (p<0.001, p=0.001 and p<0.001, respectively). Being in the IMI was also associated with a deterioration in IADL in MPI-1 (p<0.001). Concerning the Delta ESS, the linear regression showed a beneficial association of the IMI with the Delta ESS overall (p<0.001), in MPI-2 (p<0.001) and MPI-3 (p<0.001), while in MPI-1 the IMI was associated with a worse ESS development (p=0.017). The IMI had no effect on the development of the MNA in these linear regressions.

Table 10: Cox regression on survival in follow up of IMI and SOC patients

	N	%
Event †	145	30.5
Total case number	475	100

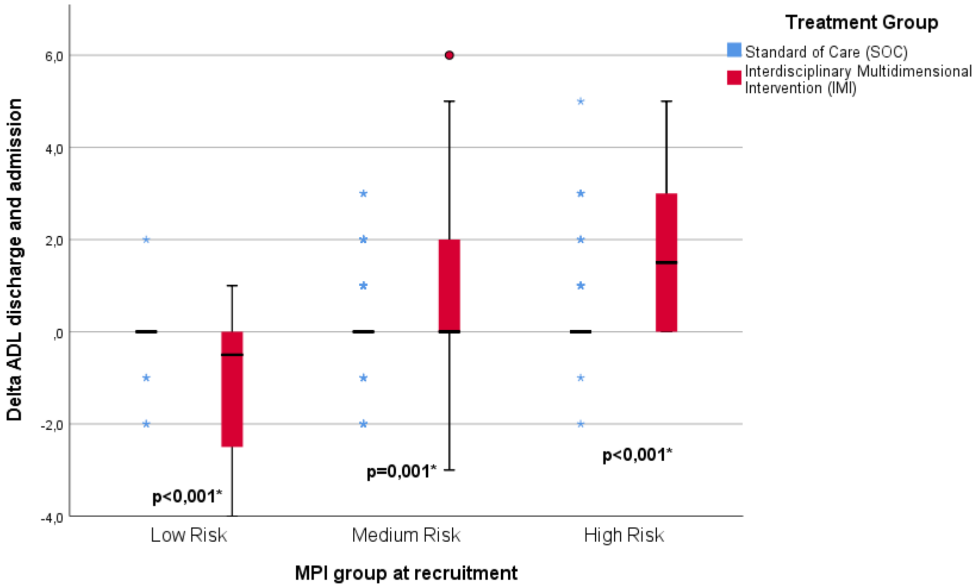
† Event categorized as death of a patient

	Coefficient	Standard error	p-value
Gender	-0.482	0.181	***0.008****
Kind of treatment	-0.198	0.240	0.409
Age at recruitment	2.833	0.475	0.066
LHS	0.028	0.015	0.107
MPI on Admission	0.010	0.006	***<0.001****

Cox regression of survival of IMI and SOC patients
* significant at 5%
Abbreviations: LHS, length of hospital stay; MPI, Multidimensional Prognostic Index

Table 10 shows a cox regression concerning the follow up of IMI and SOC collectives. Verbal data stemming from the phone-based follow ups as well as written information in the form of discharge letters was used. The calculation of survival time begins with admission of the patient. Only the MPI value on admission as well as gender were associated with survival, while the treatment group had no impact on survival likelihood at follow up.

Figure 1: Delta ADL divided by MPI group on recruitment



Boxplot of the Delta ADL according to treatment group and MPI on admission
Abbreviations: SOC, standard of care; IMI, interdisciplinary multidimensional intervention; ADL, Activities of Daily Living; MPI, Multidimensional Prognostic Index

Figure 1 shows the Delta of the Activities of Daily Living (ADL) between discharge and admission presented as a box plot displayed by MPI risk group on admission. The interdisciplinary multidimensional 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%. This figure shows that the IMI patients of MPI-2 and MPI-3 showed noticeable improvements in their ADL while the opposite was the case for MPI-1. The ADL of SOC patients remained mostly unchanged.

3.2.2. Subgroup analysis of the IMI collective

Table 11: Development of the MPI and its subdomains within the IMI collective divided by MPI risk groups [Median, Q1, Q3]

	MPI-1 **IMI** N=8	**MPI-2** **IMI** N=44	**MPI-3** **IMI** N=20
Delta MPI	0.13 (0.03, 0.175)	-0.03 (-0.12, 0)	-0.12 (-0.18, 0)
p-value†	***<0.001**** MPI-3 vs. MPI-2: p=0.327 MPI-3 vs. MPI-1: ***p<0.001**** MPI-2 vs. MPI-1: ***p=0.003****		
Delta ADL	-0.5 (-2.75, 0)	0 (0, 2)	1.5 (0, 3)
p-value†	***0.003**** MPI-3 vs MPI-2: p=0.288 MPI-3 vs. MPI-1: ***p=0.002**** MPI-2 vs. MPI-1: ***p=0.038****		
Delta IADL	-1 (-1.75, 0)	0 (0, 0)	0 (0, 0.8)
p-value†	***0.003**** MPI-3 vs. MPI-2: p=0.378 MPI-3 vs. MPI-1: ***p=0.002**** MPI-2 vs. MPI-1: ***p=0.023****		
Delta ESS	0 (-0.75, 0.75)	1 (0, 3.75)	4 (0.25, 5.75)
p-value†	***0.006**** MPI-3 vs. MPI-2: p=0.361 MPI-3 vs. MPI-1: ***p=0.004**** MPI-2 vs. MPI-1: ***p=0.047****		
Delta CIRS	0.5 (0, 1)	0 (-1, 0)	0 (-1, 0)
p-value†	0.240		
Delta MNA	-1 (-5, 0)	0 (0, 0)	0 (-0.75, 1.75)
p-value†	0.113		
Delta SPMSQ	0 (0, 0)	0 (0, 0)	0 (-1, 0)
p-value†	0.156		

Development of the Delta MPI (MPI at discharge – MPI on admission) and the Delta of its subdomains in the IMI collective divided by MPI risk group on admission
†Kruskal-Wallis-Test with paired comparison
*significant at 5%
Abbreviations: 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

In an effort to determine which patients profit most from an intervention like the IMI, a Kruskal-Wallis-Test was performed concerning the Delta MPI and the Delta of its subdomains (see Table 11). Through a paired comparison, patient subgroups who profited more than others could be identified. Concerning the Delta MPI, patients who were classified as MPI-3 on admission showed a significantly higher median improvement of the Delta MPI than patients with MPI-1 (-0.12 [0.18] vs. 0.13 [0.14]; p<0.001). The same could be observed for MPI-2 compared to MPI-1 (-0.03 [0.12] vs. 0.13 [0.14]; p=0.003). Similar developments could be seen in MPI-3 and MPI-2 subgroups concerning ADL, IADL and ESS development (see Table 11).

Table 12: Development of the MPI and its subdomains within the IMI collective divided by age groups [Median, Q1, Q3]

	Young-old (65-74 years)	Middle-old (75-84 years)	Oldest-old (85+ years)
	N=22	N=39	N=11
Delta MPI	-0.12 (-0.18, 0)	0 (-0.065, 0.0625)	-0.06 (-0.13, 0)
p-value†	***0.017**** Young old vs. middle old**: p=*0.023**** Young old vs oldest old: p>0.999 Middle old vs oldest old: p=0.248		
Delta ADL	1.5 (0, 4)	0 (0, 2)	0 (0, 2)
p-value†	***0.023**** Young old vs. middle old**: p=*0.020**** Young old vs oldest old: p>0.999 Middle old vs oldest old: p=0.800		
Delta IADL	0 (0, 0)	0 (-1, 0)	0 (0, 0)
p-value†	0.070		
Delta ESS	3 (1, 5)	0 (0, 2)	3 (1, 6)
p-value†	***0.001**** Young old vs. middle old**: p=*0.002**** Young old vs oldest old: p>0.999 Middle old vs oldest old: p=***0.039****		
Delta CIRS	0 (-1, 1)	0 (0, 0)	-1 (1, 0)
p-value†	0.238		
Delta MNA	0 (0, 1.25)	0 (-1, 0)	0 (0, 1)
p-value†	0.164		
Delta SPMSQ	0 (-1, 0)	0 (0, 0)	0 (-1, 0)
p-value†	0.276		

Development of the Delta MPI (MPI at discharge – MPI on admission) and the Delta of its subdomains in the IMI collective divided by age groups
†Kruskal-Wallis-Test with paired comparison
*significant at 5%
Abbreviations: 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

When dividing the IMI collective into three age groups, the analysis by Kruskal-Wallis-Test and the following group comparison showed favourable results in the young-old age group concerning Delta MPI (-0.12 [0.18] vs. 0 [0.13]; p=0.023), Delta ADL (1.5 [4] vs. 0 [2]; p=0.020) and Delta ESS (3 [4] vs. 0 [2]; p=0.002) compared to the middle-old age group. The oldest-old showed a significant difference in ESS-development compared to the middle-old subgroup (3 [5] vs. 0 [2]; p=0.039). However, the oldest-old subgroup, who underwent the IMI, only numbered 11 patients.

Table 13: Development of the MPI and its subdomains within the IMI collective divided by ADL group on admission [Median, Q1, Q3]

	ADL-1 (Low risk >4)	**ADL-2 (Medium risk 3-4)**	**ADL-3 (High risk 0-2)**
	N=22	N=17	N=33
Delta MPI	0 (0, 0.125)	-0.06 (-0.12, 0.034)	-0.12 (-0.183, 0))
p-value†	***0.001**** ADL-1 vs. ADL-2: p=0.175 ADL-1 vs. ADL-3: ***p<0.001**** ADL-2 vs. ADL-3: p=0.196		
Delta ADL	0 (-0.25, 0)	0 (-0.5, 1.5)	2 (0, 3.5)
p-value†	***<0.001**** ADL-1 vs. ADL-2: p=0.726 ADL-1 vs. ADL-3: ***p<0.001**** ADL-2 vs. ADL-3: ***p=0.002****		
Delta IADL	0 (-1, 0)	0 (-0.5, 0)	0 (0, 0)
p-value†	***0.013**** ADL-1 vs. ADL-2: p>0.999 ADL-1 vs. ADL-3: ***p=022**** ADL-2 vs. ADL-3: p=0.099		
Delta ESS	0 (0, 1)	1 (0, 3.5)	4 (1, 5.5)
p-value†	**<0.001*** ADL-1 vs. ADL-2: p=0.422 ADL-1 vs. ADL-3: ***p<0.001**** ADL-2 vs. ADL-3: p=0.104		
Delta CIRS	0 (-1, 0)	0 (0, 1)	0 (-1, 0)
p-value†	0.151		
Delta MNA	0 (-0.5, 0)	0 (0, 0.5)	0 (0, 1.5)
p-value†	0.172		
Delta SPMSQ	0 (-0.25, 0)	0 (0, 0)	0 (-0.75, 0)
p-value†	0.524		

Development of the Delta MPI (MPI at discharge – MPI on admission) and the Delta of its subdomains in the IMI collective as a whole as well as divided by ADL risk group on admission
†Kruskal-Wallis-Test with paired comparison
*significant at 5%
Abbreviations: 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

Table 13 shows the development of the MPI and its subdomains according to functionality on admission measured by the ADL. The patients of ADL-3 seemed to improve the most in their MPI compared to ADL-1. Similarly, ADL-3 patients showed positive changes in their ADL, IADL and ESS compared to ADL-1 patients.

Table 14: Linear regression on the influence of days in the IMI and number of therapies on the Delta MPI and its subdomains

Variable	Coefficient	Standard error	p-value*
Influence on Delta MPI			
Variable	Coefficient	Standard error	p-value*
Constant	-0.004	0.176	0.982
IMI days	<0.001	0.002	0.970
Gender	-0.006	0.025	0.819
Age	0.002	0.002	0.319
MPI on admission	-0.387	0.081	***<0.001****
LHS	-0.001	0.001	0.475
Number of therapies	0.004	0.002	0.134
Influence on Delta ESS			
Variable	Coefficient	Standard error	p-value*
Constant	-2.298	4.638	0.622
IMI days	-0.022	0.044	0.624
Gender	0.265	0.265	0.690
Age	-0.004	0.057	0.949
MPI on admission	7.452	2.134	***0.001****
LHS	0.010	0.023	0.677
Number of therapies	0.010	0.064	0.875
Influence on Delta IADL			
Variable	Coefficient	Standard error	p-value*
Constant	-0.725	1.592	0.650
IMI days	0.012	0.015	0.431
Gender	-0.019	0.227	0.934
Age	-0.004	0.020	0.827
MPI on admission	1.898	0.733	***0.012****
LHS	-0.002	0.008	0.848
Number of therapies	-0.027	0.022	0.224
Influence on Delta ADL			
Variable	Coefficient	Standard error	p-value*
Constant	3.953	3.116	0.210
IMI days	0.018	0.030	0.552
Gender	0.119	0.444	0.789
Age	-0.072	0.030	0.066
MPI on admission	4.489	1.434	***0.003****
LHS	0.016	0.016	0.295
Number of therapies	-0.081	0.043	0.065

Linear regression on the influence of the number of days in the IMI as well as number of therapies on Delta MPI (MPI at discharge – MPI on admission), Delta ESS (ESS at discharge – ESS on admission), Delta IADL (IADL at discharge – IADL on admission) and Delta ADL (ADL at discharge – ADL on admission)
Value for gender: Male=1, Female =2
* significant at 5%
Abbreviations: IMI, interdisciplinary multidimensional intervention; MPI, Multidimensional Prognostic Index; ESS, Exton Smith Scale; IADL, Instrumental Activities of Daily Living; ADL, Activities of Daily Living

Table 14 shows the results of a linear regression on the influence of IMI parameters of number of therapies and days in the IMI on the development of the MPI and selected subgroups. No influence could be found.

Table 15: Descriptive statistics of geriatric test results and development of test results between admission and discharge [Median, Q1, Q3]

	Total	MPI-1	MPI-2	MPI-3
DEMMI on admission	N=58 34.5 (27, 44)	N=7 53 (30, 67)	N=33 33 (27, 57)	N=18 31.5 (27, 39)
p-value†		0.176		
DEMMI at discharge	N=18 40 (27, 54)	N=0	N=11 41 (27, 57)	N=7 39 (33, 44)
p-value†		0.891		
Delta DEMMI	N=18 9 (0, 11.3)	N=0	N=11 9 (0, 13)	N=7 0 (0, 11)
p-value†		0.263		
DemTect [Minimum, Maximum]	N=10 12 (10, 16.5)	N=2 13.5 [Min 11, Max 16]	N=6 10 (9.3, 13.5)	N=2 24 [Min 18, Max 30]
p-value†		0.059		
GDS on admission	N=66 2 (1, 4)	N=8 2 (0.5, 3)	N=41 2 (1, 5)	N=17 3 (2, 4.5)
p-value†		0.357		
GDS at discharge	N=15 2 (1, 2)	N=1	N=10 2 (1, 3)	N=4 1 (0.25, 1.75)
p-value†		0.351		
Delta GDS	N=15 0 (-1, 0)	N=1	N=10 0 (-1, 0)	N=4 -2 (-4.5, -0.25)
p-value†		0.108		
HG Right Hand on admission	N=44 14.3 (10.7, 20.3)	N=6 19 (12.3, 27.8)	N=27 15 (10.7, 25.3)	N=11 13.33 (7.3, 16)
p-value†		0.296		
HG Right Hand at discharge [Minimum, Maximum]	N=9 11 (3, 15.8)	N=0	N=6 8.15 (2, 24)	N=3 11 [Min 10, Max 12.67]
p-value†		0.795		
Delta HG Right Hand [Minimum, Maximum]	N=9 2 (0.5, 5)	N=0	N=6 3 (1.6, 7.5)	N=3 0.67 [Min -5, Max 3.7]
p-value†		0.195		
HG Left Hand on admission	N=39 15.33 (6, 20)	N=6 18.65 (11.25)	N=24 15.82 (5.3, 23.7)	N=9 10.5 (3.2, 16.8)
p-value†		0.262		
HG Left Hand at discharge [Minimum, Maximum]	N=9 10 (3.8, 13.5)	N=0	N=6 8.5 (2, 19.4)	N=3 10 [Min 5, Max 11]
p-value†		0.897		
Delta HG Left Hand [Minimum, Maximum]	N=9 0 (-0.65, 1.7)	N=0	N=6 0 (-0.3, 2.2)	N=3 -1 [Min -6, Max 1.4]
p-value†		0.193		
MMSE [Minimum, Maximum]	N=18 26 (23, 28.3)	N=2 27.5 [Min 25, Max 30]	N=13 26 (24, 28.5)	N=3 20 [Min 17, Max 27]
p-value†		0.420		
MoCa	N=14 19 (15.5, 23.8)	N=1 17	N=5 16 (12.5, 27.5)	N=8 20.5 (17.3, 23)
p-value†		0.800		
TUG on admission	N=25 23 (18.5, 32)	N=4 20.5 (14, 24.75)	N=16 23 (19.25, 32)	N=5 22 (18, 44)
p-value†		0.537		
TUG at discharge	N=7 20 (16, 23)	N=0	N=6 19.5 (15, 22.75)	N=1 23
p-value†		0.317		

Delta TUG	N=5 0 (-29.5, 1.5)	N=0	N=4 -3 (-41.3, 1.5)	N=1 1
p-value†		0.480		

Geriatric test results and Delta of geriatric test results (value at discharge – value on admission) overall and divided by MPI risk group on admission in IMI collective
†Kruskal-Wallis-Test
*significant at 5%
Abbreviations: Q_1, First Quartile; Q_3: Third Quartile; MPI, Multidimensional Prognostic Index; DEMMI, de Morton Mobility Index; DemTect, Dementia Detection Text; GDS, Geriatric Depression Scale; HG, Hand Grip Test; MMSE, Mini Mental State Examination; MoCa, Montreal Cognitive Assessment; TUG, Timed Up and Go Test; IMI, interdisciplinary multidimensional intervention

Table 15 displays the geriatric test results on admission and at discharge as well as the Delta between discharge and admission. No significant differences could be found.

3.2.3. Comparison of SOC and IMI collectives with patients of a geriatric ward

Table 16: Descriptive statistics of the SOC, IMI and GW collectives

	Total			**MPI- 1**		
	SOC N=403 (100%)	**IMI** N=72 (100%)	**GW** N=176 (100%)	**SOC** N=111 (27.5%)	**IMI** N=8 (11%)	**GW** N=11 (6.3%)
Female, *n (%)*	157 (39.0)	30 (41.7)	111 (63.1)	36 (32.4)	5 (62.5)	6 (54.5)
p-value†	***<0.001****			0.096		
Age (years), *median (Q_1, Q_3)*	77 (73, 81)	78 (74, 82)	82 (78, 87)	75 (71, 79)	79.5 (76.5, 81)	85 (77, 89)
p-value†	***<0.001**** SOC vs. IMI: p=0.943 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p<0.001****			***<0.001**** SOC vs. IMI: p=0.071 SOC vs. GW: ***p=0.001**** IMI vs. GW: p>0.999		
LHS (days), *median (Q_1, Q_3)*	8 (5, 15)	22 (14.3, 32.8)	17.5 (13, 21)	7 (4, 13)	27 (13.8, 43)	15 (7, 21)
p-value†	***<0.001**** SOC vs. IMI: ***p<0.001**** SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p=0.032****			***<0.001**** SOC vs. IMI: ***p<0.001**** SOC vs. GW: p=0.056 IMI vs. GW: p=0.436		
Period of education (years), *median (Q_1, Q_3)*	12 (10.5, 15)	11 (9, 14)	11 (8, 13)	12 (11, 15.25)	11 (10, 14)	12 (10.5, 13.5)
p-value†	0.086			0.282		
Number of medications on admission, *median (Q_1, Q_3)*	9 (7, 12)	10 (8, 14)	9 (6, 11)	7 (5, 10)	10 (7, 12.8)	5 (4, 7)
p-value†	***0.026**** SOC vs. IMI: p=0.167 SOC vs. GW: p=0.435 IMI vs. GW: ***p=0.021****			0.106		
	MPI-2			**MPI-3**		
	SOC N=216 (53.5%)	**IMI** N=44 (61%)	**GW** N=91 (51.7%)	**SOC** N=76 (19%)	**IMI** N=20 (28%)	**GW** N=74 (42%)
Female, *n (%)*	88 (40.7)	14 (31.8)	57 (62.6)	33 (43.4)	11 (55)	48 (64.9)
p-value†	***<0.001****			***0.031****		
Age (years), *median (Q_1, Q_3)*	77 (74, 82)	77.5 (74, 82.75)	81 (78, 87)	80 (75.3, 88)	77 (70.3, 84.8)	83 (79, 87)
p-value†	***<0.001**** SOC vs. IMI: p>0.999 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p=0.008****			***0.003**** IMI vs. SOC: p=0.752 SOC vs. GW: ***p=0.021**** IMI vs. GW: ***p=0.011****		
LHS (days), m*edian (Q_1, Q_3)*	8 (5, 14)	18.5 (13, 29.5)	17 (10, 21)	12 (7, 19)	28.5 (19.8, 34.8)	18 (16, 22)
p-value†	***<0.001**** SOC vs. IMI: ***p<0.001**** SOC vs. GW: ***p<0.001**** IMI vs. GW: p=0.426			***<0.001**** SOC vs. IMI: ***p<0.001**** SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p=0.008****		
Period of education (years), *median (Q_1, Q_3)*	11 (10, 15)	12 (11, 15)	11 (9, 13)	11 (9, 13)	11 (8, 11)	11 (8, 13)
p-value†	0.484			0.238		

Number of medications on admission, *median (Q_1, Q_3)*	9 (7, 12)	10 (8, 13)	9 (7, 10)	11 (8, 13)	10 (8, 12.8)	9 (7, 12)
p-value†	0.108			***0.007**** SOC vs. IMI: p>0.999 SOC vs. GW: ***p=0.005**** IMI vs. GW: p=0.638		

Descriptive statistics of IMI, SOC and GW collectives overall and divided by MPI risk group on admission
† Chi-Square-Test or Fisher's exact test with post-hoc-analysis for frequencies, Kruskal-Wallis-Test for continuous
*significant at 5%
Abbreviations: Q_1, First Quartile; Q_3: Third Quartile; IMI, interdisciplinary multidimensional intervention; SOC, standard of care; GW, geriatric ward; MPI, Multidimensional Prognostic Index; LHS, length of hospital stay

Table 16 shows the descriptive statistics of the GW collective compared to SOC and IMI. There was a difference in gender distribution, with a post hoc analysis showing that while SOC patients were more often male (p<0.001), GW patients were significantly more often female (p<0.001). GW patients were also older than SOC and IMI patients (p<0.001). Concerning LHS, SOC patients were hospitalized for significantly fewer days than both GW and IMI patients (p<0.001 and p<0.001, respectively), while IMI patients also had a significantly longer LHS than GW (p=0.032).

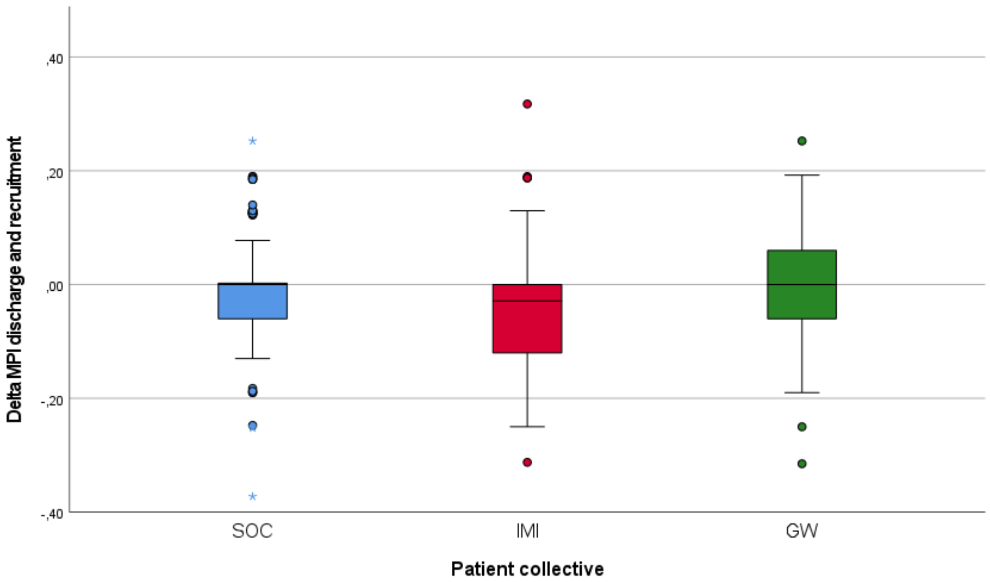
Table 17: Analysis of the MPI and Delta MPI in SOC, IMI and GW collectives

	Total			**MPI- 1**		
	SOC N=403 (100%)	**IMI** N=72 (100%)	**GW** N=176 (100%)	**SOC** N=111 (27.5%)	**IMI** N=8 (11%)	**GW** N=11 (6.3%)
MPI on admission	0.44 (0.25, 0.63)	0.56 (0.45, 0.69)	0.625 (0.5, 0.75).	0.25 (0.19, 0.31)	0.25 (0.25, 0.31)	0.25 (0.23, 0.31)
p-value†	***<0.001**** SOC vs. IMI: ***p<0.001**** SOC vs. GW: ***p<0.001**** IMI vs. GW: p=0.267			0.566		
MPI at discharge	0.44 (0.31, 0.56)	0.5 (0.44, 0.63)	0.63 (0.46, 0.75)	0.25 (0.25, 0.31)	0.38 (0.33, 0.38)	0.31 (0.31, 0.38)
p-value†	***<0.001**** SOC vs. IMI: ***p=0.014**** SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p=0.009****			***0.001**** SOC vs. IMI: ***p=0.001**** SOC vs. GW: ***p=0.344*** IMI vs. GW: p=0.277		
Delta MPI	0 (-0.06, 0.003)	-0.029 (-0.12, 0)	0 (-0.06, 0.6)	0 (-0.003, 0.06)	0.126 (0.03, 0.18)	0.06 (-0.003, 0.07)
p-value†	***0.020**** SOC vs. IMI: p=0.059 SOC vs. GW: p=0.948 IMI vs. GW: ***p=0.016****			***0.020**** SOC vs. IMI: p=0.059 SOC vs. GW: p=0.948 IMI vs. GW: ***p=0.016****		

	MPI-2			MPI-3		
	SOC N=216 (53.5%)	**IMI** N=44 (61%)	**GW** N=91 (51.7%)	**SOC** N=76 (19%)	**IMI** N=20 (28%)	**GW** N=74 (42%)
MPI on admission	0.47 (0.38, 0.56)	0.56 (0.56, 0.56)	0.5 (0.44, 0.63)	0.75 (0.69, 0.82)	0.75 (0.69, 0.75)	0.75 (0.69, 0.81)
p-value[†]	***<0.001**** SOC vs. IMI: ***p=0.002**** SOC vs. GW: ***p=0.001**** IMI vs. GW: p>0.999			0.351		
MPI at discharge	0.44 (0.38, 0.56)	0.47 (0.39, 0.56)	0.5 (0.44, 0.56)	0.69 (0.69, 0.75)	0.63 (0.56, 0.73)	0.75 (0.69, 0.81)
p-value[†]	***0.003**** SOC vs. IMI: p=0.773 SOC vs. GW: ***p=0.002**** IMI vs. GW: p=0.602			***<0.001**** SOC vs. IMI: ***p=0.010**** SOC vs. GW: p=0.128 IMI vs. GW: ***p<0.001****		
Delta MPI	0 (-0.06, 0.003)	-0.03 (-0.12, 0)	0 (-0.063, 0.06)	-0.001 (-0.06, 0.003)	-0.12 (-0.18, 0)	0 (-0.06, 0.003)
p-value[†]	***0.041**** SOC vs. IMI: p=0.158 SOC vs. GW: p=0.760 IMI vs. GW: ***p=0.035****			***0.006**** SOC vs. IMI: p=0.086 SOC vs. GW: p=0.378 IMI vs. GW: ***p=0.004****		

Analysis of MPI on admission and at discharge as well as Delta MPI (MPI at discharge – MPI on admission) for SOC, IMI and GW collectives overall and according to MPI risk group on admission
† Kruskal-Wallis-Test with paired comparison
*significant at 5%
Abbreviations: IMI, interdisciplinary multidimensional intervention; SOC, standard of care; GW, geriatric ward; MPI, Multidimensional Prognostic Index

Figure 2: Delta MPI according to patient collective



Boxplot of the Delta MPI according to SOC, IMI and GW collectives
Abbreviations: SOC, standard of care; IMI, interdisciplinary multidimensional intervention; GW, geriatric ward; MPI, Multidimensional Prognostic Index

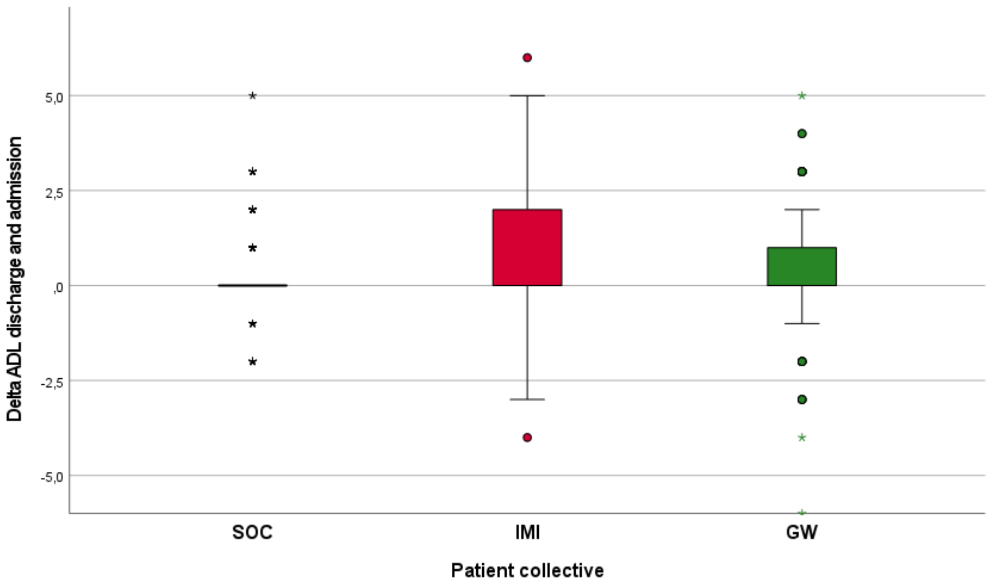
GW patients, like IMI patients, showed a significantly higher MPI on admission than SOC (p<0.001). This was evident in the overall analysis as well as in MPI-2. The worse MPI score in IMI and GW was also evident at discharge (see Table 17). The IMI collective showed the most beneficial improvement in the Delta MPI in the overall analysis as well as MPI-2 and MPI-3 – in these subgroups, the IMI collective showed statistically significant improvements compared to GW patients as well as tendencies towards an improvement compared to SOC (see Table 17 and Figure 2). IMI patients showed a worse Delta MPI than GW (p=0.016) and SOC (p=0.001) only in MPI-1.

Table 18: Analysis of the ADL and Delta ADL in SOC, IMI and GW collectives

	Total			**MPI- 1**		
	SOC N=403 (100%)	**IMI** N=72 (100%)	**GW** N=176 (100%)	**SOC** N=111 (27.5%)	**IMI** N=8 (11%)	**GW** N=11 (6.3%)
ADL on admission	5 (3, 6)	3 (1, 5)	2.5 (1, 4)	6 (6, 6)	6 (5, 6)	3 (2, 5)
p-value†	<0.001* SOC vs. IMI: p<0.001* SOC vs. GW: p<0.001* IMI vs. GW: p=0.624			0.007* SOC vs. IMI: p=0.845 SOC vs. GW: p=0.007* IMI vs. GW: p=0.672		
ADL at discharge	5 (3, 6)	4 (3, 5)	3 (1, 4)	6 (6, 6)	4.5(2.3,6)	4 (3, 5)
p-value†	<0.001* SOC vs. IMI: p=0.104 SOC vs. GW: p<0.001* IMI vs. GW: p=0.003*			<0.001* SOC vs. IMI: p=0.008* SOC vs. GW: p=0.006* IMI vs. GW: p>0.999		
Delta ADL	0 (0, 0)	0 (0, 2)	0 (0, 1)	0 (0, 0)	0 (0, 0)	0 (0, 1)
p-value†	<0.001* SOC vs. IMI: p<0.001* SOC vs. GW: p=0.003* IMI vs. GW: 0.157			0.005* SOC vs. IMI: p=0.008* SOC vs. GW: p=0.432 IMI vs. GW: p=0.513		
	MPI-2			**MPI-3**		
	SOC N=216 (53.5%)	**IMI** N=44 (61%)	**GW** N=91 (51.7%)	**SOC** N=76 (19%)	**IMI** N=20 (28%)	**GW** N=74 (42%)
ADL on admission	5 (3, 6)	3 (2, 5)	3 (2, 5)	1 (1, 2)	1 (1, 2)	1 (0.75, 2)
p-value†	<0.001* SOC vs. IMI: p=0.001* SOC vs. GW: p<0.001* IMI vs. GW: p<0.999			0.969		
ADL at discharge	5 (4, 6)	5 (3, 6)	4 (3, 5)	1 (1, 2)	2.5(1.3,4)	1 (1, 3)
p-value†	<0.001* SOC vs. IMI: p=0.894 SOC vs. GW: p<0.001* IMI vs. GW: p=0.116			0.017* SOC vs. IMI: p=0.018* SOC vs. GW: p>0.999 IMI vs. GW: p=0.024*		
Delta ADL	0 (0, 0)	0 (0, 2)	0 (0, 1)	0 (0, 0)	1.5 (0, 3)	0 (0, 1)
p-value†	0.002* SOC vs. IMI: p=0.008* SOC vs. GW: p=0.042* IMI vs. GW: p=0.922			<0.001* SOC vs. IMI: p<0.001* SOC vs. GW: p=0.849 IMI vs. GW: p=0.004*		

Analysis of ADL on admission and at discharge as well as Delta ADL (ADL at discharge – ADL on admission) for SOC, IMI and GW collectives overall and according to MPI risk group on admission
† Kruskal-Wallis-Test with paired comparison
*significant at 5%
Abbreviations: IMI, interdisciplinary multidimensional intervention; SOC, standard of care; GW, geriatric ward; MPI, Multidimensional Prognostic Index; ADL, Activities of Daily Living

Figure 3: Delta ADL according to patient collective



Boxplot of the Delta ADL according to SOC, IMI and GW collectives
Abbreviations: SOC, standard of care; IMI, interdisciplinary multidimensional intervention; GW, geriatric ward; ADL, Activities of Daily Living

Table 18 shows that on admission, SOC patients had better ADL scores than IMI and GW ($p<0.001$ and $p<0.001$, respectively). There was no significant difference between IMI and GW ADL scores on admission ($p=0.624$). However, when analysing the Delta ADL, it becomes clear that while SOC patients didn't show any change, IMI, as well as GW patients, improved their ADL scores significantly compared to SOC ($p<0.001$ and $p=0.003$, respectively, see Table 18 and Figure 3). This is also evident in the subgroup analysis in MPI-2 (see Table 18). In MPI-3, however, ADL scores on admission did not vary significantly between the collectives ($p=0.969$). Of interest, however, is the fact that IMI patients showed a significantly better Delta ADL than both SOC and GW patients ($p<0.001$ and $p=0.004$).

Table 19: Analysis of the IADL and Delta IADL in SOC, IMI and GW collectives

	Total			MPI- 1		
	SOC N=403 (100%)	**IMI** N=72 (100%)	**GW** N=176 (100%)	**SOC** N=111 (27.5%)	**IMI** N=8 (11%)	**GW** N=11 (6.3%)
IADL on admission	5 (3, 5)	4.5 (2.3, 6)	3 (2, 4)	7 (6, 8)	6 (5.3, 7.8)	4 (2, 5)
p-value†	***<0.001**** SOC vs. IMI: p=0.135 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p<0.001****			***0.001**** SOC vs. IMI: p=0.296 SOC vs. GW: ***p=0.001**** IMI vs. GW: p=0.855		
IADL at discharge	5 (3, 8)	4 (3, 6)	3 (1.25, 4)	7 (6, 8)	5 (4.3, 7.3)	3 (2, 5)
p-value†	***<0.001**** SOC vs. IMI: p=0.093 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p<0.001****			***<0.001**** SOC vs. IMI: ***p=0.036**** SOC vs. GW: ***p=0.001**** IMI vs. GW: p>0.999		
Delta IADL	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	-1(-1.8,*0*)	0 (0, 0)
p-value†	0.509			***<0.001**** SOC vs. IMI: ***p<0.001**** SOC vs. GW: >0.999 IMI vs. GW: ***p<0.001****		
	MPI-2			MPI-3		
	SOC N=216 (53.5%)	**IMI** N=44 (61%)	**GW** N=91 (51.7%)	**SOC** N=76 (19%)	**IMI** N=20 (28%)	**GW** N=74 (42%)
IADL on admission	5 (3, 7)	5 (4, 7)	4 (2, 5)	2 (1, 3)	2 (1, 4)	2 (1, 3)
p-value†	***<0.001**** SOC vs. IMI: p>0.999 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p=0.001****			0.371		
IADL at discharge	5 (3, 7)	4.5 (4, 6.8)	3 (2, 5)	2 (1, 3)	3 (1, 4)	2 (1, 3)
p-value†	***<0.001**** SOC vs. IMI: p>0.999 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p=0.002****			***0.038**** SOC vs. IMI: p=0.403 SOC vs. GW: p=0.414 IMI vs. GW: ***p=0.042****		
Delta IADL	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 1)	0 (0, 0)
p-value†	0.435			0.304		

Analysis of IADL on admission and at discharge as well as Delta IADL (IADL at discharge – IADL on admission) for SOC, IMI and GW collectives overall and according to MPI risk group on admission
† Kruskal-Wallis-Test with paired comparison
*significant at 5%
Abbreviations: IMI, interdisciplinary multidimensional intervention; SOC, standard of care; GW, geriatric ward; MPI, Multidimensional Prognostic Index; IADL, Instrumental Activities of Daily Living

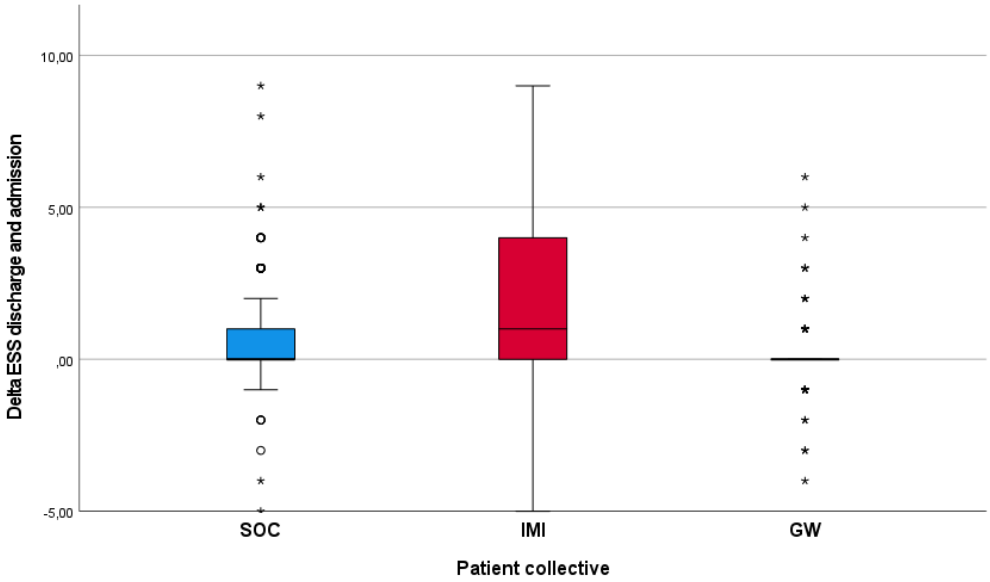
Table 19 shows the difference between the collectives concerning the IADL score. While the IMI and GW collectives showed worse scores on admission in the ADL, there were no significant differences in the Delta IADL. Singularly IMI patients of MPI-1 showed a worse Delta IADL than SOC and GW (p<0.001 and p<0.001, respectively).

Table 20: Analysis of the ESS and Delta ESS in SOC, IMI and GW collectives

	Total			MPI- 1		
	SOC N=403 (100%)	**IMI** N=72 (100%)	**GW** N=176 (100%)	**SOC** N=111 (27.5%)	**IMI** N=8 (11%)	**GW** N=11 (6.3%)
ESS on admission	15 (11, 17)	12.5 (10, 15)	15 (13, 17)	18 (16, 19)	16 (4.5, 16.75)	17 (16, 18)
p-value†	***<0.001**** SOC vs. IMI: ***p<0.001**** SOC vs. GW: p>0.999 IMI vs. GW: p***<0.001****			***0.021**** SOC vs. IMI: ***p=0.025**** SOC vs. GW: p=0.852 IMI vs. GW: p=0.529		
ESS at discharge	16 (12, 18)	15.5 (13, 17)	15 (13, 17)	18 (17, 19)	15 (3.5, 17.75)	17 (16, 18)
p-value†	0.124 SOC vs. IMI: ***p<0.001**** SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p<0.001****			***0.008**** SOC vs. IMI: ***p=0.018**** SOC vs. GW: p=0.288 IMI vs. GW: p=0.899		
Delta ESS	1 (0, 1)	1 (0, 4)	0 (0, 0)	0 (0, 0)	0 (-0.8, 0.8)	0 (0, 0)
p-value†	***<0.001**** SOC vs. IMI: ***p<0.001**** SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p<0.001****			0.175		
	MPI-2			MPI-3		
	SOC N=216 (53.5%)	**IMI** N=44 (61%)	**GW** N=91 (51.7%)	**SOC** N=76 (19%)	**IMI** N=20 (28%)	**GW** N=74 (42%)
ESS on admission	15 (12, 17)	13 (11, 15)	16 (14, 17)	9.5 (8, 12)	10 (8, 12)	13 (11, 15)
p-value†	***<0.001**** SOC vs. IMI: ***p=0.016**** SOC vs. GW: ***p=0.014**** IMI vs. GW: ***p<0.001****			***<0.001**** SOC vs. IMI: p>0.999 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p=0.001****		
ESS at discharge	16 (13, 17)	16 (14, 17)	16 (15, 17)	11.5 (8, 13)	15 (10, 16)	13 (11, 15)
p-value†	0.310			***<0.001**** SOC vs. IMI: ***p=0.001**** SOC vs. GW: ***p=0.002**** IMI vs. GW: p=0.604		
Delta ESS	0 (0, 1)	1 (0, 3.8)	0 (0, 0)	0 (0, 1)	4 (0, 6)	0 (0, 0)
p-value†	***<0.001**** SOC vs. IMI: ***p<0.001**** SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p<0.001****			***<0.001**** SOC vs. IMI: ***p=0.019**** SOC vs. GW: ***p=0.002**** IMI vs. GW: ***p<0.001****		

Analysis of ESS on admission and at discharge as well as Delta ESS (ESS at discharge – ESS on admission) for SOC, IMI and GW collectives overall and according to MPI risk group on admission
† Kruskal-Wallis-Test with paired comparison
*significant at 5%
Abbreviations: IMI, interdisciplinary multidimensional intervention; SOC, standard of care; GW, geriatric ward; MPI, Multidimensional Prognostic Index; ESS, Exton Smith Scale

Figure 4: Delta ESS according to patient collective



Boxplot of the Delta ESS according to SOC, IMI and GW collectives
Abbreviations: ESS, Exton Smith Scale; IMI, interdisciplinary multidimensional intervention; SOC, standard of care; GW, geriatric ward

Table 20 and Figure 4 show the values of the ESS score and Delta ESS divided by patient collectives and MPI risk group on admission. IMI patients had a significantly higher risk of bed sores according to the ESS on admission compared to SOC and GW (p<0.001 and p<0.001, respectively). As both the table and the boxplot show, IMI patients also improved the most in their Delta ESS compared to SOC and GW (p<0.001 and p<0.001). SOC patients also improved significantly more than GW patients (p<0.001).

Table 21: Analysis of the MNA and Delta MNA in SOC, IMI and GW collectives

	Total			MPI- 1		
	SOC N=403 (100%)	**IMI** N=72 (100%)	**GW** N=176 (100%)	**SOC** N=111 (27.5%)	**IMI** N=8 (11%)	**GW** N=11 (6.3%)
MNA on admission	9 (7, 12)	7 (5, 10)	10 (8, 11)	12 (10, - 13)	12 (9.5, 13.8)	12 (11, 13)
p-value†	***0.004**** SOC vs. IMI: ***p=0.008**** SOC vs. GW: p>0.999 IMI vs. GW: ***p=0.004****			0.706		
MNA at discharge	9 (6, 12)	8 (5, 10.8)	10 (8, 11)	11 (9, 13)	10.5 (3.8,13.5)	12 (11, 13)
p-value†	***0.006**** SOC vs. IMI: p=0.143 SOC vs. GW: p=0.120 IMI vs. GW: ***p=0.005****			0.484		
Delta MNA	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	-1 (-5, 0)	0 (0, 0)
p-value†	0.058			0.169		

	MPI-2			MPI-3		
	SOC N=216 (53.5%)	**IMI** N=44 (61%)	**GW** N=91 (51.7%)	**SOC** N=76 (19%)	**IMI** N=20 (28%)	**GW** N=74 (42%)
MNA on admission	9 (7, 11)	7 (5, 10)	11 (9, 12)	6 (4.3, 7)	6 (5, 9)	8 (6, 10)
p-value†	***<0.001**** SOC vs. IMI: ***p=0.043**** SOC vs. GW: ***p=0.003**** IMI vs. GW: ***p<0.001****			***<0.001**** SOC vs. IMI: p>0.999 SOC vs. GW: ***p<0.001**** IMI vs. GW: p=0.287		
MNA at discharge	9 (7, 12)	8 (5, 10.8)	11 (9, 13)	5 (3, 8.8)	7.5 (5.3, 9.8)	(6, 10)
p-value†	***<0.001**** SOC vs. IMI: p=0.358 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p<0.001****			***<0.001**** SOC vs. IMI: p=0.218 SOC vs. GW: ***p<0.001**** IMI vs. GW:p>0.999		
Delta MNA	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)
p-value†	0.164			0.623		

Analysis of MNA on admission and at discharge as well as Delta MNA (MNA at discharge – MNA on admission) for SOC, IMI and GW collectives overall and according to MPI risk group on admission
† Kruskal-Wallis-Test with paired comparison
*significant at 5%
Abbreviations: IMI, interdisciplinary multidimensional intervention; SOC, standard of care; GW, geriatric ward; MPI, Multidimensional Prognostic Index; MNA, Mini Nutritional Assessment

Table 21 shows that IMI patients had worse MNA scores on admission than SOC or GW patients (p=0.008 and p=0.004, respectively). However, there were no differences in the Delta MNA overall or according to MPI risk group on admission.

Table 22: Analysis of the CIRS and Delta CIRS in SOC, IMI and GW collectives

	Total			MPI- 1		
	SOC N=403 (100%)	**IMI** N=72 (100%)	**GW** N=176 (100%)	**SOC** N=111 (27.5%)	**IMI** N=8 (11%)	**GW** N=11 (6.3%)
CIRS on admission	5 (4, 6)	5.5 (4, 6.8)	4 (2, 5)	4 (3, 5)	5 (4, 6)	2 (2, 3)
p-value†	***<0.001**** SOC vs IMI: p=0.228 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p<0.001****			***0.001**** SOC vs. IMI: p=0.432 SOC vs. GW: ***p=0.002**** IMI vs. GW: ***p=0.001****		
CIRS at discharge	5 (3, 6)	5 (4,6.8)	4 (3, 5)	4 (2, 5)	5 (3.3, 7)	2 (2, 3)
p-value†	***<0.001**** SOC vs. IMI: p=0.064 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p<0.001****			***0.008**** SOC vs. IMI: p=0.265 SOC vs. GW: ***p=0.040**** IMI vs. GW: ***p=0.008****		
Delta CIRS	0 (-1, 0)	0 (-1, 0)	0 (0, 0)	0 (-1, 0)	0.5 (0, 1)	0 (0, 0)
p-value†	***<0.001**** SOC vs. IMI: p=0.130 SOC vs. GW: ***p<0.001**** IMI vs. GW: p=0.472			***0.015**** SOC vs. IMI: p=0.094 SOC vs. GW: p=0.102 IMI vs. GW: p>0.999		

	MPI-2			MPI-3		
	SOC N=216 (53.5%)	**IMI** N=44 (61%)	**GW** N=91 (51.7%)	**SOC** N=76 (19%)	**IMI** N=20 (28%)	**GW** N=74 (42%)
CIRS on admission	5 (4, 6)	6 (4, 7)	3 (2, 5)	6 (5, 6.8)	5 (4.3, 6)	4 (3, 5)
p-value†	***<0.001**** SOC vs. IMI: p>0.999 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p<0.001****			***<0.001**** SOC vs. IMI: p=0.974 SOC vs. GW: ***p<0.001**** IMI vs. GW: p=0.064		
CIRS at discharge	5 (4, 6)	5 (4,6.8)	3 (2, 5)	6 (5, 6)	5 (4, 6)	4 (3, 5)
p-value†	***<0.001**** SOC vs. IMI: p=0.372 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p<0.001****			***<0.001**** SOC vs. IMI: p=0.749 SOC vs. GW: ***p<0.001**** IMI vs. GW: p=0.198		
Delta CIRS	0 (-1, 0)	0 (-1, 0)	0 (0, 0)	0 (-1, 0)	0 (-1, 0)	0 (0, 0)
p-value†	***<0.001**** SOC vs. IMI: p=0.617 SOC vs. GW: ***p<0.001**** IMI vs. GW: p=0.248			0.409		

Analysis of CIRS on admission and at discharge as well as Delta CIRS (CIRS at discharge – CIRS on admission) for SOC, IMI and GW collectives overall and according to MPI risk group on admission
† Kruskal-Wallis-Test with paired comparison
*significant at 5%
Abbreviations: IMI, interdisciplinary multidimensional intervention; SOC, standard of care; GW, geriatric ward; MPI, Multidimensional Prognostic Index; CIRS, Cumulative Illness Rating Scale

Table 22 shows that GW patients had a significantly lower CIRS score on admission than SOC and IMI patients (p<0.001 and p<0.001, respectively). Overall and in MPI-2, SOC patients showed an improvement in their CIRS compared to GW patients (p<0.001).

Table 23: Analysis of the SPMSQ and Delta SPMSQ in SOC, IMI and GW collectives

	Total			MPI- 1		
	SOC N=403 (100%)	**IMI** N=72 (100%)	**GW** N=176 (100%)	**SOC** N=111 (27.5%)	**IMI** N=8 (11%)	**GW** N=11 (6.3%)
SPMSQ on admission	1 (0, 2)	1 (1, 2)	4 (2, 6)	1 (0, 1)	1 (0.3, 1.8)	2 (0, 3)
p-value†	***<0.001**** SOC vs. IMI: p=0.369 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p<0.001****			0.093		
SPMSQ at discharge	1 (0, 2)	1 (0, 2)	3 (1, 6)	1 (0, 1)	1 (0, 1)	1 (0, 3)
p-value†	***<0.001**** SOC vs. IMI: p>0.999 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p<0.001****			0.142		
Delta SPMSQ [Minimum, Maximum]	0 (0, 0) [-3, 3]	0 (0, 0) [-7, 1]	0 (0, 0) [-7, 3]	0 (0, 0)	0 (0, 0)	0 (0, 0)
p-value†	***<0.001**** SOC vs. IMI: ***p=0.003**** SOC vs. GW: ***p=0.001**** IMI vs. GW: p>0.999			0.413		

	MPI-2			MPI-3		
	SOC N=216 (53.5%)	**IMI** N=44 (61%)	**GW** N=91 (51.7%)	**SOC** N=76 (19%)	**IMI** N=20 (28%)	**GW** N=74 (42%)
SPMSQ on admission	1 (0, 2)	1 (0.3, 2)	2 (1, 4)	2 (1, 4)	2 (1, 4)	6 (4.75, 7)
p-value†	***<0.001**** SOC vs. IMI: p>0.999 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p=0.018****			***<0.001**** SOC vs. IMI: p>0.999 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p<0.001****		
SPMSQ at discharge	1 (0, 2)	1 (0, 2)	2 (0, 3)	2 (1, 4)	1 (1, 3)	6 (3, 7)
p-value†	***<0.001**** SOC vs. IMI: p>0.999 SOC vs. GW: ***p=0.001**** IMI vs. GW: p=0.053			***<0.001**** SOC vs. IMI: p=0.430 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p<0.001****		
Delta SPMSQ [Minimum, Maximum]	0 (0, 0) [-2, 2]	0 (0, 0) [-4, 1]	0 (0, 0) [-5, 1]	0 (0, 0)	0 (-1, 0)	0 (-0.25, 0)
p-value†	***0.009**** SOC vs. IMI: p=0.316 SOC vs. GW: ***p=0.012**** IMI vs. GW: p>0.999			***0.007**** SOC vs. IMI: ***p=0.008**** SOC vs. GW: p=0.206 IMI vs. GW: p=0.185		

Analysis of SPMSQ on admission and at discharge as well as Delta SPMSQ (SPMSQ at discharge – SPMSQ on admission) for SOC, IMI and GW collectives overall and according to MPI risk group on admission
† Kruskal-Wallis-Test with paired comparison
*significant at 5%
Abbreviations: IMI, interdisciplinary multidimensional intervention; SOC, standard of care; GW, geriatric ward; MPI, Multidimensional Prognostic Index; SPMSQ, Short Portable Mental Status Questionnaire

Table 23 indicates that GW patients had a significantly worse SPMSQ score on admission than SOC and IMI patients (p<0.001 and p<0.001, respectively).

Table 24: Delta MPI and Delta of its subdomains according to age group on admission in SOC, IMI and GW collectives

	Young-old (65-74 years)			Middle-old (75-84 years)			Oldest-old (85+ years)		
	SOC N=129	**IMI** N=22	**GW** N=22	**SOC** N=235	**IMI** N=39	**GW** N=88	**SOC** N=39	**IMI** N=11	**GW** N=66
Delta MPI	0 (-0.06, 0.005)	-0.12 (-0.12, 0)	0.001 (-0.08, 0.06)	0 (-0.06, 0)	0 (-0.065, 0.063)	0 (-0.6, 0)	0 (-0.058, 0.005)	-0.06 (-0.125, 0)	0 (-0.02, 0.06)
p-value†	***0.001**** SOC vs. IMI: ***p<0.001**** SOC vs. GW: >0.999 IMI vs. GW: ***0.024****			0.633			***0.020**** SOC vs. IMI: ***p=0.024**** SOC vs. GW: p>0.999 IMI vs. GW: ***p=0.021****		
Delta ADL	0 (0, 0)	1.5 (0, 4)	0 (-0.3, 2)	0 (0, 0)	0 (0, 2)	0 (0, 1)	0 (0, 0)	0 (0, 2)	0 (0, 1)
p-value†	***<0.001**** SOC vs. IMI: ***p<0.001**** SOC vs. GW: p=0.556 IMI vs. GW: ***p=0.025****			***<0.001**** SOC vs. IMI: p=0.561 SOC vs. GW: ***p<0.001**** IMI vs. GW: p=0.330			0.065		

Delta IADL [Minimum, Maximum]	0 (0, 0)	0 (0, 0)	0 (-1, 0.25)	0 (0, 0)	0 (-1, 0)	0 (0, 1)	0 (0, 0) [-3, 0]	0 (0, 0) [-2, 2]	0 (0, 0) [-4, 2]
p-value†	0.901			***0.003**** SOC vs. IMI: p=0.051 SOC vs. GW: p=0.176 IMI vs. GW: ***p=0.002****			0.139		
Delta ESS	0 (0, 1)	3 (1, 5)	0 (0, 0)	0 (0, 1)	0 (0, 2)	0 (0, 0)	0 (0, 1)	3 (1, 6)	0 (0, 0)
p-value†	***<0.001**** SOC vs. IMI: ***p<0.001**** SOC vs. GW: p=0.061 IMI vs. GW: ***p<0.001****			***0.004**** SOC vs. IMI: p>0.999 SOC vs. GW: ***p=0.008**** IMI vs. GW: ***p=0.025****			***<0.001**** SOC vs. IMI: ***p=0.008**** SOC vs. GW: ***p=0.002**** IMI vs. GW: ***p<0.001****		
Delta CIRS	0 (-1, 0)	0 (-1, 1)	0 (0, 0)	0 (-1, 0)	0 (0, 0)	0 (0, 0)	0 (-1, 0)	-1 (-1, 0)	0 (0, 0)
p-value†	***0.036**** SOC vs. IMI: p=0.837 SOC vs. GW: ***p=0.040**** IMI vs. GW: p=0.859			***<0.001**** SOC vs. IMI: ***p=0.022**** SOC vs. GW: ***p<0.001**** IMI vs. GW: p>0.999			0.116		
Delta MNA	0 (0, 0)	0 (0, 1.25)	0 (0, 1)	0 (0, 0)	0 (-1, 0)	0 (0, 0)	0 (0, 0)	0 (0, 1)	0 (0, 0)
p-value†	***0.010**** SOC vs. IMI: p=0.129 SOC vs. GW: ***p=0.035**** IMI vs. GW: p>0.999			0.181			0.214		
Delta SPMSQ [Minimum, Maximum]	0 (0, 0)	0 (-1, 0)	0 (-1, 0)	0 (0, 0) [-3, 3]	0 (0, 0) [-4, 1]	0 (0, 0) [-7, 1]	0 (0, 0)	0 (-1, 0)	0 (0, 0)
p-value†	***0.002**** SOC vs. IMI: ***p=0.002**** SOC vs. GW: 0.518 IMI vs. GW: p=0.354			***0.023**** SOC vs. IMI: p=0.801 SOC vs. GW: ***p=0.022**** IMI vs. GW: p>0.999			0.217		

Analysis of Delta MPI and Delta of its subdomains for SOC, IMI and GW collectives according to age group on admission
† Kruskal-Wallis-Test with paired comparison
*significant at 5%
Abbreviations: IMI, interdisciplinary multidimensional intervention; SOC, standard of care; GW, geriatric ward; MPI, Multidimensional Prognostic Index; ADL, Activities of Daily Living; IADL, Instrumental Activities of Daily Living; ESS, Exton Smith Scale; CIRS, Cumulative Illness Rating Scale; MNA, Mini Nutritional Assessment; SPMSQ, Short Portable Mental Status Questionnaire

Table 24 shows the differences in development of the Delta MPI and Delta of its subdomains according to age group on admission between the three collectives in question. IMI and GW patients of the young-old age group improved more in their ADL compared to SOC patients (p<0.001 und p=0.025, respectively). While there were some other small differences, they were distributed between age groups so that there was no single age group that seemed to profit more than others.

Table 25: Delta MPI and Delta of its subdomains according to ADL risk group on admission in SOC, IMI and GW collectives

	ADL-1 (Low risk >4)			ADL-2 (Medium risk 3-4)			ADL-3 (High risk 0-2)		
	SOC N=231	**IMI** N=22	GW	**SOC** N=82	**IMI** N=17	GW	**SOC** N=90	**IMI** N=33	GW
Delta MPI	0 (-0.003, 0.003)	0 (0, 0.125)	0.06 (0.002, 0.08)	-0.001 (-0.06, 0.005)	-0.06 (-0.12, 0.034)	-0.003 (-0.06, 0.06)	0 (-0.06, 0.006)	-0.12 (-0.183, 0)	0 (-0.06, 0.004)
p-value†	***<0.001**** SOC vs. IMI: p=0.280 SOC vs. GW: ***p<0.001**** IMI vs. GW: p=0.262			0.669			***<0.001**** SOC vs. IMI: ***p=0.002**** SOC vs. GW: p>0.999 IMI vs. GW: ***p=0.001****		
Delta ADL	0 (0, 0)	0 (-0.25, 0)	-0.5 (-1.3, 0)	0 (0, 1)	0 (-0.5, 1.5)	0 (0, 1)	0 (0, 0.25)	2 (0, 3.5)	0 (0, 2)
p-value†	***<0.001**** SOC vs. IMI: p=0.302 SOC vs. GW: ***p<0.001**** IMI vs. GW: ***p=0.004****			0.557			***<0.001**** SOC vs. IMI: ***p<0.001**** SOC vs. GW: p=0.069 IMI vs. GW: ***p=0.001****		
Delta IADL [Minimum, Maximum]	0 (0, 0)	0 (-1, 0)	0 (-2, 0)	0 (0, 0)	0 (-0.5, 0)	0 (0, 1)	0 (0, 0) [-5, 1]	0 (0, 0) [-2, 2]	0 (0, 0)
p-value†	***<0.001**** SOC vs. IMI: ***p<0.001**** SOC vs. GW***: p<0.001**** IMI vs. GW: p>0.999			***0.040**** SOC vs. IMI: p=0.553 SOC vs. GW: p=0.247 IMI vs. GW: p=0.054			0.182		
Delta ESS	0 (0, 1)	0 (0, 1)	0 (0, 0)	0 (0, 1)	1 (1, 3.5)	0 (0, 0)	0 (0, 1)	4 (1, 5.5)	0 (0, 0)
p-value†	***0.050**** SOC vs. IMI: p>0.999 SOC vs. GW: p=0.068 IMI vs. GW: p=0.120			***<0.001**** SOC vs. IMI: p=0.134 SOC vs. GW: ***p=0.017**** IMI vs. GW: ***p=0.001****			***<0.001**** SOC vs. IMI: ***p<0.001**** SOC vs. GW: ***p=0.001**** IMI vs. GW: ***p<0.001****		
Delta CIRS	0 (-1, 0)	0 (-1, 0)	0 (0, 0)	0 (-1, 0)	0 (0, 1)	0 (0, 0)	0 (-1, 0)	0 (-1, 0)	0 (0, 0)
p-value†	***<0.001**** SOC vs. IMI: p=0.384 SOC vs. GW: ***p=0.001**** IMI vs. GW: p=0.602			***0.005**** SOC vs. IMI: ***p=0.014**** SOC vs. GW: p=0.061 IMI vs. GW: p=0.644			0.131		
Delta MNA	0 (0, 0)	0 (-0.5, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0.25)	0 (0, 0)	0 (0, 1.5)	0 (0, 0)
p-value†	0.470			0.225			0.178		
Delta SPMSQ	0 (0, 0)	0 (-0.25, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (-0.75, 0)	0 (0, 0)
p-value†	***0.010**** SOC vs. IMI: p=0.054 SOC vs. GW: p=0.099 IMI vs. GW: p>0.999			0.855			***0.001**** SOC vs. IMI: ***p=0.011**** SOC vs. GW: ***p=0.007**** IMI vs. GW: p>0.999		

Analysis of Delta MPI and Delta of its subdomains for SOC, IMI and GW collectives according to ADL risk group on admission

† Kruskal-Wallis-Test with paired comparison

*significant at 5%

Abbreviations: IMI, interdisciplinary multidimensional intervention; SOC, standard of care; GW, geriatric ward; MPI, Multidimensional Prognostic Index; ADL, Activities of Daily Living; IADL, Instrumental Activities of Daily Living; ESS, Exton Smith Scale; CIRS, Cumulative Illness Rating Scale; MNA, Mini Nutritional Assessment; SPMSQ, Short Portable Mental Status Questionnaire

Again, when analysing the Delta MPI and the Delta of its subdomains according to ADL risk group on admission, differences seemed small, and there was no clear group that profited more than others. IMI patients, as well as GW patients with a high risk ADL score on admission, showed a beneficial development concerning their Delta ADL compared to SOC patients of the same risk group. On the other hand, GW and IMI patients showed a worse development in their Delta IADL compared to SOC in ADL-1.

4. Discussion

4.1. Main results and limitations of the study

The main result of this study is that an intervention like the IMI shows signs of improving the multidimensional prognosis and functionality in geriatric patients in acute non-geriatric hospital care compared to standard care, particularly in the oldest-old and functionally impaired patients.[35] However, these results must be interpreted with caution due to the limitations listed below and the limited comparability between the collectives in particular. Nevertheless, the comparison strongly suggests a benefit gained by the intervention. To our knowledge, this is the first study that has examined the effect of a geriatric intervention measured by a prognostic CGA-based tool like the MPI.

There is extensive literature describing and analysing mono- or multidimensional interventions and physical exercise programs for hospitalized geriatric patients in acute care, both in geriatric and non-geriatric settings. The methods, settings and results of these interventions vary greatly. In the following chapter, the effects of the IMI on patients compared to SOC patients are discussed and compared to previous studies that have examined the effects of similar interventions.

Before comparing the changes that occurred in the collectives, it is important to compare the SOC and IMI collectives at baseline, as there were some significant differences. SOC patients were more likely to be new admissions, while IMI patients were more often transferred from a different internal ward. Furthermore, IMI patients had significantly worse MPI, ADL, IADL, ESS and MNA scores on admission compared to SOC patients. In addition, IMI patients more often presented the geriatric syndromes of incoherence/ delirium and immobility on admission, although the latter is not surprising as immobility was one selection criteria for the IMI. Nevertheless, these differences must be taken into consideration when interpreting the results of the analysis.

Overall, the IMI collective showed an improvement in their prognosis measured by the CGA-based MPI. Their Delta MPI improved in the median by 0.03 points, while the SOC collective showed no change in the median. While this is a statistically significant difference between the collectives, the aforementioned fact that IMI patients had a worse MPI on admission compared to SOC has to be taken into account when interpreting these results. Because of this difference at baseline, it can be argued that the improvement of the IMI patients was due to their overall worse prognosis to begin with, as patients with a poor prognosis have more possibilities to improve than patients with a better initial status. However, when looking at the results of the subgroup analysis divided by MPI risk group on admission, only IMI patients of MPI-2 had a worse MPI score on admission than the SOC patients. The MPI-3 patients of MPI-3 of both collectives, however, had the same initial MPI in the median and IMI patients of MPI-3 showed a significant improvement in their Delta MPI compared to SOC patients, which strongly suggests the improvement was related to the intervention.

At discharge, the IMI collective had developed a better prognosis than SOC patients in MPI-3 but a worse prognosis than SOC patients in MPI-1. This was also the case with the Delta MPI, which improved significantly in IMI patients compared to SOC patients in MPI-2 and MPI-3, while IMI patients of MPI-1 suffered a worsening of their prognosis compared to SOC patients. The linear regression of the influence of the treatment group on the Delta MPI shows the same development. While previous studies also found that patients of MPI-1 are more likely to suffer from an MPI deterioration compared to MPI-2 and MPI-3,[255,282] this difference between collectives is still somewhat surprising, as one would not expect an intervention such as the IMI to affect a patient in a negative way. However, when considering these results, one must note that there were only eight IMI patients in the MPI-1 group, and therefore these results must be interpreted with caution. Furthermore, the IMI patients showed a significantly higher LHS than SOC patients. This was to be expected, as one inclusion criterion for the IMI was an estimated LHS of at least one week. However, prolonged LHS has been associated with adverse health outcomes[44,283] and has also been proven to coincide with a worsening of the MPI score.[282] Consequently, the negative development of the MPI in the IMI patients of MPI-1 could be due to their prolonged hospitalization compared to the comparatively healthy SOC patients, and that the IMI patients suffered from the long LHS rather than profited from it. More randomized studies are necessary in order to determine the validity of these results and interpretations.

The prognosis amelioration of IMI patients of MPI-2 and MPI-3 compared to SOC patients suggests that high risk patients on admission profit more from geriatric intervention than patients with a lower risk on admission. While previous studies also found that patients of MPI-2 and MPI-3 on admission tend to improve in their MPI-measured prognosis during hospitalization,[282] the fact that there was a significant difference between the development of SOC and IMI patients suggests IMI-associated improvements despite the limitations of this study. This was to be expected, as patients of MPI-2 and MPI-3 had more deficiencies in MPI subdomains which could be addressed and improved by an intervention like the IMI. Furthermore, even though we could not detect a significant difference in geriatric test results divided by MPI risk group on admission, some tendencies were noticeable. For example, a higher MPI score on admission correlated with a worse score in the DEMMI, suggesting a higher MPI might coincide with lower functionality. It is likely that with a larger patient collective, a higher MPI on admission would be associated with worse test scores in other tests as well, which would then provide an IMI with even more opportunities to improve the different domains of a patient. Exercise interventions have proven to be beneficial in several areas: the development of handgrip strength, controlling likelihood measured - by the GDS - as well as improving cognitive function - measured by the MMSE,[212] - yet this was not measurable in this case. More randomized studies with a consistent implementation of geriatric tests on admission and at discharge are necessary to determine the correlation between geriatric test results and the MPI as well as the development of those results during and after the IMI.

One of the other main parameters that was of interest to us was the functional development of IMI patients compared to SOC patients, measured by the ADL and the IADL. Overall, the patients who received the IMI showed an improvement in their ADL score compared to the SOC collective. This was particularly evident in the MPI-3 group, where IMI patients improved in the median by 1.5 points in their ADL score, while there was no change among the SOC patients ($p<0.001$). Similarly, IMI patients in MPI-3 improved their IADL score. Slaets et al. found a similar beneficial development of functionality measured by ADL after psychogeriatric intervention that focused on physiotherapy during acute hospitalization.[34] However, the impact of geriatric interventions on functionality scores has not been proven consistently by the studies and reviews conducted.[234] For example, Deschodt et al.'s meta-analysis of geriatric consultation teams did not yield beneficial results concerning functionality.[254]

Remarkably, similar to the development of the Delta MPI, IMI patients in MPI-1 showed worsening ADL- and IADL-scores compared to SOC patients of the same subgroup ($p<0.001$). Comparable results were found in the longitudinal study of functional development during hospitalization by Palese et al., who found that hospital-associated functional decline is correlated with a high level of functionality on admission.[207]

Other previous studies have shown no beneficial results concerning functional development during hospitalization when undergoing geriatric intervention.[47] Nikolaus et al. conducted a randomized controlled study in which they compared an intervention group who received both CGA and in-hospital and post-discharge interventions (comparable to the IMI) to a group that only received CGA and to a group that received standard care.[48] However, Nikolaus et al. randomized the allocation to different collectives, therefore excluding the selection bias we found in our study, and added a third collective that did not receive any form of assessment or intervention. Furthermore, the ADL scores on admission did not differ statistically between the collectives in the study of Nikolaus et al., while there were statistically significant differences in the ADL as well as the IADL scores between the IMI and SOC collectives in this present study. Nikolaus et al. found no significant differences in the development of the ADL between the groups between admission and discharge, although they did find a benefit in the intervention group concerning IADL independence at 12 months after discharge.[48] When considering the differences between their study and ours, it has to be discussed whether the functional improvement seen in the IMI collective compared to the SOC collective could stem from the worse scores the former collective presented on admission. While this cannot be conclusively ruled out, the difference between collectives on admission stems from a difference between MPI-2 collectives, similarly to the MPI development. For example, the MPI-3 patients of IMI and SOC did not differ in their ADL on admission, so that the improvement of IMI patients in that risk group cannot be associated with a worse baseline compared to SOC patients.

As an interesting and relevant side note, according to Sepulveda-Loyola et al., upholding functionality and undergoing regular exercise can counteract the negative impacts of social isolation to some degree.[62] Therefore, our study is even more relevant in current times shaped by the COVID-19 pandemic and social distancing.

Concerning the development of the CIRS, there was no difference between IMI and SOC patients in MPI-2 and MPI-3. However, in MPI-1, IMI patients showed a significant worsening of their CIRS score in the median by 0.5 points. Therefore, IMI patients received more new diagnoses during their hospital stay than SOC patients. Due to the small patient collective, this phenomenon must be verified with a larger number of patients. Possibly, this development of the CIRS coincides with the development of the MPI in MPI-1, which also worsened significantly with IMI patients. Furthermore, it is generally not surprising that the CIRS would increase in both collectives after a CGA, as it has been proven that implementing a CGA improves diagnostic accuracy and often leads to the diagnosis of so far unnoticed problems.[15]

A remarkable difference between the IMI and SOC patients was the higher LHS in the IMI collective. This was more than three times longer than in the SOC collective. In general, it must be noted that Geriatrics is one of the medical fields that coincides with the longest LHS. In Germany, it is only surpassed by the fields of psychotherapeutic medicine, child and adolescent psychiatry as well as general psychiatry.[284] In this manner, it is not completely surprising that a designated geriatric treatment like the IMI is associated with a higher LHS even in a non-geriatric setting.

There have been varying results in literature concerning the association between in-hospital interventions in geriatric patients and LHS. The study by Nikolaus et al. described above showed a reduced LHS in the intervention group compared to the group receiving only CGA.[48] This has been supported by other studies examining multidimensional interventions performed by mobile teams,[34,45,285] as well as performed by personnel on geriatric wards.[286–288] Recommendation-based geriatric teams had no impact on LHS.[235,254] A reduction in LHS was particularly notable in programs that included geriatric trauma patients after femur or hip fracture.[285] However, a systematic review and meta-analysis by Bachmann et al. also stated that inpatient rehabilitation coincides with a longer LHS.[289]

It must be considered that one inclusion criteria of the IMI was an expected LHS of at least one week, which could explain the longer LHS in IMI patients to some extent.[35] This inclusion criteria is comparable to previous studies on the matter.[173] In their evaluation of the effect of a geriatric consultation team, McVey et al. excluded patients if they were likely to be hospitalized for less than 48 hours.[169] Notably, the IMI was a pilot project, which, due to its lack of fulfilment of the GCT criteria (see 2.5.3.), could not be billed to the patients‘ health insurances and therefore did not generate additional income. Therefore, it is safe to exclude an artificially prolonged LHS above the time needed for acute medical care in order to reach the mandatory number of days enrolled in a GCT.

Furthermore, the IMI collective showed a significantly worse mean ADL- as well as IADL-score on admission compared to the SOC collective. A Chinese study by Shen et al. found that functional deficits in the ADL and IADL measured on admission were associated with a higher LHS in a geriatric department.[283] Even though our study was conducted in a non-geriatric ward, these findings could still somewhat explain the prolonged LHS of IMI patients.

Concerning discharge destination, we found that IMI patients were more likely to transition through a geriatric rehabilitation facility while SOC patients were more often discharged straight home. However, the rate of admissions to long-term care between collectives was similar, so this transition through rehabilitation seems to not have had adverse effects on the living situation of IMI patients.[35] In contrast to our findings, Germaine et al. found that being treated by a geriatric team during hospitalization could improve the likelihood of being discharged home.[45] It can be hypothesized that IMI patients received more attention in the discharge process due to the treatment by an interdisciplinary team which recognized further rehabilitation needs after the conclusion of acute care and started early discharge planning accordingly. This might have resulted in the organization of a rehabilitation slot.[35]

A follow up was performed for both IMI and SOC patients after three, six and 12 months. Our study found no difference between mortality rates in the overall IMI and SOC collectives after three and 12 months. Yet, IMI patients, on the whole, had a higher mortality rate after six months compared to SOC patients, which was particularly evident in MPI-2. In contrast, IMI patients of MPI-3 had a lower mortality rate after 12 months compared to SOC. A cox regression did not reveal a significant connection between IMI and SOC collective on survival rates. Due to the small patient collectives and these conflicting results concerning mortality, we could draw no clear conclusion about the impact of the IMI on mortality in the follow up.

More studies with larger and more random collectives are necessary. In comparison with previous studies, Slaets et al. found a trend of a higher mortality rate in the intervention group, although it was not statistically significant.[34] A meta-analysis by Deschodt et al. found a reduced mortality after six and eight months respectively after discharge, following a team-led intervention that consisted of recommendations to physicians responsible for treatment, but not after one year.[254] In an RCT by Thomas et al., the mortality rate in the team-based intervention group was lower compared to standard care after six months.[172] However, many other previous studies have shown no effect of an intervention on mortality rates.[48,173,235,290] Therefore, the lack of clear results concerning the mortality rate and the possible benefits of team-based intervention agrees with previous results that found no long-term protective effects. However, we only inquired whether a patient was alive or not during follow up. In future studies, it would be of worth to assess the MPI at each point in the follow up in order to determine whether the beneficial results on the MPI-measured prognosis in IMI patients', results in long-term prognosis amelioration.

Rehospitalization shortly after hospital discharge can be due to multiple causes, including disease progression, lack of adherence to the treatment plan by the patient or suboptimal treatment quality during hospitalization.[291,292] Therefore, early readmission rates after hospitalization are sometimes used as an indicator of the quality of care.[293] There was no difference between the IMI and SOC collectives concerning rehospitalization rates after three and 12 months respectively while IMI patients were slightly more likely to have been rehospitalized at the six month follow up. Again, in the subgroup analysis this was evident in MPI-2 as well. However, due to low patient numbers in the follow up, this result must be interpreted with caution.

A previous meta-analysis of randomized and controlled clinical trials by Linertová et al. showed a similar lack of improvement in rehospitalization rates through hospital interventions and discharge planning when compared to a control group as our study did, with only three out of 17 in-hospital interventions showing any benefit on rehospitalization rates.[291] Other studies supported these results.[235,254,294] Slaets et al., however, found that a functionality-focused multidimensional intervention led to fewer readmissions after six months than usual care treatment.[34]

According to Linertová et al., more benefits were apparent in programs that included some form of CGA during hospitalization and were followed by home visits after discharge by nurses or by a multidisciplinary team.[291] However, as this strategy requires intensive resources and is highly complex in post-discharge communication with the patient as well as outpatient health care providers, it seems unlikely to be included in standard geriatric care for hospitalized patients. Overall, these results show the complexity of reducing hospital readmission rates and the need for further studies on the subject, as many previous intervention studies showed no benefit on readmission rates.[48,212] This limits the recommendations that can be made concerning an improvement of the IMI that could lead to reduced rehospitalizations at this point in time.

Concerning admissions to long-term care, the IMI also showed no benefit compared to SOC during all observed follow ups, except in the subgroup of MPI-3, where the IMI patients were less likely to be admitted to long-term care after three months. This is in line with several previous studies that examined geriatric intervention.[48,173,235] However, some studies found geriatric interventions beneficial. Nikolaus et al., for example, found an initial beneficial effect on institutionalization rates in their intervention group, although they effect was no longer noticeable after 12 months.[48] However, Slaets et al. determined that an intervention group was less likely to be admitted to long-term care after undergoing a multidimensional intervention after 12 months compared to standard care.[34]

When looking at the prevalence of falls, IMI patients were more likely to have fallen after three months, particularly in MPI-1, while there was no significant difference between IMI and SOC after six and 12 months respectively. A previous study evaluating physical mobility program interventions during hospitalization also did not lead to a reduced likelihood of falls.[212] However, we did not find a difference in the TUG – a geriatric test associated with a higher likelihood of falls – between the IMI of different MPI risk groups on admission.[259] Possibly, the higher likelihood of falls in IMI patients of MPI-1 was due to their overall worsening in prognosis during hospitalization as reflected in the MPI. Further studies are necessary in order to draw a clear conclusion on this subject.

Finally, the domains of the grade of care as well as home care use were assessed during follow up. IMI patients showed an increase in their grade of care /nursing needs at discharge as well as three months after hospitalization compared to SOC. This difference was no longer evident at six and 12 months after hospitalization. Home care use increased in IMI patients at discharge as well as after six and 12 months. This would suggest that the beneficial effect of the IMI on functional scores like the ADL does not last in the long-term. This is comparable to other studies that examined geriatric interventions. For example, a prospective study by Buecking et al. determined that the initial functional benefits of a GCT on post-fracture patients did not last for more than six months and that those patients also showed an increase in their grade of care.[247] However, as we did not assess the MPI and its subdomains in the follow up, no clear conclusion can be drawn on the longevity of ADL improvement.

Overall, the follow up of our study did not show consistent results that show either beneficial or adverse effects of the IMI on the enrolled patients. However, the follow up collectives were small as, particularly in later follow ups, the already small baseline collectives were reduced even more due to deaths or patients lost. More large-scale studies that include larger patient collectives are necessary in order to determine the long-term effects of a multidimensional intervention during acute hospitalization in a non-geriatric setting.

Several limitations must be considered when addressing the results of the present study. First and foremost, the small patient collectives must be emphasized. The IMI collective, in particular, was made up of only 72 patients overall. In the subgroup analysis, the number consequently sank even more, down to as low as eight patients in MPI-1 and even lower in some follow up domains. Therefore, the conclusions from the subgroup analysis have to be interpreted with caution. However, because the IMI was a pilot project at the time of recruitment for this study, these issues were temporary, as from October 2019 active allocation to the IMI was relocated to another ward. This specialised geriatric ward continues the principles of the IMI but does so in a more systematic and prioritizing manner under the medical co-management by geriatricians and specialists from other medical fields.[35]

Second, the comparability of the two main collectives of SOC and IMI was limited by lack of randomization to either group, as the treating physicians allocated patients according to the criteria listed above. Therefore, a selection bias existed. In addition, there were some statistically significant differences between both collectives on admission, for instance, a worse MPI in the IMI group or differences in sources of referral. All these factors limited the comparability between the collectives and the conclusions drawn from them. However, the development of IMI patients deserves attention, and there are some promising indications of the benefits of such a treatment. Nevertheless, more studies with a homogeneous approach and patient randomization are necessary.

Third, the study was of a retrospective nature, which by itself limited the conclusions that could be drawn. However, the main data used was obtained by a prospective observational study (MPI-InGAH), thereby raising the quality of the data.[35]

Fourth, although an improvement in the MPI could be observed, this was only measured at 0.03 points in the median. The question remains whether this relatively small change actually makes a difference for patients. More studies are needed in order to determine whether this sort of difference in MPI is associated with, for example, improved functionality or quality of life. Furthermore, with some patients hospitalized for only two or three days on our ward, one must question whether an IMI treatment can influence scores like the MPI and its subdomains over such a short period of time.

Fifth, the IMI as a pilot study in a non-geriatric ward was not prioritized over high-performance medical treatments or diagnostic procedures during acute hospitalization.

Therefore, IMI therapies could not always take place as many patients were undergoing regular dialysis or other time consuming treatments, thus limiting the effect the IMI might have had on MPI-related prognosis if all the therapies could have taken place. However, as a continuation and improvement of the present study conditions, the University Hospital of Cologne has already introduced a new randomized-controlled study in a newly established geriatric ward that focuses specifically on geriatric intervention and its implementation in a controlled setting ("*Vun nix kütt nix*" – see chapter 5.). Thus, many of these limitations will be negated with the goal of taking an important step towards a controlled and generalized approach to an early geriatric intervention during acute hospitalization of older patients.[35]

4.2. Patient selection

In order to use resources in the most efficient and targeted way possible, it is important to select patients for an intervention like the IMI who have the highest likelihood of profiting from it. Kolb et al. made a valid point. Instead of the often posed question, "*Who is a geriatric patient?*" one should ask, "*Who can profit from geriatric medicine?*" in order to determine patients who should receive more specialized geriatric attention.[75] Some conclusions concerning patient selection can be drawn from our data.

IMI patients of MPI-2 and MPI-3 showed a greater improvement in their MPI as well as in the subdomains of ADL, IADL and ESS compared to IMI patients of MPI-1. This was also the case when compared to SOC patients where IMI patients fared better in the higher risk MPI subgroups concerning Delta MPI, Delta ADL, Delta IADL and Delta ESS. Because of these results, and due to the fact that the MPI is a valid predictor of pre-frailty and frailty, one can conclude that frailty is an indicator of the likelihood that patients would profit from the IMI.

A similar development could be seen in functionally impaired patients on admission: IMI patients with a high risk functional score on admission (ADL-3) improved significantly in their MPI, their ADL and their ESS compared to IMI patients with a higher functionality at baseline. This again was also the case when comparing IMI patients to SOC patients. It appears that functionally impaired patients on admission improve more after undergoing geriatric intervention, and these findings are supported by previous studies.[295] Rubenstein et al. determined that particularly patients with a low functionality baseline on admission as well as patients over 75 profited from being treated in a geriatric ward.[296] Germain et al. also ascertained that patients with a low functionality on admission profited most from a CGA and subsequent physiotherapy-based intervention.[45] They also established that a geriatric assessment team could reduce the LHS, especially in patients with a low functionality at baseline.[45] Therefore, the conclusion that functionally impaired geriatric patients should receive either a team-based or a ward-based treatment during acute hospitalization can be drawn with some certainty.

When divided by age group on admission, particularly the young-old IMI patients showed beneficial developments concerning MPI, ADL, IADL and ESS in the intra-IMI analysis. Furthermore, the oldest-old patients improved in their ESS compared to the middle-old patients. This was also the case when comparing IMI and SOC patients divided by age groups.

In summary, patients who seemed to profit most from the IMI were functionally impaired on admission and displayed a medium or high risk prognosis in their MPI. Furthermore, the young-old, as well as the oldest-old, showed improvements. This can aid physicians in the selection process of potential patients for projects like the IMI. However, further studies with larger patient collectives are necessary to verify the findings discussed here.

4.3. Composition of geriatric interventions and their role in an acute non-geriatric setting

The IMI is an intervention designed to unite the main geriatric principles – a CGA, a multidimensional intervention as well as input at the point of care – in order to provide the best possible treatment for geriatric patients and to prevent or counteract hospital-associated functional decline.

As described above, a multitude of studies concerning mobile geriatric teams treating patients in acute medical care in a non-geriatric setting have been conducted. The results of these studies have shown positive tendencies, but overall consistent beneficial results have been lacking.[254] A comprehensive systematic review and meta-analysis by Deschodt et al. from the year 2013 supported this, as the only consistent benefit they found was a slight reduction of mortality in the medium term.[254] However, as the interventions themselves have been very diverse in form and measured outcomes, it is important to differentiate between the kinds of care provided by these teams. This chapter compares previous team-based interventions with the IMI with the goal of determining whether a best standard of care can be found.

Concerning the composition of an intervention like the IMI, the concept of using an interdisciplinary team in the treatment of geriatric patients is unanimously accepted as the best care independent of whether the patients are located in a non-geriatric or geriatric acute setting, as the multitude of special needs geriatric patients have can scarcely be met by an individual specialist.[297] A geriatric team consists mainly of physiotherapists, occupational therapists, as well as geriatric nurses under the leadership of a geriatrician and has been proven to be effective and is seen as the standard in the field of geriatric early rehabilitation.[10,34,168,298] Therefore, many previously described interventions have followed this pattern that is also in usage in the IMI. Furthermore, the addition according to individual patient needs of pharmacists or speech therapists is in line with other intervention programs in acute care. The IMI included a daily treatment by different members of the team as well as weekly rounds by the whole team, which is comparable to other studies on this matter.[168]

Furthermore, hospital-associated functional decline starts early. A study by Hirsch et al. determined that functional decline can be detected as early as day two of the hospital stay.[194] This proves the importance of immediately beginning early rehabilitative measures during acute hospitalization. The IMI aimed at starting as soon as patients were allocated to the program. However, due to relocation from different wards and the fact that only two patients could be enrolled in the IMI simultaneously, not all IMI patients received additional attention in the first days of hospitalization.

A survey by Deschodt et al. found that, similar to the IMI, most geriatric consultation teams use some form of CGA to determine the suitability of a patient for the treatment and to detect possible treatable problems.[252] However, of the studied teams, fewer than half actually performed a treatment on the patient. The other teams merely made recommendations to the treating physicians.[252] This is important when comparing results of previous geriatric teams with IMI results, as, in the case of the latter, an individual treatment was performed on top of the CGA and in addition to the recommendations made to treating physicians.

Mobile geriatric teams that merely give recommendations to medical staff have not been proven to be consistently beneficial for patients. McVey et al. performed an RCT concerning the effect of a recommendation-based geriatric consultation team on functional status, hospital-acquired complications, rehospitalizations and discharge destination. They could not show that the intervention group benefited more than the control group.[169,294,299] A meta-analysis by Deschodt et al. supported this and did not find evidence that a geriatric team could improve functionality, shorten LHS or improve readmission rates by only giving recommendations to treating physicians.[254]

However, it has been shown that geriatric consultation programs in the form of recommendations made by mobile teams lead to higher use of physiotherapy and occupational therapy in patients during hospitalization. Furthermore, it appears that such programs can increase the use of rehabilitative services after discharge and in general promote the awareness of functional deficiencies in geriatric patients.[300] This again underlines the importance of the presence of geriatric personnel during hospitalization, as specialized professionals are needed to make note of certain problems a patient might have that are not noticed in standard care.

One of the problems that has been described previously in literature when it comes to geriatric teams is the fact that they often have little control over the implementation of their recommendations or have little say in the day-to-day hospital life. Indeed, it has been argued that the limited benefits that have been found for team based interventions in past studies are due to a lack of adherence to recommendations made by the teams,[235,301] although no clear figure could be given regarding how many of the recommendations were not implemented. Only a recent study by Deschodt et al. quantified the percentage of implemented recommendations by treating medical professionals. Here, it was found that about 70% of recommendations made by a geriatric team were adhered to, and that this number increased if the recommendations were made by experienced members of the team or if the number of total recommendations made was small.[302] While implementing the IMI, an additional problem occurred: the patients on the ward in question underwent high-performance medicine that often included regular dialysis, and the patients were, therefore, sometimes not able to undergo treatment due to timing issues with the IMI therapists. Therefore, the full potential of the IMI could often not be reached, as not all planned treatments could be administered. In order to ensure that the treatment takes place, better communication and higher importance must be placed on treatments like the IMI. As hypothesized before by Deschodt et al., increased functional benefit might be achieved by giving the geriatric team more control and participation in the planning of day-to-day hospital proceedings and, therefore, being able to enact the geriatric therapies and recommendations better.[235] The newly introduced study "*Vun nix kütt nix*" (see chapter 5.), currently running in the newly established ward at the University Hospital of Cologne, aims to implement these findings by prioritizing geriatric interventions through improved coordination with medical treatments and treating physicians.

Due to the general lack of consistent benefits of recommendation-based interventions, many studies examined the combination of recommendations with other intervention components like early rehabilitation. These programs have been found to be beneficial in reducing mortality,[168,303] improving functionality,[34,303] and necessitating fewer admissions to long-term care.[303] For example, Shyu et al. found that team-led intervention that focused on recommendations to treating physicians improved early rehabilitation and the discharge process, mobility and ADL up to twelve months after discharge.[304,305] It is important to note, however, that these were post-surgery patients after treatment for hip fracture, which is a very different patient collective from ours. Still, the combination of recommendations and early rehabilitation is the foundation of the IMI and, therefore, the interventions themselves are comparable.

Hogan et al. performed an RCT that demonstrated that the involvement of a geriatric consultation team could reduce short term mortality, polypharmacy and improved the mental status in geriatric patients hospitalized for an acute medical illness in the general ward of an acute care hospital.[168] The intervention focused on improving functional deficits, polypharmacy, and urinary incontinence, as well as optimizing discharge planning. This was accomplished by making treatment recommendations to the physicians in charge as well as providing additional care from the members of an interdisciplinary team.[168] Bachmann et al. performed a review of geriatric interventions during acute hospitalization of older people in general or orthopaedic wards. They found that even though geriatric patients are vulnerable and prone to functional and general health deterioration, older adults can profit greatly from the right kind of intervention. Their review revealed the potential for substantial improvement concerning functionality, institutionalization and the reduction of mortality. However, so far no clear propositions concerning the framework of such interventions can be made due to insufficient data. [289]

Not all studies examining team-based interventions could show similar benefits.[235,290,306] A randomised trial by Kircher et al. with a geriatric team that focused on recommendations to treating physicians, discharge planning and social care did not find patients benefited more than patients in standard care.[173] Campion et al. also found no benefit concerning rehospitalization but hypothesized that a geriatric consultation team "promotes Geriatrics, teaches interdisciplinary teamwork, improves awareness of functional problems of patients, and increases the use of rehabilitative services".[300]

Therefore, it becomes evident that making clear recommendations concerning the composition and goal setting of a geriatric team-based intervention is difficult. However, it seems that a focus on functional outcomes can lead to beneficial results.

Some authors have suggested that, due to this lack of evidence, the focus should be put on geriatric co-management, meaning that a geriatrician should be consulted on major decisions in a geriatric patient's treatment plan.[253] A review conducted by van Grootven et al. found that geriatric co-management could reduce LHS and hospital-associated complications and functionality, although evidence and the quality of the examined trials were weak.[253] However, a trial of geriatric co-management performed by Arbaje et al. showed no beneficial results compared to patients in standard care except for a slight tendency for a smoother transition planning, albeit this was not statistically significant.[251] These examples show that despite initial promising results of mobile geriatric teams, not all studies could show the benefits of this form of care compared to standard care.[290]

A basis for IMI, as well as for many other interventions, is some form of CGA. So far, CGA is not standard for geriatric patients in acute care, although patients in an acute geriatric setting are more likely to receive an assessment than patients in a non-geriatric setting.

While both the SOC and IMI collectives received a CGA on admission as well as at discharge in the course of the MPI-InGAH study, only the IMI patients underwent a targeted treatment plan addressing the deficits found in the assessment. SOC patients did not receive any additional care but underwent the usual amount of physiotherapy during acute care. Yet, Stuck et al. and Ellis et al. found that such team-led CGA-based interventions in acute non-geriatric care did not provide any benefits for patients.[33,149] In contrast to this, however, are the geriatric wards and units that implemented CGA and have been found to reduce the mortality rate and the likelihood of living at home (see Chapter 4.4.).

It is important to note, however, that much of the data going into the reviews and meta-analysis by Stuck et al. and Ellis et al. stem from hospitals and projects in the United States of America. Many of the trials, including the ground-breaking work by Rubenstein and his colleagues, were conducted in VA hospitals.[30,236] VA hospitals do not represent a wide and unbiased patient collective, as patients hospitalized there are mostly male and have profited from prepaid health care for many years.[30] While many of these VA hospitals developed some kind of CGA and Geriatric Evaluation and Management (GEM) programs, and despite the clear evidence showing the CGA's benefits, normal non-VA hospitals were confronted with more difficulties when trying to open some form of CGA or GEM due mostly to financial difficulties.[159] Therefore, more randomized studies with a more representative patient collective seem necessary in order to evaluate the specific setting in which CGA is effective.

The additional costs IMI may have caused were not assessed in this study. As a pilot study, it was evident from the beginning of the study that the IMI treatments would not be equal to medical treatments concerning planning and time allocation, therefore potentially limiting the number of treatments performed. As a result, the IMI could not be billed as a geriatric complex treatment, as it was not guaranteed that the required framework for billing (see Chapter 2.5.3.) could be met.

There have been mixed results concerning the costs of a geriatric intervention. Nikolaus et al. found reduced costs as a result of their intervention that consisted of CGA, in-hospital physical and occupational therapy as well as post-discharge home intervention.[48] In this study, reduced costs were mainly due to a delay in institutionalizations. Naughton et al. determined that geriatric management by a geriatric team led to reduced costs mainly due to a reduced need for pharmaceuticals and laboratory expenditures.[307] Covinsky et al. found in their randomized controlled study that a geriatric unit dedicated to improving functionality in hospitalized geriatric patients did not increase costs.[308] Based on their calculation, the cost-equality was mainly due to a reduced LHS in the geriatric ward compared to standard care, which is in line with other studies.[34,286,308] In their systematic review of randomized controlled trials of multidimensional interventions, Morton et al. estimated that overall costs could be reduced by about 280 US dollars per patient per hospitalization by geriatric intervention.[288] However, the authors drew no clear conclusion about the reason for these cost benefits, and as the data was not recent, this conclusion must be treated with caution. Overall, as many studies incorporating geriatric interventions also lead to an increased LHS, it may be assumed that, initially, geriatric intervention leads to higher costs per patient.[289] More long-term studies are necessary in order to determine the overall cost development.

One of the problems concerning early geriatric rehabilitation is the difficulty for the hospital to bill the health insurances for services granted to the patient.[309] Since the implementation of the DRG system in 2003 in Germany, hospitals are only allowed to bill for early rehabilitative measures if the patient is still in need of acute medical care and if the rehabilitation procedures fulfil certain requirements (see 2.5.3.).[309] This has resulted in, on the one hand, a significant number of rehabilitative wards that implement the said early rehabilitation procedures. In 2012, the GCT was billed 301.326 times.[309] However, on the other hand, if a ward is not specialized in this sort of treatment and falls short of the requirements – like the ward housing the IMI - the hospital cannot receive any financial reimbursement for its rehabilitative efforts, which might not meet requirements of a GCT but are still beneficial for a patient.

The German DRG system and the ensuing conditions for receiving reimbursement for early rehabilitative measures are, therefore, not without criticism. The OPS categorization for a GCT, as described in 2.4.3., means that patients receive therapies in accordance with their hospital stay – however, once these therapies have exceeded the number of therapies included in the OPS key, there is no financial motivation for the hospital to provide more therapies, even though a patient might profit from them. This can lead to a suboptimal distribution of resources, as they cannot be individualized to each patient's early rehabilitation potential, but have to be implemented according to a billing system.[310]

Unlike a GCT, the IMI unfortunately could not fulfil all the necessary requirements in order to fall into the above category. The shortcomings were mainly due to the fact that the minimal number of therapies performed by the interdisciplinary team could not be guaranteed for IMI patients, although the goal of the IMI was a daily treatment by a physiotherapist and an occupational therapist. This shortcoming was due to the fact that acute medical procedures of a patient often took priority over geriatric treatments, meaning that regular dialysis appointments, examinations and high-performance medical treatments that the often nephrological patients underwent during their stay in our ward impeded the performance of planned treatments. Furthermore, as the IMI was a pilot project implemented in the ward, communication structures, besides the weekly interdisciplinary team meetings, had not been firmly established, meaning the treating physicians had no standardized way of informing the

IMI therapists when a patient had a certain medical procedure. This highlights again that circumstances around an intervention like the IMI can complicate its implementation through a lack of coordination with other medical specialities or, for example, a complicated documentation system.[310]

The GCT today is commonly implemented during acute care in geriatric wards and shows promising results for, among others, functional improvements.[311] However, a GCT is still uncommon in acute non-geriatric wards, such as the ward that incorporated the IMI in the pilot project. As not every hospital has a geriatric department and there is a lack of capacity in the wards that provide acute geriatric care, many older patients that could profit from specialized geriatric attention do not receive it in a standard care ward. This was evident in the results of our study. Although the IMI, as a pilot project, incorporated less therapy in the median than a GCT, the ensuing prognosis and functional amelioration warrant further research in the form of randomized studies examining CGA-based interventions in non-geriatric settings.

Overall, when analysing the IMI concept, it is evident that it combines many features of previously studied interventions, thereby providing a broad approach that aims at combining all beneficial results observed concerning the outcomes of team-led interventions. The IMI personnel gave recommendations to treating physicians based on deficits found in the CGA and in the geriatric tests and additionally provided individual therapy where needed, thereby surpassing the normal amount of functional therapy and combining two intervention concepts. When viewing studies that examine geriatric team-based interventions, it is evident that although the treatment approach was very varied, there was often little information in the published works about the exact way and frequency a therapy form was implemented. Therefore, given the information available, it was not possible to set a concrete framework for a multidimensional team-based intervention, as it was not clear which elements are responsible for the prognosis and functional amelioration.

4.4. Geriatric interventions in an acute geriatric setting

The previous chapter highlighted the current scientific status of geriatric team-based interventions in a non-geriatric setting. The situation is very different in geriatric wards. These provide a controlled and standardized environment for the treatment of geriatric patients. Conditions that might be adverse for older people in a standard care hospital ward are addressed in geriatric wards. For instance, tripping hazards are minimized, distracting sounds are avoided where possible, paths are clearly marked and the alien hospital atmosphere is meliorated by friendly wall paint.[287] The treatment in these wards focuses on geriatric assessment, upholding functionality and providing individualy targeted treatments.[236] The benefits of geriatric wards have been described elsewhere (see 2.5.3.). However, similar to interventions led by geriatric teams, there is a high variety of intervention approaches as well as a lack of information concerning the details of the intervention implementation or CGA structure within the standardized framework of a geriatric complex treatment.[242]

When comparing GW patients with IMI and SOC patients, some differences between the patient collectives must be mentioned. Firstly, GW patients were older and more often female. This is not altogether surprising, as one can imagine that older patients are, by reflex, more often considered for in-hospital geriatric placement than their younger counterparts. Secondly, there were significant differences in the LHS between all three collectives. SOC patients stayed the shortest amount of time, which, unlike IMI patients, was to be expected as one of the criteria for selecting IMI patients was a LHS of at least one week (see 4.1.). GW patients were also hospitalized significantly longer than SOC patients. When comparing IMI and GW, it is of interest to note that IMI patients showed a significantly higher LHS overall than GW, although subgroup analysis showed this difference to be evident only in the subgroup of MPI-3.

It is furthermore evident that the patients hospitalized in the GW of the St. Marien-Hospital had an overall worse prognosis than SOC patients of the University Hospital regarding their MPI ($p<0.001$). Interestingly, when examining the Delta MPI, GW patients showed a better development compared to IMI patients in MPI-1 while IMI patients improved more in their Delta MPI overall, in MPI-2 and in MPI-3. There was no statistical difference concerning the Delta MPI between GW and SOC patients. This is surprising, as one would expect GW patients to also show an improvement in their prognosis in all subgroups compared to SOC and a larger prognosis amelioration than IMI patients, as geriatric wards have so far been shown to be superior to mobile teams such as the IMI in previous studies.[33,301] Admittedly, the comparability between the three collectives is limited as there was no randomization and the treatments were delivered by different personnel. In addition, the IMI was delivered in a modern University hospital that treats patients with rare or severe diseases. By contrast, the St. Marien-Hospital is a smaller urban hospital with a smaller focus on specialized internal medicine. This difference in patient collectives and recruitment location might be reflected in the CIRS, which was significantly higher in the IMI and SOC collectives compared to the GW collective ($p<0.001$), implying a higher burden of comorbidity in IMI patients. Thus, one could argue that higher morbidity and higher burden of illness on admission could result in a higher MPI, which, consequently, through high-performance medicine treating underlying medical problems, has the chance to improve at discharge. Therefore, more studies are necessarys with more homogenous patient collectives and randomized controlled settings in order to determine the differences in patients' prognosis between standard care, team-based interventions and geriatric wards.

A previous study by Bordne et al. analysed the data of over 600 patients who were also admitted to the St. Marien-Hospital. They found that geriatric patients undergoing GCT in the hospital's acute geriatric ward showed an improvement in their ADL. However, there was no control group.[312] Our GW collective, as well as the IMI collective, showed improvements in their ADL compared to the SOC collective treated in the University hospital. However, both those collectives also had significantly lower ADL scores to start with, thus limiting the value of this assumption due to different conditions at baseline. There was no difference in functional development between IMI and GW except for MPI-3, where IMI patients improved more in their Delta ADL than GW patients, while there were no significant differences in their ADL-scores on admission. Thus, similar to the MPI, these results indicate a more positive development in IMI patients compared to GW patients, particularly in high risk MPI groups, but these conclusions have to be drawn carefully and have to be supplemented by more extensive studies.

Another difference between the collectives was a higher ESS on admission in IMI patients compared to SOC and GW (see Table 20). Furthermore, SOC and IMI patients both improved more in their ESS compared to GW patients. The improvement of IMI patients in comparison to the other collectives could be interpreted as being due to their worse baseline score. However, the fact that GW patients did not improve their ESS score compared to SOC is surprising as one would expect that intense geriatric treatment involving mobility and attention to nutrition would reduce the risk of bedsores.[18,313]

Overall, according to our data, GW patients did not differ in their MPI development compared to SOC and were inferior in their prognosis development compared to IMI patients. GW patients improved equally in their ADL compared to IMI and showed a better Delta ADL than SOC patients. There were no differences between collectives overall concerning the development of the IADL and MNA. Furthermore, when analysing developments according to ADL risk group on admission as well as age group on admission, no clear statement as to which groups profited most can be made on the base of our data.

These observations stand in contrast to previous studies, which found improved functional scores compared to standard care.[30,237,238] Due to the lack of a follow up in the GW collective, we were not able to determine differences in survival or institutionalization rates and therefore were not able to say whether a reduction of the mortality rate in our GW collective was similar to previous collectives after treatment in a geriatric unit.[30,241]

Therefore, our results of the present patient collectives cannot replicate the status quo that geriatric wards are superior to geriatric teams and standard care, although research clearly suggests that geriatric wards provide the best surroundings for older patients to be treated in, as they combine specialized knowledge with the best possible environment in a situation of stress.[30,33,254] In order to see how the prognosis according to the MPI is influenced by treatment in a geriatric ward, more studies with random allocation of patients are necessary. Projects like these are already underway, among others the "*Vun nix kütt nix*" study in the University Hospital of Cologne (see chapter 5.).

5. Outlook

The underlying goal of this dissertation was to determine whether a pilot intervention like the IMI can have measurable favourable effects on the multidimensional prognosis and functionality of older patients hospitalized for acute disease in a non-geriatric ward undergoing high-performance medicine. This was seen as especially important in the light of an ageing population, worldwide problems like the COVID-19 pandemic, rising obesity rates and the undisputed longstanding awareness of the adverse effects that hospitalization causes in frail geriatric patients.

In summary, the IMI project can be deemed successful as the IMI patients improved in multidimensional prognosis as well as in functionality compared to the control group, measured by the CGA-based MPI. This suggests that patients not hospitalized in a geriatric ward can profit from treatment provided by specially trained personnel, just like patients in a geriatric ward have been proven to profit from interventions such as GCT. As not every hospital can have a geriatric ward, and as geriatric wards have limited capacities for an ever older patient population, this highlights the need for geriatric thinking to be implemented into daily hospital life outside of geriatric wards. Further studies will be necessary to determine whether this beneficial effect on the MPI and its subdomains can be replicated, which would then validate the MPI as a feasible tool for the evaluation of geriatric treatments.

However, this study discovered that only patients with a medium or high risk prognosis on admission profited from the IMI, while patients in the low risk prognosis group suffered from a prognosis deterioration. These findings provide important information for the evaluation of patients who might be eligible for an intervention like the IMI in future. The MPI, as a validated and easy to implement prognostic tool, can be of help to determine a patient’s possible benefit from the IMI in the selection process. Further selection criteria for an IMI suggested by this study encompass patients that are highly functionally impaired on admission as well as patients categorized into the young-old and oldest-old age risk group. If these findings can be replicated in future studies, this could show that the MPI is indeed a useful tool on admission to determine potential benefits to be gained by geriatric intervention.

While these results are promising and encouraging for projects like the IMI, several limitations of this study (see Chapter 4.1.) need to be addressed in future studies. One of the limitations of this study was the lack of data concerning geriatric test results as well as a lack of MPI or functional assessment in the follow up. Therefore, the effects of the IMI on geriatric tests results during hospitalization are limited, and statements concerning the longevity of prognosis and functional improvement are impossible to make. It will be interesting to see these limitations addressed in further studies.

A further problem was the fact that acute medical treatments took priority over IMI therapies. Naturally, necessary acute medical interventions and diagnostic measures that are vital for the patients' outcome or survival need to be prioritized. However, many therapies of the IMI could not take place due to scheduling problems with procedures like dialysis or radiological examinations. This, to be sure, could be communicated beforehand with therapists in, for instance, a daily meeting at the beginning of the day, where treating physicians present a daily status of the patient to the whole team. Thus, the coordination of treatments of medical as well as functional aetiology would be much facilitated. In many geriatric wards, this is already the case. This again shows the need for improvement of geriatric care for older patients not hospitalized in a geriatric ward.

In general, there is still a need for additional research as comparability between geriatric-team based interventions in a non-geriatric setting is limited and, therefore, no overall recommendation concerning treatment composition and targeted patient groups can be made. Currently, team-based interventions are still, in general, less effective than ward-based programs, as the effect on mortality seems minimal and an impact on functionality has not been regularly documented.[254] Therefore, one cannot generally recommend introducing a team-based program in a hospital due to lack of evidence. In view of scientific findings like these, Gray suggested that a geriatric ward can be beneficial in hospitals that display a high percentage of geriatric patients. Geriatric teams would then not be used for the treatment of those patients but for the identification of patients eligible for allocation to such a ward.[250] Furthermore, smaller hospitals or hospitals with a lower number of older patients that might never have a geriatric ward could rely on team-based systems in order to provide patients with the geriatric care they need. Therefore, programs like the IMI that show promising results justify the continued research into interventions in a non-geriatric setting, especially as not every patient can be hospitalized in a specialized geriatric ward. More randomized controlled studies, however, are necessary to determine the effect of a CGA-based mobile intervention like the one studied in this project, with a focus on assessing the longevity of the functional improvement and development of quality of life in accordance with changes in the MPI.

As part of this project, we also compared IMI with the GCT patients received in a geriatric ward. Interestingly, the data did not show that the GCT was superior to the IMI as we would have expected when considering the consensus of current research. However, this might be due to the limitations detailed above (see Chapter 4.4.).

In order to negate many of the limitations of this study listed above, IMI recruitment was relocated to another ward in October 2019. This specialised geriatric ward of the University Hospital of Cologne continues the principles of the IMI but does so in a more systematic and prioritizing manner, with a focus on equality and coordination between medical treatments and geriatric interventions as well as comprehensive discharge planning in cooperation with general physicians and family. It thereby aims to incorporate the positive scientific findings that exist concerning geriatric wards with the promising results of the IMI found in this study. The study is called "*Vun nix kütt nix"*, which translates into "nothing comes from nothing". Patients admitted to the ward in question are screened for inclusion criteria and, after receiving their permission to participate, are randomized into intervention and control groups. Similar to MPI-InGAH, participating patients receive a CGA and MPI calculation on admission and at discharge. Therefore, when that study is concluded, it will be interesting to evaluate the development of the MPI and its subdomains in the geriatric ward compared to the ward examined in the present study.

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7.3. Geriatric tests

A: Comprehensive Geriatric Assessment (CGA)-based Multidimensional Prognostic Index (MPI) calculation

UNIKLINIK KÖLN | Klinik II für Innere Medizin Nephrologie, Rheumatologie, Diabetologie und Allgemeine Innere Medizin **Altersmedizinischer Bewertungsbogen** Pat.-ID:___________

ALTERSMEDIZINISCHER BEWERTUNGSBOGEN

(Klinische Altersforschung / Zentrum Altersmedizin)

I.	Patientenidentifizierung	S. 1
II.	Relevante Informationen zu Therapie, Ernährung und Untersuchungen	S. 2
III.	Screening & Soziale Anamnese	S. 3
IV.	Comprehensive Geriatric Assessment mit Prognoseberechnung	S. 4-9
V.	Interpretation und Empfehlung *(Freitext)*	S. 10
VI.	Follow up	S. 11

PATIENTENIDENTIFIZIERUNG

☐ *Komplexbehandlung* ☐ *Usual Care*

Datum und Uhrzeit	
Patienten-Identifikationsnummer	
Geburtsdatum	
Geschlecht	
Hauptdiagnose	
Aufnahmediagnose	
Hospitalisiert *(von - bis)*	
	Verlegung von ☐ intern / ☐ extern ☐ Neuaufnahme

MEDIKAMENTENANAMNESE

Aufnahmezeitpunkt:

	Basistherapie (Medikamente/ Nahrungsergänzung)
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	

Medikamentenallergien: ☐ NEIN ☐ JA:

1	
2	
3	

Ernährungstherapie: ☐ NEIN ☐ JA:

1	
2	

INSTRUMENTELLE-DIAGNOSTISCHE VERFAHREN

	Instrumentelle-Diagnostik während des Krankenhaus-aufenthaltes (Code*)	Datum
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

*Code	Verfahren
1	Röntgenuntersuchung
2	Ultraschalluntersuchung
3	Computertomografie (CT)
4	Magnetresonanz–tomografie (MRT)
5	Endoskopie
6	Nuklearmedizinische Untersuchung
7	Herzkatheter

KUMULATIVE KRANKHEITS-RATING SKALA (C.I.R.S.) *

	0 KEINE	1 LEICHT	2 MITTEL	3 SCHWER	4 EXTREM SCHWER	Aufn.	Mitte	Entlass.
1. Herz (ausschließlich)								
2. Hypertonie (Bewertung hängt vom Schweregrad ab; Organschäden werden separat bewertet)								
3. Gefäße (Blut, Blutgefäße und -zellen, Knochenmark, Milz, Lymphsystem)								
4. Respiratorisches System (Lungen, Bronchien, Trachea unterhalb des Larynx)								
5. Augen, Ohren, Nase, Rachen, Larynx								
6. Oberer Gastrointestinaltrakt (Ösophagus, Magen und Duodenum; Pankreas; ausschließlich Diabetes)								
7. Unterer Gastrointestinaltrakt (Dickdarm und Dünndarm, Hernien)								
8. Leber und Gallengangsystem								
9. Nieren (ausschließlich)								
10. Restlicher Urogenitaltrakt (Ureteren, Blase, Urethra, Prostata, Genitalien)								
11. Bewegungsapparat und Haut								
12. Neurologisches System (Gehirn, Rückenmark, Nerven, ausschließlich Demenzerkrankungen)								
13. Endokrinium und Stoffwechsel (einschließlich Diabetes, Schilddrüse, Brust, systemische Infektionen, Toxizität)								
14. Psychiatrische Erkrankungen/Verhaltensstörungen (einschließlich Demenzerkrankungen, Depression, Angststörungen, Agitation/Delir/Psychose)								
KOMORBIDITÄT INDEX CIRS CI SCORE Anzahl der Elemente mit einem Score von 3 oder höher (die psychiatrische Erkrankungen ausgeschlossen)								
SCORE DER SCHWEREN ERKRANKUNGEN CIRS SI SCORE Mittelwert aller Einzelposten (die psychiatrische Erkrankungen ausgeschlossen)								

** Salvi F, Miller MD, Grilli A et al (2008) A manual of guidelines to score the modified Cumulative Illness Rating Scale and its validation in acute hospitalized elderly patients. J Am Geriatr Soc 56:1926–1931. https://doi.org/10.1111/j.1532-5415.2008.01935.x*

SOZIALANAMNESE

Lebensumstände	☐ mit Kindern/ Verwandten ☐ mit Ehepartner ☐ mit privatem Betreuer ☐ in einer betreuten Wohneinrichtung ☐ Alleine ☐ Andere____________
Ausbildungszeit (in Jahren)	
Beruf vor der Rente	

PATIENTENSCREENING

Intellektuelles Verstehen?	☐ NEIN ☐ JA
Kognitive Beeinträchtigung bekannt?	☐ NEIN ☐ JA
Körperlich mobil?	☐ NEIN ☐ JA
Alleinlebend?	☐ NEIN ☐ JA
Pflegegrad vorhanden?	☐ NEIN ☐ JA ( ) Home Service? ( )
Gesundheitliche Vorausplanung (ACP)?	☐ NEIN ☐ JA
Hospitalisiert im letzten Jahr?	☐ NEIN ☐ JA
Stürze im letzten Jahr?	☐ NEIN ☐ JA
Mangelernährung und/oder Dehydratation?	☐ NEIN ☐ JA
Schluckstörung?	☐ NEIN ☐ JA
Seh- oder Hörprobleme?	☐ NEIN ☐ JA
Inkontinenz?	☐ NEIN ☐ JA
Einnahme von mehr als 3 Medikamenten pro Tag?	☐ NEIN ☐ JA

AKTIVITÄTEN DES TÄGLICHEN LEBENS (ADL)*

	Retro.	Aufnahme	Mitte	Entlassung
A) BADEN[1]				
- Ohne Hilfe (kommt selbst in und aus der Badewanne/ Dusche)	1	1	1	1
- Mit Hilfe aber nur bei einem Körperteil (wie z.B. Rücken oder Beine)	1	1	1	1
- Mit Hilfe bei mehr als einem Körperteil (oder wäscht sich nicht)	0	0	0	0
B) AN- & AUSKLEIDEN[2]				
- Kommt selbstständig an die Kleidung und zieht sich komplett ohne fremde Hilfe an	1	1	1	1
- Kommt selbstständig an die Kleidung und zieht sich komplett ohne fremde Hilfe an, außer Schnürsenkel-binden	1	1	1	1
- Zieht sich mit Hilfe an/ wird angezogen/ bleibt zum Teil unbekleidet	0	0	0	0
C) TOILETTENBENUTZUNG[3]				
- Geht zur Toilette, Selbstreinigung und Anordnen von Kleidung ohne Hilfe[4]	1	1	1	1
- Benötigt Hilfe beim Gang zur Toilette / bei der anschließenden Reinigung / beim Anordnen von Kleidung / beim Gebrauch von Nachtpfannen/Toilettenstuhl	0	0	0	0
- Geht nicht zur Toilette für Ausscheidungen	0	0	0	0
D) BETT-/(ROLL-)STUHLTRANSFER				
- Bewegt sich in und aus dem Bett sowie in und aus dem Stuhl ohne Hilfe[5]	1	1	1	1
- Bewegt sich in und aus dem Bett sowie in und aus dem Stuhl mit Hilfe	0	0	0	0
- Kommt nicht aus dem Bett heraus	0	0	0	0
E) KONTINENZ				
- Steuert Urinieren und Stuhlgang vollständig selbst	1	1	1	1
- Hat gelegentlich “Unfälle”	0	0	0	0
- Betreuung hilft den Urin oder den Stuhlgang zu halten, Kathetergebrauch oder Inkontinenz	0	0	0	0
F) ESSEN				
- Unabhängiges Essen (es wird keine Hilfe gebraucht)	1	1	1	1
- Unabhängiges Essen außer Fleisch kleinschneiden oder Brot buttern	1	1	1	1
- Bekommt Hilfe beim Essen oder wird teilweise/ komplett von Sondennahrung oder intravenös ernährt	0	0	0	0
TOTAL				

[1] entweder Waschlappen-Pflege oder Badewanne oder Dusche
[2] bekommt Kleidung aus Kleiderschrank und Schubladen selbstständig heraus – inkl. Unterwäsche, Oberbekleidung, Büstenhalter
[3] Gang zur Toilette für Darm- und Harnausscheidung, Selbstreinigung nach Ausscheidung und Anordnen von Kleidung
[4] evtl. Gebraucht von Hilfsobjekten wie Gehstock, Rollator oder Rollstuhl,; evtl. Zusätzlicher Gebrauch von Nachtpfannen oder Toilettenstuhl mit eigenständiger Entleerung am Morgen
[5] evtl. Gebrauch von Hilfsobjekten wie Gehstock oder Rollator

**cf. Katz S, Ford AB, Moskowitz RW et al. Studies of illness in the aged. The index of ADL: A standardized measure of biological and psychological function. JAMA 1963; 185: 914-19; author’s translation*

INSTRUMENTELLE AKTIVITÄTEN DES TÄGLICHEN LEBENS (IADL)*

*cf. *Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist 1969;9:179-86; author's translation cf. www.kcgeriatrie.de (13.05.2016)*

	Retro	Aufn	Mitte	Entlass
A) FÄHIGKEIT DAS TELEFON ZU BENUTZEN				
Benutzt Telefon aus eigener Initiative, wählt Nummern	1	1	1	1
Wählt einige bekannte Nummern	1	1	1	1
Nimmt ab, wählt nicht selbstständig	1	1	1	1
Benutzt das Telefon überhaupt nicht	0	0	0	0
B) EINKAUFEN				
Kauft selbstständig die meisten benötigten Sachen ein	1	1	1	1
Tätigt wenige Einkäufe	0	0	0	0
Benötigt bei jedem Einkauf Begleitung	0	0	0	0
Unfähigkeit zum Einkaufen	0	0	0	0
C) KOCHEN				
Plant und kocht erforderliche Mahlzeiten selbstständig	1	1	1	1
Kocht erforderliche Mahlzeiten nur nach Vorbereitung durch Drittpersonen	0	0	0	0
Kocht selbstständig, hält aber benötigte Diät nicht ein	0	0	0	0
Benötigt vorbereitete und servierte Mahlzeiten	0	0	0	0
D) HAUSHALT				
Hält Haushalt instand oder benötigt zeitweise Hilfe bei schweren Arbeiten	1	1	1	1
Führt selbstständig kleine Hausarbeiten aus, z.B. Abwasch, Bett machen etc.	1	1	1	1
Führt selbst kleine Hausarbeiten aus, kann aber die Wohnung nicht rein halten	1	1	1	1
Benötigt Hilfe in allen Haushaltsverrichtungen	0	0	0	0
Nimmt überhaupt nicht teil an täglichen Verrichtungen im Haushalt	0	0	0	0
E) WÄSCHE				
Wäscht sämtliche eigene Wäsche	1	1	1	1
Wäscht kleine Sachen, wie Strümpfe etc.	1	1	1	1
Gesamte Wäsche muss auswärts versorgt werden	0	0	0	0
F) TRANSPORTMITTEL				
Benutzt unabhängig öffentliche Transportmittel, eigenes Auto	1	1	1	1
Bestellt und benutzt selbstständig Taxi, jedoch keine öffentlichen Transporte	1	1	1	1
Benutzt öffentliche Transportmittel in Begleitung	1	1	1	1
Beschränkte Fahrten im Taxi oder Auto in Begleitung	0	0	0	0
Reist überhaupt nicht	0	0	0	0
G) MEDIKAMENTE				
Nimmt Medikamente in genauer Dosierung und zum korrekten Zeitpunkt selbstständig	1	1	1	1
Nimmt vorbereitete Medikamente korrekt	0	0	0	0
Kann korrekte Einnahme von Medikamenten nicht handhaben	0	0	0	0
H) GELDHAUSHALT				
Regelt finanzielle Geschäfte selbstständig (Budget, Schecks, Einzahlung, Gang zur Bank)	1	1	1	1
Erledigt täglich kleinere Ausgaben, benötigt aber Hilfe bei Einzahlung, Bankgeschäften	1	1	1	1
Ist nicht mehr fähig mit Geld umzugehen	0	0	0	0
GESAMT				

MINI NUTRITIONAL ASSESSMENT SHORT FORM (MNA-SF)

SCREENING FÜR MANGELERNÄHRUNG*

** cf. Rubenstein LZ, Harker JO, Salva A, Guigoz Y, Vellas B. Screening for Undernutrition in Geriatric Practice: Developing the Short-Fom Mini Nutritional Assessment (MNA-SF). J. Geront 2001;56A: M366-377; author's translation cf. www.mna-elderly.com (13.05.2016)*

BMI: kg/m²					**Retro**	**Auf.**	**Mitte**	**Ent.**
Body Mass Index (BMI) **Gewicht:________kg** **Größe:________cm**	0 BMI <19	1 BMI = 19-20	2 BMI = 21-22	3 BMI > 23				
Gewichtsverlust (GV) in den letzten 3 Monaten	0 GV > 3 kg	1 nicht bekannt	2 GV 1-3 kg	3 kein GV				
Mobilität	0 bettlägerig oder in einem Stuhl mobilisiert	1 in der Lage, sich in der Wohnung zu bewegen	2 verlässt die Wohnung					
Neuropsychologische Probleme	0 schwere Demenz oder Depression	1 leichte Demenz	2 keine psychologi-schen Probleme					
Hat der Patient in den letzten 3 Monaten weniger gegessen?[1]	0 starke Abnahme der Nahrungs-aufnahme	1 leichte Abnahme der Nahrungs-aufnahme	2 keine Abnahme der Nahrungs-aufnahme					
Akute Krankheit oder Während der letzten 3	**psychischer Stress Monate?**	0 ja	2 nein					
GESAMT (max. 14 Punkte)								

[1] wegen Appetitverlust, Verdauungsproblemen, Schwierigkeiten beim Kauen oder Schlucken

KURZER FRAGEBOGEN DES MENTALEN ZUSTANDES (SPMSQ)*

	Retrospektive	Aufnahme	Mitte	Entlassung
Welches Datum ist heute?[1]	1	1	1	1
Welcher Wochentag ist heute?	1	1	1	1
Wie heißt der Ort an dem wir uns befinden?[2]	1	1	1	1
Wie ist Ihre Wohnadresse?	1	1	1	1
Wie alt sind Sie?	1	1	1	1
Wann sind sie geboren worden?	1	1	1	1
Wer ist im Moment deutscher Kanzler?[3]	1	1	1	1
Wer war der Kanzler davor?[3]	1	1	1	1
Was war der Mädchenname Ihrer Mutter?	1	1	1	1
Subtrahieren sie 3 von 20 und subtrahieren Sie erneut 3 von der neu erhaltenen Zahl, 3-mal hintereinander.[4]	1	1	1	1
GESAMT				

Notieren Sie sich die Fehler.

[1] *Nur richtig, wenn Tag, Monat und Jahr stimmen*

[2] *Richtig, sobald irgendeine Beschreibung zutrifft*

[3] *Nachname ausreichend*

[4] *Der gesamte Rechenweg muss richtig sein um als korrekt zu gelten*

** cf. Pfeiffer E. A short portable mental status questionnaire for the assessment of organic brain deficit in elderly patients. J Am Geriatr Soc. 1975; 23:433-441; author's translation*

EXTON SMITH SKALA (ESS)*

FÜR DIE BEURTEILUNG DES DEKUBITUS-RISIKOS

	Retro.	Aufnahme	Mitte	Entlassung
KÖRPERLICHER ZUSTAND				
Gut	4	4	4	4
Leidlich	3	3	3	3
Schlecht	2	2	2	2
Sehr schlecht	1	1	1	1
GEISTIGER ZUSTAND				
Klar	4	4	4	4
Apathisch/ Teilnahmslos	3	3	3	3
Verwirrt	2	2	2	2
Stupurös	1	1	1	1
AKTIVITÄT				
Geht ohne Hilfe	4	4	4	4
Geht mit Hilfe	3	3	3	3
Rollstuhlbedürftig	2	2	2	2
Bettlägerig	1	1	1	1
BEWEGLICHKEIT				
voll	4	4	4	4
Kaum eingeschränkt	3	3	3	3
Sehr eingeschränkt	2	2	2	2
Voll eingeschränkt	1	1	1	1
INKONTINENZ				
Keine	4	4	4	4
Manchmal	3	3	3	3
Meistens Urin	2	2	2	2
Urin und Stuhl	1	1	1	1
GESAMT				

** cf. Bliss MR., McLaren R., Exton-Smith AN. Mattresses for preventing pressure sores in geriatric patients. Mon Bull Minist Health Public Health Lab Serv 1966; author's translation cf. www.evidence.de (13.05.2016)*

ZUSAMMENFASSUNG

Umfassendes Geriatrisches Assessment	**CIRS** Cumulative Illness Rating Scale	**Barthel Index ADL** Activities of Living	**IADL** Instrumental Activities of Living	**MNA-SF** Mini Nutritional Assessment Short Form	**SPMSQ** Short Portable Mental Status Questionnaire	**ESS** Exton Smith Scale	**MPI Multi-dimensional Prognostic Index**
Gesamtscore							
Keine Einschränkungen	0	6-5	8-6	≥ 12	0-3	16-20	**0-0.33**
Mittelgradige Einschränkungen	1-2	4-3	5-4	8-11	4-7	10-15	**0.34-0.66**
Schwere Einschränkungen	≥ 3	2-0	3-0	<=7	8-10	5-9	**0.67-1**

MPI - Multidimensionaler Prognostischer Index*

	Gering (Wert=0)	**Mäßig** (Wert=0.5)	**Hoch** (Wert=1)	Aufn.	Mitte	Entlass.
CIRS	0	1-2	≥3			
ADL	6-5	4-3	2-0			
IADL	8-6	5-4	3-0			
MNA-SF	>=12	8-11	<=7			
SPMSQ	0-3	4-7	8-10			
ESS	16-20	10-15	5-9			
Medikamentenanzahl	0-3	4-6	≥7			
Lebensumstände	Lebt zusammen mit der Familie	Lebt in Betreuung	Lebt alleine			
GESAMTER MPI SCORE						

** cf. Pilotto A, Ferrucci L, Franceschi M et al. Development and validation of a Multidimensional Prognostic Index for 1-Year Mortality from a Comprehensive Geriatric Assessment in Hospitalized Older Patients. Rejuvenation Res 2008; 11:151-61; author's translation*

ZUSAMMENFASSUNG, INTERPRETATION DER TESTERGEBNISSE UND EMPFEHLUNG

GERIATRISCHE SYNDROME

☐ Inkontinenz ☐ Instabilität ☐ Immobilität ☐ Intellekt. Abbau ☐ Inanition ☐ Armut ☐ Polypharmazie
☐ Reakt. Depression / Irritabilität ☐ Hör-/Sehprobleme ☐ Insomnia ☐ irritables Colon ☐ Delir ☐ Iatrogene Erkrankung ☐ Diabetes mellitus ☐ Chron. Schmerzen ☐ Soz. Isolation ☐ Schluckstörung ☐ Störung im Flüssigkeitshaushalt

PATIENTEN-RESSOURCEN

☐ Körperlich ☐ Räumlich ☐ Sozial ☐ Ökonomisch ☐ Spirituell ☐ Motivational ☐ Emotional ☐ Mnestisch ☐ Kompetenzbezogen ☐ Intellektuell

____

Vor- und Nachname des Studiendurchführenden

___________________________________ ________________________

Ort und Datum Unterschrift des Studiendurchführenden

Prof. Dr. Dr. Maria Cristina Polidori Nelles FRCP
Leiterin Arbeitsgruppe Klinische Altersforschung
Klinik II für Innere Medizin, Uniklinik Köln
Kerpener Straße 62
50937 Köln
Telefon: +49 221 478-32753
Telefax: +49 221 478-86710
Email: maria.polidori-nelles@uk-koeln.de

FOLLOW-UP

Verlegung/ Entlassung nach stationärem Klinikaufenthalt

☐ nach Hause ☐ in Geriatrische Reha/ Akutgeriatrie ☐ auf Intensivstation ☐ andere interne Verlegung ☐ andere externe Verlegung

FOLLOW UP	**Entlassung**		**3 Monate**		**6 Monate**		**12 Monate**	
Patient lebt? ggf. Patient verstorben	☐ja	☐nein *Todestag* ___/___/____	☐ja	☐nein *Todestag* ___/___/____	☐ja	☐nein *Todestag* ___/___/____	☐ja	☐nein *Todestag* ___/___/____
Pflegestufe beantragt oder **erhöht?**	☐ja	☐nein	☐ja	☐nein	☐ja	☐nein	☐ja	☐nein
Ambulanter Pflegedienst beantragt?	☐ja	☐nein	☐ja	☐nein	☐ja	☐nein	☐ja	☐nein
Institutionalisierung veranlasst?	☐ja	☐nein	☐ja	☐nein	☐ja	☐nein	☐ja	☐nein
Weiterbehandlung/Konsil veranlasst oder durchgeführt?	☐ja	☐nein						
Sturz während Hospitalisierung	☐ja	☐nein						
Stürze zuhause	☐ja	☐nein	☐ja	☐nein	☐ja	☐nein	☐ja	☐nein
Einnahme wie vieler versch. **Medikamenten** pro Tag?	☐ <3 ☐ 3-5	☐ >5 ☐ >9	☐ <3 ☐ 3-5	☐ >5 ☐ >9	☐ <3 ☐ 3-5	☐ >5 ☐ >9	☐ <3 ☐ 3-5	☐ >5 ☐ >9
Rehospitalisierung geplant?	☐ja	☐nein	☐ja	☐nein	☐ja	☐nein	☐ja	☐nein
Rehospitalisierung auf 15.II, UK **Andere Klinik** Angabe: Aufenthalte/Anzahl Tage			______ ______	______ ______	______ ______	______ ______	______ ______	______ ______

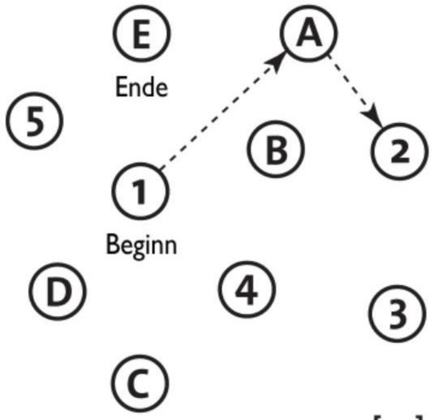
☐ Eine Kontaktaufnahme zum Patienten ist nicht mehr möglich. Letztes Datum, an dem der Patient noch am Leben war: ___/___/____

B: Montreal Cognitive Assessment (MoCa)[314]

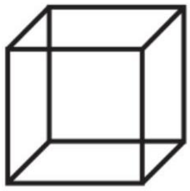
MONTREAL COGNITIVE ASSESSMENT (MOCA)

NAME :
Ausbildung : Geburtsdatum :
Geschlecht : DATUM :

VISUOSPATIAL / EXEKUTIV — PUNKTE



[ ]



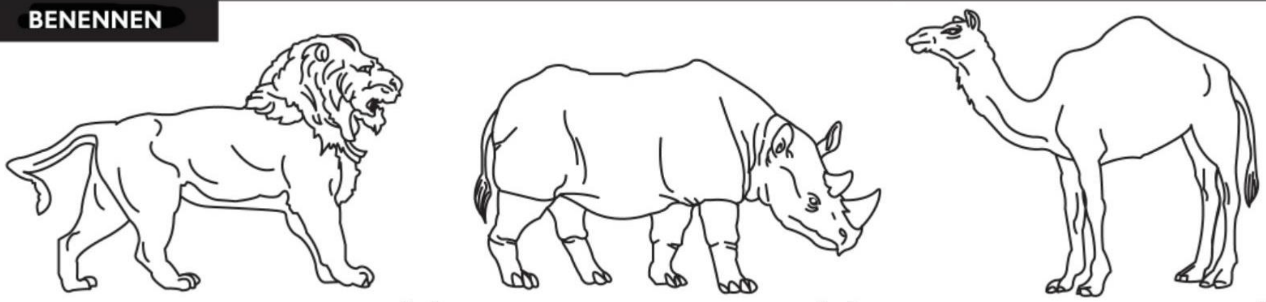
Würfel nach-zeichnen [ ]

Eine Uhr zeichnen (Zehn nach elf)
(3 Punkte)

[ ] Kontur [ ] Zahlen [ ] Zeiger

__/5

BENENNEN



[ ] [ ] [ ]

__/3

GEDÄCHTNIS

Wortliste vorlesen, wiederholen lassen.
2 Durchgänge. Nach 5 Minuten überprüfen (s.u.)

	GESICHT	SAMT	KIRCHE	TULPE	ROT
1.Versuch					
2.Versuch					

Keine Punkte

AUFMERKSAMKEIT Zahlenliste vorlesen (1 Zahl/ Sek.)

In der vorgegebenen Reihenfolge wiederholen [ ] 2 1 8 5 4
Rückwärts wiederholen [ ] 7 4 2 __/2

Buchstabenliste vorlesen (1 Buchst./Sek.). Patient soll bei jedem Buchstaben „A" mit der Hand klopfen. Keine Punkte bei 2 oder mehr Fehlern
[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B __/1

Fortlaufendes Abziehen von 7 , mit 100 anfangen [ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65
4 oder 5 korrekte Ergebnisse: **3 P.**, 2 oder 3 korrekt: **2 P.**, 1 korrekt: **1 P.**, 0 korrekt: **0 P.** __/3

SPRACHE **Wiederholen:** „Ich weiß lediglich, dass Hans heute an der Reihe ist zu helfen." [ ]
„Die Katze versteckte sich immer unter der Couch, wenn die Hunde im Zimmer waren." [ ] __/2

Möglichst viele Wörter in einer Minute benennen, die mit dem Buchstaben F beginnen [ ] _____ (N ≥ 11 Wörter) __/1

ABSTRAKTION Gemeinsamkeit von z.B. Banane und Apfelsine = Frucht [ ] Eisenbahn - Fahrrad [ ] Uhr - Lineal __/2

ERINNERUNG

		GESICHT	SAMT	KIRCHE	TULPE	ROT	Punkte nur bei richtigem Nennen OHNE Hinweis
	Worte erinnern OHNE HINWEIS	[ ]	[ ]	[ ]	[ ]	[ ]	__/5
Optional	Hinweis zu Kategorie						
	Mehrfachauswahl						

ORIENTIERUNG [ ] Datum [ ] Monat [ ] Jahr [ ] Wochentag [ ] Ort [ ] Stadt __/6

Normal ≥ 26 / 30

TOTAL __/30
+ 1 Punkt wenn ≤ 12 Jahre Ausbildung

www.mocatest.org Untersucher: ____________________

C: Mini Mental State Examination (MMSE)[315,316]

Mini-Mental-Status-Test (MMST)

Der MMST erlaubt anhand eines einfachen Fragebogens eine Abschätzung der kognitiven Fähigkeiten eines älteren Menschen. Die Testdauer beträt ca. 10 Minuten.
Ergebnisinterpretation: Bei weniger als 13 Punkten, werden globale kognitive Störungen angenommen und die Voraussetzungen für das Kompetenzzentrum können bejaht werden.

Testperson : ______________ **Geburtsdatum:** ______________

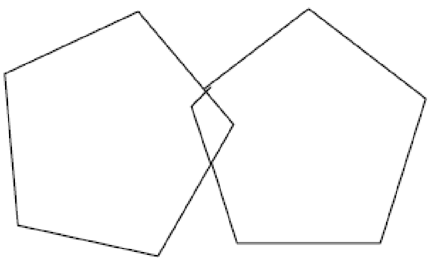
Datum der Erhebung: ________ **Erhebung wurde durchgeführt von** ______________

		Punkte	
I. Orientierung	(1) Datum	1	0
	(2) Jahr	1	0
Zeit (z.B. Welchen Tag haben wir heute?)	(3) Jahreszeit	1	0
	(4) Wochentag	1	0
	(5) Monat	1	0
Ort (z.B. Wo sind wir jetzt?)	(6) Bundesland	1	0
	(7) Landkreis/Stadt	1	0
	(8) Stadt/Stadtteil	1	0
	(9) Klinik/Praxis/Pflegeheim	1	0
	(10) Station/Stockwerk	1	0
	Summe (max. 10):		
II. Merkfähigkeit (Der Untersucher nennt die Gegenstände und fordert auf, diese zu wiederholen)	(11) Apfel	1	0
	(12) Pfennig	1	0
	(13) Tisch	1	0
maximal 6 Wiederholungen	Summe (max. 3):		
III. Aufmerksamkeit und Rechenfertigkeit	(14) >93 < L	1	0
	(15) >86< H	1	0
Ziehen Sie von 100 jeweils 7 ab oder buchstabieren Sie "STUHL" rückwärts	(16) >79 < oder U	1	0
	(17) >72 < T	1	0
	(18) >65 < S	1	0
	Summe (max. 5):		
IV. Erinnerungsfähigkeit	(19) Apfel	1	0
Was waren die Dinge, die Sie sich vorher gemerkt haben?	(20) Pfennig	1	0
	(21) Tisch	1	0
	Summe (max. 3):		

V. Sprache				
Was ist das? (Der Untersucher zeigt zwei Gegenstände und fordert die Testperson auf diese zu benennen)	(22) (23)	Armbanduhr Bleistift	1 1	0 0
Sprechen Sie nach: (Der Untersucher fordert die Testperson auf, nachzusprechen)	(24)	„Sie leiht ihm kein Geld mehr" (max. 3 Wdh.)	1	0
Kommandos befolgen	(25)	Nehmen Sie bitte das Papier in die Hand.	1	0
	(26)	Falten Sie es in der Mitte.	1	0
	(27)	Lassen Sie es auf den Boden fallen.	1	0
	(28)	Bitte schließen Sie die Augen!	1	0
	(29)	Schreiben Sie einen vollständigen Satz	1	0
	(30)	Fünfecke nachzeichnen (Alle 10 Ecken müssen wiedergegeben sein und 2 davon müssen sich überschneiden)	1	0
		Summe (max. 9):		

Gesamtsumme:

Fünfeck



Abgezeichnetes Beispiel

D: Geriatric Depression Scale (GDS)[269,317]

Geriatric Depression Scale (GDS)

Nach Sheikh und Yesavage 1986

		Ja	Nein
1.	Sind Sie grundsätzlich mit Ihrem Leben zufrieden?		.
2.	Haben Sie viele von Ihren Tätigkeiten und Interessen aufgegeben?	.	
3.	Haben Sie das Gefühl, Ihr Leben sei leer?	.	
4.	Ist Ihnen oft langweilig?	.	
5.	Sind Sie meistens guter Laune?		.
6.	Befürchten Sie, dass Ihnen etwas Schlechtes zustoßen wird?	.	
7.	Sind Sie meistens zufrieden?		.
8.	Fühlen Sie sich hilflos?	.	
9.	Sind Sie lieber zu Hause statt auszugehen und etwas zu unternehmen?	.	
10.	Glauben Sie, dass Sie mit dem Gedächtnis mehr Schwierigkeiten haben als andere Leute?	.	
11.	Finden Sie es wunderbar jetzt zu leben?		.
12.	Finden Sie sich so, wie Sie jetzt sind, eher wertlos?	.	
13.	Fühlen Sie sich energiegeladen?		.
14.	Finden Sie, Ihre Lage sei hoffnungslos?	.	
15.	Glauben Sie, die meisten anderen Leute haben es besser als Sie?	.	

Beurteilung:

0-5 Punkte: unauffällig

5-10 Punkte: leichte bis mäßige Depression ______ Punkte

10-15 Punkte schwere Depression

E: Timed Up and Go Test (TUG)[37,318]

Timed "up & go"-Test

(modifiziert nach D. Podsiadlo & S. Richardson)

Durchführung:
Die Testperson soll ohne Fremdhilfe aus dem Sitzen aufstehen, 3 Meter hin- und zurückgehen und sich wieder hinsetzen (Hilfsmittel sind erlaubt).

Auswertung:
Die Auswertung des Tests erfolgt in Abhängigkeit von der benötigten Zeit:

Zeit [Sek.]	Bedeutung
≤10	Alltagsmobilität uneingeschränkt
11-19	Geringe Mobilitätseinschränkung, in der Regel noch ohne Alltagsrelevanz
20-29	Abklärungsbedürftige, funktionell relevante Mobilitätseinschränkung
≥30	Ausgeprägte Mobilitätseinschränkung, in der Regel Interventions-/ Hilfsmittelbedarf

F: Dementia Detection Test (DemTect)[39,319]

DemTect

Name: ______________________ Untersuchungsdatum: ______________________

Vorname: ______________________ geb.: ______________ Alter: __________

Schulbildung: ______________________ Beruf (evtl. vor Rente): ______________________

1) Wortliste

1.	Teller ☐	Hund ☐	Lampe ☐	Brief ☐	Apfel ☐	Hose ☐	Tisch ☐	Wiese ☐	Glas ☐	Baum ☐
2.	Teller ☐	Hund ☐	Lampe ☐	Brief ☐	Apfel ☐	Hose ☐	Tisch ☐	Wiese ☐	Glas ☐	Baum ☐

Richtig erinnerte Begriffe (max. 20) ☐

2) Zahlen-Umwandeln (siehe Rückseite)

Richtige Umwandlungen (max. 4) ☐

3) Supermarktaufgabe (1 Min.)

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Genannte Begriffe (max. 30) ☐

4) Zahlenfolge rückwärts

1. Versuch	2. Versuch		
7-2	8-6	☐	2
4-7-9	3-1-5	☐	3
5-4-9-6	1-9-7-4	☐	4
2-7-5-3-6	1-3-5-4-8	☐	5
8-1-3-5-4-2	4-1-2-7-9-5	☐	6

Längste richtig rückwärts wiederholte Zahlenfolge (max. 6) ☐

5) Erneute Abfrage der Wortliste

Teller	Hund	Lampe	Brief	Apfel	Hose	Tisch	Wiese	Glas	Baum
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Richtig erinnerte Begriffe (max. 10) ☐

DemTect

2) Zahlen-Umwandeln

Beispiel	5 → fünf	drei → 3

209 = ______________________

4054 = ______________________

sechshunderteinundachtzig = ______________________

zweitausendsiebenundzwanzig = ______________________

Auswertung

Umrechnung:

Aufgabe	Einzelergebnis (bitte übertragen)	Punkte laut Umrechnungstabelle
1. Wortliste	☐	☐
2. Zahlen-Umwandeln	☐	☐
3. Supermarktaufgabe	☐	☐
4. Zahlenfolge rückwärts	☐	☐
5. Erneute Abfrage der Wortliste	☐	☐
Summe der Punkte		☐

Gesamtergebnis DemTect:

Punktzahl	Diagnose	Handlungsempfehlung
13-18	altersgemäße kognitive Leistung	nach 12 Monaten bzw. bei Auftreten von Problemen erneut testen
9-12	Leichte kognitive Beeinträchtigung	nach 6 Monaten erneut testen – Verlauf beobachten
≤ 8	Demenzverdacht	weitere diagnostische Abklärung, Therapie einleiten

G: De Morton Mobility Index (DEMMI)[42,320]

de Morton Mobility Index (DEMMI)

	0	1	2
Bett			
1. Brücke	☐ nicht möglich	☐ möglich	
2. Auf die Seite rollen	☐ nicht möglich	☐ möglich	
3. Vom Liegen zum Sitzen	☐ nicht möglich	☐ geringe Unterstützung ☐ Supervision	☐ selbständig
Stuhl			
4. Sitzen im Stuhl ohne Unterstützung	☐ nicht möglich	☐ 10 Sek.	
5. Aus dem Stuhl aufstehen	☐ nicht möglich	☐ geringe Unterstüzung ☐ Supervision	☐ selbständig
6. Aus dem Stuhl aufstehen, ohne die Arme zu Hilfe zu nehmen	☐ nicht möglich	☐ möglich	
Statisches Gleichgewicht (ohne Gehhilfe)			
7. Ohne Unterstützung stehen	☐ nicht möglich	☐ 10 Sek.	
8. Stehen mit geschlossenen Füßen	☐ nicht möglich	☐ 10 Sek.	
9. Auf den Fußspitzen stehen	☐ nicht möglich	☐ 10 Sek.	
10. Im Tandemstand mit geschlossenen Augen stehen	☐ nicht möglich	☐ 10 Sek.	
Gehen			
11. Wegstrecke +/- Gehhilfe *Gehhilfe (kennzeichnen): keine/ Gehbock/ Stock/ Rollator/ andere*	☐ nicht möglich ☐ 5m	☐ 10m ☐ 20m	☐ 50m
12. Selbständiges Gehen	☐ nicht möglich ☐ geringe Unterstützung ☐ Supervision	☐ selbständig mit Gehhilfe	☐ selbständig ohne Gehhilfe
Dynamisches Gleichgewicht (ohne Gehhilfe)			
13. Stift vom Boden aufheben	☐ nicht möglich	☐ möglich	
14. vier Schritte rückwärts gehen	☐ nicht möglich	☐ möglich	
15. Springen	☐ nicht möglich	☐ möglich	
ERGEBNISSE DER SPALTEN			

leicht

Sitzen ohne Unterstützung
Brücke
Ohne Unterstützung stehen
Aus dem Stuhl aufstehen
Auf die Seite rollen
Vom Liegen zum Sitzen
Stehen mit geschlossenen Füßen
Stift vom Boden aufheben
Rückwärts gehen
Wegstrecke
Aus dem Stuhl aufstehen ohne Arme
Selbständiges Gehen
Springen
Zehenstand
Tandemstand geschlossene Augen

schwer

ROHWERT (Summe der Spaltenergebnisse) /19

DEMMI SCORE (MDC_{90} = 9 Punkte; MCID = 10 Punkte) /100

DEMMI- Rohwert Umrechnungstabelle

Rohwert	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
DEMMI score	0	8	15	20	24	27	30	33	36	39	41	44	48	53	57	62	67	74	85	100

Name Patient: ____________
Datum: ____________
Name Tester: ____________
Unterschrift: ____________

Kommentare:

8. Preliminary Publication of results

Veröffentlichtes Paper in einer wissenschaftlichen Zeitschrift

07/2021 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
Franziska M. Müller, Anna M. Meyer, Lena Pickert, Annika Heeß, Ingrid Becker, Thomas Benzing, M. Cristina Polidori. Geriatric Care 2021; volume 7:9723. https://doi.org/10.4081/gc.2021.9723

Poster auf wissenschaftlichen Konferenzen

09/2019 Einfluss einer multidimensionalen, altersmedizinischen Behandlung auf die Prognose älterer, multimorbider Patienten auf internistischer Akutstation
Franziska M. Müller, Anna M. Meyer, Lena Pickert, Annika Heeß, Ingrid Becker, Alberto Pilotto, Paul Brinkkötter, Thomas Benzing, M. Cristina Polidori i.R. des 31. Jahreskongress der Deutschen Gesellschaft für Geriatrie (DGG), Frankfurt am Main, Deutschland