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Kognition bei älteren multimorbiden stationären Patienten: Einfluss auf Endpunkte bei Entlassung und dreimonatiger Nachbeobachtung

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Bei der Auswahl und Auswertung des Materials sowie bei der Herstellung des Manuskriptes habe ich Unterstützungsleistungen von folgenden Personen erhalten:
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Weitere Personen waren an der Erstellung der vorliegenden Arbeit nicht beteiligt. Insbesondere habe ich nicht die Hilfe einer Promotionsberaterin/eines Promotionsberaters in Anspruch genommen. Dritte haben von mir weder unmittelbar noch mittelbar geldwerte Leistungen für Arbeiten erhalten, die im Zusammenhang mit dem Inhalt der vorgelegten Dissertationsschrift stehen.

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Die dieser Arbeit zugrundeliegende prospektive klinische Studie („Vün nix küt nix“) wurde mit meiner Mitarbeit von Univ. Prof. Dr. med. Dr. M. C. Polidori Nelles, Leiterin der Universitären Alternsmedizin der Klinik für Innere Medizin II der Universität zu Köln und Dr. med. A. M. Meyer, Stationsärztin auf der Station 17.1. der Klinik für Innere Medizin II der Uniklinik Köln entwickelt.

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Das vorliegende Manuskript habe ich verfasst. Das Mentorium-Lektorat hat die Endfassung dieser Arbeit grammatikalisch und sprachlich überarbeitet, auf die geistige und inhaltliche Gestaltung dieser Arbeit jedoch keinen Einfluss genommen.

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Contents

Abbreviations

AD: Alzheimer's disease

ADL: Activities of Daily Living

APOE ε4: Apolipoprotein E ε4

BI: Barthel-Index

CDT: Clock Drawing Test

CGA: Comprehensive Geriatric Assessment

CD: Cognitive Deficit

CI: Confidence Interval

CIRS: Cumulative Disease Rating Scale

CSF: Cerebrospinal Fluid

DEMMI: De Morton Mobility Index

DEP: "Severe to total dependency" (subgroup of functional status based on Barthel-Index)

DLBs: Dementia with Lewi Bodies

DRKS: Deutsches Register Klinischer Studien [German Register of Clinical Studies]

EQ-5D-5L: EuroQol 5-Dimension 5-Level

ESS: Exton Smith pressure ulcer risk Scale

FDG-PET: Fluorodeoxyglucose Positron Emission Tomography

FIM: Functional Independence Measure

FTD: Frontotemporal Dementia

HAMT: Hodkinson Abbreviated Mental Test

HGS: Handgrip strength

IADL: Instrumental Activities of Daily Living

INDEP: "Independence to moderate dependency" (subgroup of functional status/BI)

IQR: Interquartile range

L/M RM: Low to moderate Risk of frailty/ poor prognosis (MPI subgroup)

LTCF: Long-Term Care Facility

M: Mean

mCD: Mild Cognitive Deficit

Mdn: Median

MNA-SF: Mini Nutritional Assessment – Short Form

MoCA: Montreal Cognitive Assessment

MMSE: Mini Mental State Examination

MPI: Multidimensional Prognostic Index

MRI: Magnetic Resonance Imaging

N: Total number of participants of the study

n: Number of participants in a subgroup

nCD: No Cognitive Deficit
NIA-AA: National Institute on Ageing and Alzheimer's Association
PET: Positron Emission Tomography
PFC: Prefrontal Cortex
OR: Odds Ratio
ROS: Reactive Oxygen Species
SARC-F: Strength, Assistance with walking, Rise from a chair, Climb stairs and Falls
sCD: Severe Cognitive Deficit
SCD: Subjective Cognitive Decline
SD: Standard deviation
SPMSQ: Short Portable Mental State Questionnaire
SPSS: Statistical Package for the Social Sciences
Suppl.: Supplement
TMT-A and -B: Trail Making Test – Parts A and B
TMTe: TMT-efficiency
TMTpr: TMT-prorated
TUG: Timed-Up-and-Go
VaD: Vascular Dementia
VAS: Visual Analogue Scale
vs: versus
WCST: Wisconsin Card Sorting test

1. Abstracts

1.1. Abstract in English

Cognitive deficits in older multimorbid patients hospitalised for non-neuropsychiatric reasons often remain undiagnosed but are associated with poor therapy adherence and unfavourable disease trajectories. This study aimed to investigate the relationship of cognition on hospital admission with patients' functional status and frailty at discharge, as well as mortality, hospital readmission, admission to a long-term care facility (LTCF) and falls one and three months after discharge in older hospitalised multimorbid patients. It was hypothesised that better cognition upon admission would predict better outcomes at and after discharge. One hundred and thirty-one (N = 131) older (≥ 65 years), multimorbid (≥ two chronic diseases) inpatients at Ageing Medicine Ward of the Department II of Internal Medicine at the University Hospital of Cologne underwent upon admission comprehensive geriatric assessment (CGA) with Multidimensional Prognostic Index (MPI) calculation and a neuropsychological battery (Montreal Cognitive Assessment – MoCA, Trail Making Test Parts A and B – TMT-A & -B). Outcomes were functional ability (Barthel-Index – BI) and frailty/ poor prognosis (CGA-based MPI) at discharge as well as by phone collected one- and three-months post-discharge mortality, readmission to hospital, admission to LTCF, and falls. Of 131 patients, n = 121 (92.4%) showed global cognitive deficit upon admission. Of those, n = 6 cases were already known (n = 1 mild cognitive impairment – MCI, n =5 dementia), while 95% were patients with a newly identified mild or severe cognitive deficit (mCD or sCD). Patients with better performance in MoCA, TMT-A, and -B upon admission showed significantly higher functional ability at discharge ($p < .001$, $p = .008$, $p = .003$, respectively). MoCA ($R^2 = .227$, $p < .001$) and TMT-B [OR (95% CI) = 1.006 (1.002, 1.009), $p = .003$] predicted BI independent of demographic factors (age, gender, education, MPI upon admission). Patients with better MoCA scores showed lower frailty at discharge ($p = .005$), but MoCA did not predict MPI. Neither MoCA nor TMT anticipated any of the post-discharge outcomes. In conclusion, better cognitive function upon hospital admission appears protective against functional loss at discharge in older multimorbid German inpatients. Therefore, early cognitive assessment in this population is crucial to identify patients who will develop functional deficits at discharge to ensure timely implementation of preventive strategies or individually adapted therapy schemata. Given the demographic transition and the hospitalisation rate, cognitive testing should be an integral part of the geriatric evaluation upon admission to an acute hospital.

1.2. Zusammenfassung

Kognitive Defizite bei älteren multimorbiden Patienten, die aus nicht-neuropsychiatrischen Gründen ins Krankenhaus aufgenommen werden, bleiben häufig unerkannt, gehen jedoch mit einer schlechten Therapieadherenz und ungünstigen Krankheitsverläufen einher. Ziel dieser Studie war es, den Zusammenhang zwischen der Kognition bei der Krankenhausaufnahme und dem Funktionsstatus und der Gebrechlichkeit der Patienten bei der Entlassung, sowie der Mortalität, der Wiederaufnahme ins Krankenhaus, der Aufnahme in eine Langzeitpflege-einrichtung (LTCF) und Stürzen ein und drei Monate nach der Entlassung bei älteren hospitalisierten multimorbiden Patienten zu untersuchen. Es wurde die Hypothese aufgestellt, dass bessere Kognition bei der Aufnahme bessere Endpunkte bei und nach der Entlassung vorhersagen würde. 131 ältere (≥ 65 Jahre), multimorbide (≥ 2 chronische Erkrankungen) stationäre Patienten der Universitären Altersmedizin der Klinik II für Innere Medizin des Universitätsklinikums Köln wurden bei der Aufnahme einer umfassenden geriatrische Beurteilung (Comprehensive Geriatric Assessment – CGA) mit Berechnung des multidimensionalen prognostischen Index (Multidimensional Prognostic Index – MPI) und einer neuropsychologischen Batterie (Montreal Cognitive Assessment – MoCA, Trail Making Test Teile A und B – TMT-A & -B) unterzogen. Die Endpunkte waren funktionelle Fähigkeit (Barthel-Index – BI) und Gebrechlichkeit/ ungünstige Prognose (CGA-basiertes MPI) bei der Entlassung sowie telefonisch erhobene Mortalität, Wiederaufnahme ins Krankenhaus, Einweisung in eine LTCF, und Stürze 1 und 3 Monate nach der Entlassung. Von 131 Patienten zeigten n = 121 (92.4%) bei der Aufnahme ein globales kognitives Defizit. Davon waren n = 6 Fälle bereits bekannt (n = 1 leichte kognitive Beeinträchtigung – MCI, n = 5 Demenz), während 95% waren Patienten mit neu identifizierten leichten bzw. schweren kognitiven Defiziten (mCD bzw. sCD). Patienten mit einer besseren Leistung in MoCA, TMT-A und -B bei der Aufnahme zeigten bei der Entlassung eine signifikant höhere funktionelle Fähigkeit ($p < .001$, $p = .008$ bzw. $p = .003$). MoCA ($R^2 = .227$, $p < .001$) und TMT-B [OR (95% CI) = 1.006 (1.002, 1.009), $p = .003$] konnten BI unabhängig von demografischen Faktoren (Alter, Geschlecht, Bildung, MPI bei Aufnahme) vorhersagen. Patienten mit einer besseren Leistung in MoCA zeigten eine geringere Gebrechlichkeit bei der Entlassung ($p = .005$), MoCA konnte jedoch den MPI nicht vorhersagen. Weder MoCA noch TMT konnten die Postentlassungsendpunkte vorhersagen. Bessere kognitive Funktion bei der Aufnahme bei älteren multimorbiden Patienten scheint zu schützen vor einem Funktionsverlust bei der Entlassung. Daher ist eine frühzeitige kognitive Beurteilung in dieser Population wichtig, um Patienten zu identifizieren, die bei der Entlassung funktionelle Defizite entwickeln, damit eine rechtzeitige Umsetzung präventiver Strategien oder individuell angepasster Therapieschemata erfolgen kann. Angesichts des demografischen Wandels und der Krankenhauseinweisungsrate sollten kognitive Tests ein integraler Bestandteil der geriatrischen Beurteilung bei der Aufnahme ins Akutkrankenhaus sein.

2. Introduction

2.1. Cognition, dementia, multimorbidity, and frailty: How do they relate?

Cognitive impairment in older adults is a multifactorial syndrome influenced by several risk factors. Internal diseases, immobility, medication, lifestyle including inactivity and nutrition, as well as social isolation can trigger cognitive impairment. In its extreme form, it leads to dementia (Polidori & Düzel, 2024). This term refers to a chronic neuropsychiatric syndrome with progressive cognitive and functional deterioration (Dening & Sandilyan, 2015). More than 46 million people worldwide have dementia, and due to demographic transition, the prevalence is expected to exceed 131 million by the year 2050 (Alzheimer's Disease International, 2015). In this context, cognition is a substantial clinical outcome during dementia diagnostics. Change in cognitive function serves as a reference outcome to evaluate diagnostic accuracy and therapeutic success in dementia (Teipel et al., 2023). Many neurodegenerative diseases account for the clinical manifestation of dementia, among others, Alzheimer's disease (AD), vascular dementia (VaD), frontotemporal dementia (FTD), or dementia with Lewi Bodies (DLBs). However, AD is the leading cause of dementia (Winblad, 2016) and is responsible for up to 80% of all cases (Jellinger, 2006 in Jessen, 2019a). AD was initially diagnosed post-mortem based on autopsy findings (Escher et al., 2019; McKhann et al., 1984 in Jessen 2019a). In 2011, the National Institute on Ageing and Alzheimer's Association (NIA-AA) proposed a series of diagnostic criteria for AD, updated in 2018 from the NIA-AA research framework to recommend a biological definition of AD. AD is considered a continuum with a disease course in six stages. An ordinary basis is in vivo detectable abnormal biomarker changes in the cerebrospinal fluid (CSF), including a decrease of the β-Amyloid1-42 and an increase of the phosphorylated tau protein (p-tau). The deposition of Aβ42 in the brain has a toxic influence on synapses, and the aggregation of amyloid oligomers in the extracellular space of the grey matter leads to the formation of amyloid plaques. These plaques do not cause cognitive impairment directly, but the subsequent tauopathy, inflammation, and formation of reactive oxygen species (ROS) lead to neurodegeneration and, finally, to cognitive decline (Jack et al., 2018; Jessen, 2019a; Jessen et al, 2022).

The six stages of the AD have been described as an asymptomatic initial phase (stage 1), in which, though pathological changes are developing, no subjective complaints or objective deficits are present (Jessen, 2019a). This phase can last up to 15 years and is followed by stage 2, where the first subjective complaints regarding one's cognitive abilities appear. It is about a gradual deterioration of cognitive function perceived by a person or a third party without evidence of objective cognitive deficits. These individuals perform cognitive tests within the normal range. This stage is called "subjective cognitive decline" (SCD), and it lasts 5 to 10 years (Jessen, 2014; Jessen et al., 2014; Jessen et al., 2023). Stage 3 is characterised by

slight cognitive deficits documented by cognitive tests and introduces the phase of “mild cognitive impairment” (MCI). It lasts many years, and despite cognitive impairment, patients retain their functional abilities in daily life activities (Rostamzadeh & Jessen, 2020). Stages four, five, and six correspond to mild, moderate, and severe dementia characterised by progressive cognitive and functional impairment up to severe motoric deficits, including immobility and swallow disability with entire dependency on a caregiver. Dementia lasts a few years and leads to death (Jessen, 2019a; Jessen, 2019b).

Besides CSF, further biomarkers are used for the early detection of AD and the identification of the AD stage. Magnetic resonance imaging (MRI) depicts brain volume and atrophy. Among others, the medial temporal lobe, including the hippocampus and the entorhinal cortex, are typically affected brain areas. Positron emission tomography (PET) is used to detect amyloid plaques. Furthermore, the fluorodeoxyglucose-PET (FDG-PET) shows the metabolic activity of the brain, which in the case of AD is reduced, especially in the temporal and parietal lobes (Jessen, 2019a).

Based on such biomarkers, Yildirim and colleagues (2023) found that asymptomatic patients in stage 1 of AD had greater hippocampal volume than healthy controls. Moreover, amyloid-positive SCD patients had smaller hippocampal volume than amyloid-negative SCD participants. They interpreted their findings as a sign of a brain reserve that compensates for the beginning pathology in patients in stage one and is responsible for the missing cognitive complaints and the asymptomatic character of this stage. This study showed that AD brain atrophy is not linear and provides evidence for an in vivo differentiation between preclinical stages one and two of AD (Yildirim et al., 2023). Furthermore, Jessen and colleagues (2023) found that amyloid-positive SCD patients showed slightly worse cognitive and functional abilities and more substantial hippocampal atrophy than amyloid-positive controls (Jessen et al., 2023).

Though SCD patients perform within the normal cognitive range, they had in a recent study a higher frequency of APOEε4 genotype and a trend towards higher Aβ42 but showed no difference in tau protein compared to controls (Jessen et al., 2018). Further studies found that SCD patients demonstrate biomarker profiles and brain neuroimaging patterns similar to those of MCI and AD (Meiberth et al., 2015¸ Wang et al., 2020), while 27% of them develop in the course of the four following years MCI and 14% progress to dementia (Wang et al., 2020). SCD is, therefore, considered a preclinical indicator and risk factor of MCI and AD, especially in the presence of amyloid plaques and APOEε4 (Jessen, 2019a; Jessen et al., 2020; Koppara et al., 2015; Slot et al., 2019). Similarly, MCI is considered a risk factor for the development of dementia and, therefore, a prodromal stage of it. Patients with MCI can either regress to normal cognition or progress to dementia depending on a variety of factors, including age, gender, and CSF profile. Missing amyloidosis, tauopathy, and neurodegeneration are associated with

a good prognosis. On the contrary, AD's typical CSF profile is associated with a more than 90% risk of AD progression in the next five years (Jessen, 2019a; Rostamzadeh et al., 2020). There is also evidence of hippocampal atrophy and loss of the practice effect through repeated cognitive testing in MCI patients compared to SCD and controls (Amaefule et al., 2021; Teipel, et al., 2023). MCI is, therefore, considered a prodromal but not a preclinical stage of AD since it encompasses manifested clinical and cognitive symptoms that are not present in preclinical phases like the asymptomatic (stage 1) and the SCD phase (stage 2).

Pathological AD changes occur up to 30 years before symptom onset (Escher et al., 2019; Jessen, 2019a). Among others, chronic stress, neurotic traits of personality, and anxiety are associated with AD development (Escher et al., 2019). Further factors that relate to cognitive impairment are multimorbidity, frailty, and functional disability (Pereira-Rodrigues et al., 2022). These concepts describe interconnected and partially overlapping conditions with an unfavourable influence on general health and an association with increased risk of adverse events, such as hospitalisation, admission to LTCF, falls, and mortality (Jedrzejczyk et al., 2022; Pivetta et al., 2020; Villacampa-Fernandez et al., 2017). Multimorbidity is defined as the co-existence of two or more chronic diseases in the same person and is common among older adults, women, and people with low socioeconomic background (Calderon-Larranaga et al., 2019; Marengoni et al., 2011; Pivetta et al., 2020). About 75% of people over 70 are multimorbid, and prevalence is expected to double by 2035 (Calderon-Larranaga et al., 2019). These patients tend to be more often hospitalised than non-multimorbid older adults and account for 50% to 99% of older inpatients in the global North (Anpalahan & Gibson, 2008; Aubert et al., 2019; Clerencia-Sierra et al., 2015; Gudnadottir et al., 2022; Marengoni et al., 2011; McPhail, 2016; Pereira et al., 2021; Pereira-Rodrigues et al., 2022). Pathophysiology of multimorbidity includes a systemic inflammation that promotes vulnerability and results in frailty (Pivetta et al., 2020). Frailty is characterised by changes in multiple body systems and is associated with biological, psychological, sociodemographic, and lifestyle factors (Jedrzejczyk et al., 2022; Pivetta et al., 2020). Frailty embraces numerous geriatric syndromes, like immobility, sensory or cognitive impairment, and reduced everyday skills. It increases the susceptibility of older adults to adverse health events and functional disability (Jedrzejczyk et al., 2022; Pivetta et al., 2020). The latter refers to losing skills essential for independent living, including daily activities and complex social and cognitive behaviours (Pivetta et al., 2020).

Cognitive impairment, multimorbidity, frailty, functional deficits as well as hospitalisation itself reduce patients' quality of life, increase the risk of adverse events and render patient treatment and management more challenging (Peterson & Braunschweig, 2016; Pivetta et al., 2020; Veronese et al., 2019; Villacampa-Fernandez et al., 2017). Given the estimated increase in future prevalence and the demographic transit, public and private expenditures on health services are expected to expand (Pivetta et al, 2020; Villacampa-Fernandez et al., 2017). Early

identification of geriatric inpatients with undiagnosed cognitive deficits who will develop frailty and functional deficits during the hospital stay is, therefore, vital for the timely implementation of preventive strategies.

2.2. Cognitive impairment in hospitalised patients

The prevalence of dementia and delirium in hospitalised older patients ranges from 9% to 63% and 10% to 31%, respectively (Mukadam & Sampson, 2011; Reynish et al., 2017). Dementia accounts for 40% of unplanned hospital admissions of older people (Reynish et al., 2017; Sampson et al., 2009). Delirium refers to an acute cognitive deficit accompanied by consciousness disorder (Neufeld & Thomas, 2013) and is responsible for 20% of emergency hospital admissions in older patients (Reynish et al., 2017). Hence, rates of undiagnosed all-cause cognitive impairment in older non-neuropsychiatric inpatients range from 21% to 40% (Buurman et al., 2012; Jackson et al., 2016; Pedone et al., 2005; Reynish et al., 2017) and even reach 60.5% in vascular patients with aortic or lower limb arterial interventions (Partridge et al., 2014). Burton and colleagues (2012) found that 54% of 110 patients receiving hospice care (half of them inpatient) had an undetected cognitive impairment (Burton et al., 2012). Patients with undiagnosed cognitive deficits tend to be multimorbid (von Renteln-Kruse et al., 2015). Cognitive impairment is associated either directly or through intermediate factors, like sarcopenia, with adverse outcomes both during and after hospitalisation, such as falls, prolonged hospital stay, higher hospital and post-discharge mortality, hospital readmission or admission to LTCF (s. in Fogg et al., 2018; Fogg et al., 2017; Reynish et al., 2017; Sampson et al., 2009). It is, therefore, vital to identify hospitalised patients with undiagnosed cognitive impairment early to be aware of their multiple vulnerabilities to adverse health events and ensure qualified supervision.

2.3. Cognition and adverse outcomes at hospital discharge

Impaired cognition is associated with adverse events during hospitalisation and at discharge. These include dehydration, infections, pressure ulcers, falls, and prolonged hospital stays. The association of cognition with these endpoints is either independent or mediated, among others, by sarcopenia, restricted mobility, and reduced functional ability (s. in Fogg et al., 2018). This study focused on the latter.

2.3.1. *Cognition and functional status*

Functional skills refer to the ability to execute personal or instrumental self-care activities of daily living (pADL or IADL), such as bathing, dressing, housekeeping, and cooking respectively (De Vos et al., 2012; Gill et al., 2004; Hebert et al., 1999; Hoogerduijn et al., 2010). Community-dwelling older adults demonstrate functional and motor disability between 44% and 68%, depending on how frail they are (Avila-Funes et al., 2008; Suijker et al., 2014). Functional

deterioration in this group is associated with increased mortality, hospital, and LTCF admission. Risk factors include age, female sex, low level of education, living alone/ social isolation, cognitive impairment, and hospitalisation (Agüero-Torres et al., 2002; Hoyer et al., 2013; Lewis et al., 2021; Stuck et al., 1999). To the latter, research has shown that about a third of inpatients older than 70 years of age experience functional decline during hospital stay, while this number reaches 50% for 85-year-old inpatients or older and 65% for those aged ≥ 90 (s. in De Vos et al., 2012; s. in Lafreniere et al., 2017). Among inpatients with a functional decline during hospitalisation, 40% show loss of independence in more than three ADL domains, while in 50% of them, the persistence of up to three months post-discharge has been documented (s. in Lafreniere et al., 2017; Zisberg et al., 2015). Factors contributing to functional deficits during hospital stay include age, operational status before admission, and length of hospital stay (Bakker et al., 2010; Boyd et al., 2008; Hoogerduijn et al., 2007). Other authors reported that it is not the length of hospital stay but rather the number of days of bed rest that plays a role in functional decline during hospitalisation (Calero-Garcia et al., 2017). Immobilisation in older inpatients has been identified as a risk factor for partial loss of the ability to perform ADL during hospitalisation (Gill et al., 2004; Lafrenière et al., 2017; Zisberg et al., 2015).

Furthermore, cognition has been found to predict functional status in community-dwelling older adults (s. in Van Grootven & Van Achterberg, 2022). Hartley and colleagues showed in their review article that cognitive deficit in older hospitalised patients is also associated with functional decline. Hence, the direction of causality could not be inferred (s. in Hartley et al., 2017). Older hospitalised patients with cognitive impairment are more likely to develop functional deficits during hospital stay compared to inpatients without cognitive deficits (s. in Hartley et al., 2017; s. in Lafont et al., 2011; s. in Lafreniere et al., 2017; Pedone et al., 2005). Screening tests of global cognition, most often the Mini-Mental State Examination (MMSE) or the MoCA, have been implemented to investigate this relationship. Research has been conducted predominantly in neurological in- or outpatients with stroke or dementia, as well as in rehabilitation patients and showed an association of both tests with the Barthel Index (BI), the ADL, the Lawton Instrumental Activities of Daily Life – IADL scale or the Functional Independence Measure – FIM (Brown et al., 2014; Colombo et al., 2004; Lee et al., 2019; Millan-Calenti et al., 2012; Sanchez-Silverio et al., 2022). Honda and colleagues (2021) found that MMSE predicts functional decline at discharge, assessed with the FIM in older Japanese patients after cardiovascular surgery (Honda et al., 2021). MoCA is an independent predictor of functional status at discharge in stroke patients (Saberi et al., 2020; Sanchez-Silverio et al., 2022; Toglia et al, 2011), with higher MoCA scores upon admission being associated with better functional outcomes (Durant et al., 2016; Lim et al., 2018; Millan-Calenti et al., 2012). Pedone and colleagues (2005) reported that cognitive impairment, assessed with the

Hodkinson Abbreviated Mental Test (HAMT) upon admission in older Italian inpatients, predicts functional decline (ADL) independent of age, sex, comorbidities, disability status upon hospital admission, and polypharmacy. A following Norwegian study reported that functional deficits evaluated with Brody's physical self-maintenance scale (PSMS) and Lawton's IADL one year after hospital discharge were associated with cognitive impairment assessed with the MMSE upon hospital admission and that worsening of cognition within this time was accompanied by a respective decline in functional skills (Helvik et al., 2013).

The executive components of MoCA have shown the strongest association with functional status (Lim et al., 2018; Sanchez-Silverio et al., 2022; Toglia et al., 2011). Executive functions include higher-order cognitive abilities like planning, organising, executing complex activities in multiple steps and cognitive flexibility, such as inhibition and set-shifting (Arbuthnott et al., 2000). Executive functions are, therefore, located in interconnected brain areas (Oosterman et al., 2010; Terada et al., 2013), including the prefrontal cortex, the visual cortex, and the cerebellum (Bowie et al., 2006; Moll et al., 2002; Zakzanis et al., 2005). In particular, activated brain areas during TMT-B vs TMT-A are the left dorsolateral and medial prefrontal cortex (PFC), the left middle and superior temporal gyrus as well as the angular gyrus, the left supplementary motor cortex, the intraparietal sulcus and the right inferior medial frontal cortex (Jacobson et al., 2011; Moll et al., 2002; Zakzanis et al., 2005).

TMT-B and Wisconsin Card Sorting test (WCST) have been used to evaluate executive functions and were found to predict functional status regardless of age, sex, and education in community-dwelling older adults and nursery home residents (Bell-McGinty et al., 2002). Further studies confirmed the role of executive functions in functional independence, reporting that patients with executive deficits were more often dependent on ADL and IADL than those without and that executive function was a stronger predictor than global cognition (Ghaffari et al., 2021; Johnson et al., 2007; Mansbach & Mace, 2019; Marshall et al., 2011; Verreckt et al., 2022). Further studies have confirmed the role of executive functions in functional abilities (Huijben-Schoenmakers et al., 2016) using tests of inhibition like the STROOP (Aretouli & Brandt, 2010).

Contrary to all the above studies, other authors have not confirmed the predictive value of cognition on functional status. Yu and colleagues reported that MoCA and MMSE did not predict operational performance as measured by FIM in geriatric Australian inpatients (Yu et al., 2018). Further studies found in rehabilitation stroke patients that those with cognitive deficits showed more substantial functional deficits at discharge compared to patients with intact cognition, but the latter was not associated with more significant operational gain through the rehabilitation process (Paker et al., 2010; Yu & 2005).

2.3.2. *Cognition and risk of frailty/ poor prognosis*

Although there is no universally accepted definition of frailty, there is scientific consensus that frailty describes a geriatric clinical condition characterised by the increased vulnerability of a person towards internal and external stressors due to diminished homeostatic reserves (s. in Dent et al., 2016; s. in Proietti & Cesari in Veronese, 2018, pp. 1-2). Frailty is linked to advanced age and, therefore, in part, biologically influenced. It mirrors a decline in numerous physiological systems resulting in cumulative cellular damage and proneness to adverse health events, such as cognitive impairment and dementia, falls, hospitalisation, or mortality (Rockwood, 2005; Rockwood & Mitnitski, 2007; Theou et al., 2018; Searl & Rockwood, 2015; Ward et al., 2022). In this respect, frailty is a dynamic accumulation of deficits without necessarily meaning the presence of illness or disease (s. in Dent et al., 2016; Rockwood, 2005; Rockwood et al., 1994; Rockwood et al., 2007). Although frailty is different from sarcopenia, multimorbidity, and disability, a frail person can be sarcopenic, multimorbid, and/ or disabled (s. in Dent et al., 2016; s. in Proietti et al. in Veronese, 2018, pp. 1-2). Besides physiological changes in medical health and mobility, frailty encompasses psychological, social, and lifestyle components, so cognitive, emotional, and nutritional elements and a person's living conditions are relevant. Many instruments have been developed to assess the above aspects of frailty. Some examples are Fried's Frailty Phenotype (2001), Mitnitski's Frailty Index (2001), Rockwood's Clinical Frailty Scale (2005), and Pilotto's Multidimensional Prognostic Index – MPI (2008).

The MPI has been developed as a measure to predict all-cause 1-year mortality in older hospitalised patients. It is calculated based on information from the Comprehensive Geriatric Assessment (CGA) on clinical, cognitive, functional, and nutritional aspects of a patient's health condition and co-/ multimorbidity, medication, and social support (Pilotto et al., 2008). It reflects a patient's risk of frailty/ poor prognosis. Three grades of this risk are identified in MPI, i.e., low (0.0 – 0.33), moderate (0.34 – 0.66), and high (0.67 – 1.0). Higher scores are associated with older age, female gender, lower education, and higher mortality one, six- and 12 months post-discharge (Angleman et al., 2015; Pilotto et al., 2008; Pilotto et al., 2019; Volpato et al., 2015). MPI has also been found to correlate with the length of hospital stay (Angelman et al., 2015; Brunet et al., 2019; Pilotto et al., 2016), rehospitalisation (Brunet et al., 2019; Pilotto et al., 2019), post-discharge admission to an LTCF (Pilotto et al., 2019) as well as recurrent falls (Veronese et al., 2020). In hospitalised older patients with dementia, MPI accurately discriminates among those with a low, moderate, and high risk of one-, six- and 12-months post-discharge risk of mortality (Pilotto et al., 2009). MPI predicts mortality in outpatients with cognitive impairment as well (Gallucci et al., 2014). Overbeek and colleagues (2022) found that older outpatients with dementia demonstrate a significantly higher MPI score than those with MCI, although MPI predicts mortality in both patient groups (Overbeek et al.,

2022). In older outpatients without cognitive impairment, MPI has been associated with the number of geriatric syndromes and resources as well as the grade of care (Meyer et al., 2019).

2.4. Cognition and adverse post-discharge outcomes

2.4.1. *Cognition and mortality*

Research shows that hospitalisation per se is for older patients a turning point for cognition (Chinnappa-Quinn et al., 2020) and that cognitive decline is associated with increased in-hospital (Fogg et al., 2019; Kim et al., 2013) or post-discharge mortality (Agrawal et al., 2019). Agraval and colleagues (2019) examined the relationship between cognition and functional skills with post-discharge mortality. They found that MMSE, Clock Drawing Test (CDT), Barthel-Index, and the ADL and IADL subtests of CGA correlated with and predicted four-year mortality in geriatric patients. Wu and colleagues (2014) found in a large longitudinal study with community-dwelling older adults that mild and severe cognitive deficits measured by SPMSQ are associated with mortality three years later (Wu et al., 2014). Further, it has been reported that the combination of Mini-Cog with Hand-grip-strength (HGS) (Joyce et al., 2018; Patel et al., 2015) or the MMSE with the CDT (Yao et al., 2020) predicted six-month-post-discharge mortality in heart patients, while Huynh and colleagues (2016) found that MoCA predicts 30-day mortality and readmission in heart patients (Huynh et al., 2016). Other authors found no association between global cognition measured with Mini-Cog and one-year mortality (Shami et al., 2019). Similarly, further research detected no significant difference in inhospital or post-discharge mortality in surgical older (≥65 age years) patients with (MoCA < 26) or without (MoCA ≥ 26) cognitive impairment (Hanna et al., 2020).

2.4.2. *Cognition and hospital readmission*

Cognition is associated with hospital readmission, too (Cornette et al., 2005). Cardiovascular patients with cognitive deficits show a higher risk of readmission (Huynh et al., 2016; Ishihara et al., 2022; Yao et al., 2020). Patel and colleagues (2015) found that performance in Mini-Cog predicts six-month readmission and mortality in heart patients; Kim (2020) reported an association of MoCA with readmission as well, whereas Wang-Hansen and colleagues (2022) showed that a higher score in MMSE is a predictor of 30-day readmission to hospital in multimorbid patients 75 years of age or older (Kim, 2020; Patel et al., 2015; Wang-Hansen et al., 2022). SPMSQ has also been found to predict a composite endpoint of adverse outcomes, including rehospitalisation, admission to LTCF, and mortality three, six, and 12 months post-discharge in older patients of an emergency hospital department (Schönstein et al., 2019). Risk factors for readmission are, among others, multimorbidity, number of prior hospitalisations, and length of hospital stay (Kansagara et al., 2011; Lo et al., 2021; Zhou et al., 2016), whereas data upon admission predict future rehospitalisation (Logue et al., 2016). Logue and colleagues (2016) showed that comorbidity and polypharmacy (≥5 medications)

are associated with the risk of readmission. They found, however, no significant influence of cognition evaluated through subjective assessment by nurses (Logue et al., 2016).

2.4.3. *Cognition and admission to Long Term Care Facility (LTCF)*

The term “admission to LTCF” refers to admission in a care home, often intended for a prolonged stay, where residents are not expected to return to independent community living (Harrison et al., 2017). The most frequent reasons for admission to a nursing home are family requests, cognitive and functional decline, motor instability, and risk of falls, and it takes place either from home or directly from the hospital after discharge (Luppa et al., 2010; Luppa et al., 2012). People admitted to care homes are female individuals older than 80 years who live alone and show cognitive impairment (Harrison et al., 2017). Predictors of post-discharge admission to LTCF include higher age, low self-reported health status, cognitive and functional deficits as well as polypharmacy (Luppa et al., 2010). Therefore, the typical post-discharge patient admitted to an LTCF is an older, single, or widowed female with a lower MMSE score and impaired mobility (Harrison et al., 2017; Luppa et al., 2010; Luppa et al., 2012). MMSE predicts admission to LTCF in patients with dementia (Luppa et al., 2012), while CGA is a post-discharge predictor for surgery patients (Kim et al., 2013). In stroke patients, age and cognitive decline predict three-year admission to LTCF (Pasquini et al., 2007). However, Geubbels and colleagues (2015) failed to identify any predictive value of MoCA regarding post-discharge destination in the same patient collective (Geubbels et al., 2015). Similarly, other authors suggested age, socio-familiar variables (i.e., living alone), and functional ability assessed with Barthel-Index as independent risk factors for post-discharge admission to LTCF but found no association with cognition (Baztán et al., 2004).

2.4.4. *Cognition and falls*

Falls belong to the most relevant adverse post-discharge outcomes and constitute one of the leading causes of chronic disability in older adults, resulting not rarely in fractures (Tinetti, 2003; Yeung et al., 2019). Falls are most often related to muscle atrophy and sarcopenia, poor balance and coordination (Reijnierse et al., 2019; Tinetti, 2003), polypharmacy (Taylor et al., 2014; Tinetti, 2003) as well as cognitive impairment (Hauer et al., 2020; Taylor et al., 2014; Zhang et al., 2019). Regarding the latter, research has shown that falls are particularly associated with immediate memory (Van Schoor et al., 2002), verbal fluency, visuospatial and constructional abilities (Hauer et al., 2020; Taylor et al., 2014) as well as executive function (Taylor et al., 2014; Zhang et al., 2019).

2.5. Research questions and aim of the study

From the above, it becomes clear that early identification of older multimorbid hospitalised patients with undiagnosed cognitive deficits is vital to control in advance risk factors that facilitate adverse events during (e.g., functional disability, frailty/ poor prognosis) and after

hospitalisation and to implement geriatric treatment schemata or preventive strategies adapted to patients' needs that improve useful ability in daily life activities.

To the relationship between cognition and functional abilities literature has shown that cognitive impairment is associated with functional deficits (Helvik et al., 2013; Van Grootven & Van Achterberg, 2022). However, studies have chiefly concentrated either on community-dwelling older adults (Lee et al., 2019; Millan-Calenti et al., 2012; Agüero-Torres et al., 2002; Dodge et al, 2005; McGuire et al., 2006) or hospitalised neurological patients with stroke or dementia (Brown et al., 2014; Sanchez-Silverio et al., 2022) without always considering multimorbidity. What is more, cognitive and functional status have been evaluated using many different instruments, mostly MMSE for cognition and ADL/IADL for operational ability. However, MoCA has higher internal reliability and a stronger association with functional status than MMSE and is free of ceiling effect (Toglia et al., 2011). Hence, it seems to be a better tool for assessing global cognition. There is, to the author's knowledge, no recent study that investigated a potential protective effect of intact cognition (i.e., absence of cognitive deficit) on functional status in geriatric multimorbid German inpatients with no vs. mild vs. severe cognitive deficit using the MoCA and the TMT-A and -B to assess cognition upon admission and the BI to evaluate functional status at discharge.

Regarding MPI, it has been found to predict post-discharge mortality in hospitalised patients with dementia and older outpatients with or without MCI (Overbeek et al., 2022; Pilotto et al., 2009). To the author's knowledge, it has not been investigated whether retained cognitive ability upon hospital admission is associated with better MPI at discharge in older multimorbid German inpatients compared to those with cognitive deficits.

The influence of cognition on adverse post-discharge outcomes is controversial. Research has repeatedly delivered evidence showing that impaired cognition is associated with increased post-discharge mortality, hospital readmission, admission to an LTCF, and falls (Agrawal et al., 2019; Kim, 2020; Luppa et al., 2012; Patel et al., 2015; Wang-Hansen et al., 2022; Zhang et al., 2019). However, other authors have not confirmed these findings (Baztán et al., 2004; Logue et al., 2016; Shami et al., 2019). It is, therefore, unclear whether and to what extent cognition upon admission influences these outcomes one- and three months post-discharge. To the author's knowledge, no recent study has investigated the relationship between global cognition measured with MoCA and executive function measured with TMT-A & -B upon admission with these adverse outcomes one and three months after discharge in older multimorbid German inpatients.

Therefore, this study's purpose was to investigate the above questions. Specifically, outcomes included the relationship of cognition (MoCA, TMT-A and -B) upon hospital admission with functional status (BI) and risk of frailty/ poor prognosis (MPI) at discharge, as well as mortality, hospital readmission, admission to LTCF and falls one- and three-months post-discharge.

Questions were: Does intact cognition (i.e., absence of cognitive deficit) upon hospital admission (baseline) measured with MoCA, TMT-A, and -B in older multimorbid inpatients positively influence and/ or predict:

i. Functional ability at discharge assessed with Barthel-Index?

ii. Risk of frailty/ poor prognosis at discharge measured by MPI?

iii. Mortality, hospital readmission, admission to LTCF, and falls one- and three-months post-discharge documented via a telephone interview?

The hypothesis was that patients with intact cognitive function upon admission would show fewer functional deficits and lower risk of frailty/ poor prognosis at discharge than those with cognitive deficit and that baseline global cognition and executive function would predict these outcomes. It was also expected that patients with normal cognition upon admission would show a decreased mortality rate, hospital readmissions, admission to LTCF, and falls one- and three months post-discharge. That baseline cognition would predict these outcomes.

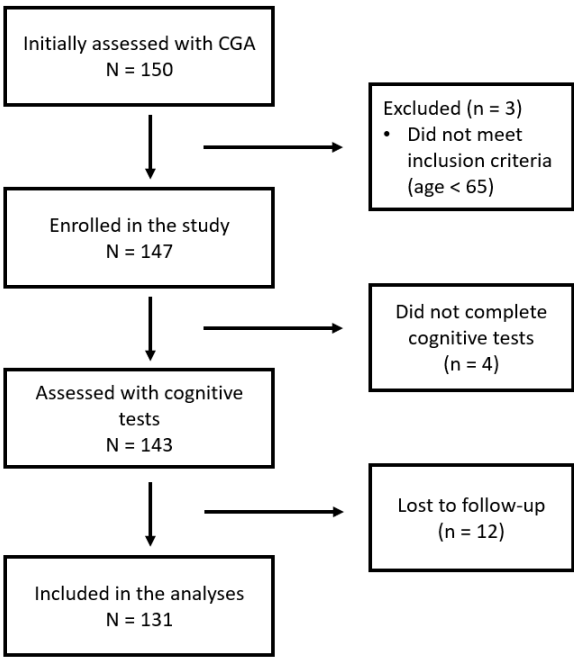
3. Methods

The study followed the Declaration of Helsinki 1964 principles and its later amendments. It was approved by the ethics committee of the University Hospital of Cologne (EK 18-394 from 18.11.2020) and was registered in the German Register of Clinical Studies (DRKS00022873). All participants gave their informed consent for the enrolment.

3.1. Participants

The study occurred at the Ageing Medicine Ward (Universitäre Altersmedizin) of the Department II of Internal Medicine University Hospital of Cologne in Germany. Patients admitted to this ward are typically treated for an acute illness accompanied by a variety of chronic diseases, most often cardiological, nephrological, or infections. They are frail with multiple geriatric syndromes, and resources. Inclusion criteria were age of 65 years or older, multimorbidity (≥ two chronic diseases that require long-term treatment), admission to the geriatric ward for at least four days, no to increased nursing needs (reflecting a degree of care < 4 according to the German nursing insurance with grades ranging from 0 to 5 and 0 denoting no dependency), knowledge of the German language and informed consent by the patient or by a proxy. Patients were excluded if they did not meet the inclusion criteria. Further exclusion criteria were refusal to participate or to complete the cognitive tests, as well as patients being unable to be contacted at both one- and three-month follow-ups to collect information about mortality, rehospitalisation, admission to LTCF, and falls. From 150 patients enrolled within 12 months beginning in June 2020, N = 131 was analysed for this study (Figure 1).

Figure 1. *Flow chart on patient recruitment from initial assessment to data analysis.*



Of the initially 150 assessed patients, 131 were included in the analyses after excluding those, who did not meet the inclusion criteria, did not complete the cognitive tests or were lost to follow-up.

3.2. Instruments

A series of clinical diagnostic tools were implemented to assess the geriatric and cognitive status and the motor and functional abilities of the patients. The Comprehensive Geriatric Assessment (CGA) was employed for the geriatric evaluation. Global cognition was measured using the Montreal Cognitive Assessment (MoCA), whereas visuospatial scanning and executive function were evaluated with the Trail Making Test (TMT) parts A and B, respectively. Functional status at discharge was assessed with Barthel-Index (BI), while the risk of frailty/ poor prognosis upon admission and at discharge were estimated with the CGA-based MPI.

3.2.1. *Geriatric assessment and MPI*

The CGA was first described by Rubenstein and colleagues (1985) as a multidimensional diagnostic tool that collects information about medical, functional, nutritional, cognitive, and psychosocial aspects of older patients' health conditions (Rubenstein & Kane, 1985). It has been used since its development by healthcare professionals to evaluate the geriatric status of frail older adults for medical, psychosocial, and rehabilitative purposes (Ellis et al., 2011; Ellis et al., 2017; Parker et al, 2018; Rubenstein et al., 1985; Rubenstein et al., 1989). Based on the information collected from six subscales of the CGA, Pilotto and colleagues (2008) developed the Multidimensional Prognostic Index (MPI) to estimate frailty and prognosis in older patients (Pilotto et al., 2008). The calculation of MPI considers daily life functionality at personal (Activities of Daily Living – ADL, Katz et al., 1963) and instrumental level (Instrumental Activities of Daily Living – IADL, Lawton & Brody, 1969), cognition (The Short Portable Mental Status Questionnaire – SPMSQ, Pfeifer, 1975), nutritional status (Mini Nutritional Assessment-Short Form – MNA-SF, Rubenstein et al., 2001), pressure ulcer risk (Exton Smith Pressure Ulcer Risk Scale – ESS, Bliss et al., 1966), multimorbidity (Cumulative Disease Rating Scale – CIRS, Linn et al., 1968; Salvi et al., 2008), living conditions and number of medication (Pilotto et al., 2019; Sancarlo et al., 2011). MPI scores take values between 0 and 1 and can be divided into three groups corresponding to a low (MPI-1 = 0.00 – 0.33), medium (MPI-2 = 0.34 – 0.66), or high (MPI-3 = 0.67 – 1.00) risk of frailty/ poor prognosis (Pilotto et al., 2008). Research has shown that MPI is associated with and/ or predicts several post-discharge trajectories, including mortality, rehospitalisation, and admission to LTCF (Pilotto et al., 2019), and it allows monitoring of patients' outcomes during and after hospitalisation (Pickert et al., 2020; Veronese et al., 2019; Volpato et al., 2016).

Further tests included in the CGA are the Goodglass and Kaplan Communication Scale (Goodglass & Kaplan, 1983), Rosenberg's self-esteem Scale (von Collani & Herzberg, 2003), the quality-of-life questionnaire EQ-5D-5L, the Visual Analogue Scale (VAS) for the subjective rating of one's current health status from Ludwig and colleagues' German value set (Ludwig et al., 2018), and the SARC-F sarcopenia subscale (Malmstrom et al., 2016). In addition, CGA includes subtests assessing geriatric syndromes (polypharmacy, instability, incontinence,

inanition, immobility, irritability/ depression, cognitive impairment, insomnia, poverty, swallowing disorders, chronic pain, sensory impairment, irritable colon, iatrogenic disease, social isolation, fluid/electrolyte disorders, incoherence/delirium) and geriatric resources (physical, social, financial, competence-related, intellectual, spiritual, motivational, emotional, mnestic, good living conditions) (Meyer et al., 2020). All participants were assessed with the above tests.

3.2.2. *Cognitive assessment*

Global cognition was measured using the MoCA. TMT Parts A and B were used to evaluate visuospatial and executive functions.

3.2.2.1. *Montreal Cognitive Assessment (MoCA)*

MoCA was developed by Nasreddine and colleagues (2005) as a paper-and-pencil diagnostic tool of global cognition in clinical settings with good to outstanding reliability and validity (Davis et al., 2015; Freitas et al., 2012; Nasreddine et al., 2005). It measures within 10 minutes global cognition as well as individual cognitive functions. It includes an adapted task from the TMT-B, in which alternation among numbers and letters evaluates executive function. Visuospatial abilities are assessed through a 3-dimensional cube drawing task and the clock drawing test. Short- and long-term memory are assessed through immediate and delayed recall of a list of five words. Language is evaluated with phonemic verbal fluency (name words that begin with the letter “F,” which also assesses executive function), naming, and a repetition task of two syntactically complex sentences. Working memory and attention are measured using a forward and backward digit span task, a serial subtraction task, and a sustained attention task (i.e., tap with one’s finger at each letter “A,” which also assesses inhibition, part of the executive function). Nevertheless, abstract thinking is tested with a word-similarities task. An examination of time and place orientation is also included. Each item takes one point for a correct answer and zero points for a mistake, so tasks take between one and six points depending on how many items they include. Maximal score is 30 points (Nasreddine et al., 2005). Performance is affected by age, education, and premorbid intelligence (Bruijnen et al., 2020). A cut-off score of < 26 for the diagnosis of MCI shows a sensitivity level of 90% and a specificity level of 87% (Nasreddine et al., 2005). As a lower cut-off between MCI and dementia has been proposed, a score of 17 with a sensitivity of 92.3% for MCI and 100% for dementia. This cut-off can be adjusted at higher scores (i.e., 19 or 20) depending on the sensitivity required (Trzepacz et al., 2015). Positive and negative predictive values of MoCA are exceptional for MCI (89% and 91%, respectively) and dementia (89% and 100%, respectively) too (Nasreddine et al., 2005).

3.2.2.2. *Trail Making Test (TMT)*

The Trail Making Test is a paper-and-pencil instrument that was initially developed as “Partington’s Pathways” (Partington et al., 1949) and was part of the Army Individual Test

Battery in the United States of America as a measure of intelligence (War Department, Adjutant General's Office, 1944). Later, it was further developed by Reitan (Reitan 1955, 1958) and integrated into the Halstead-Reitan Battery (Reitan & Wolfson, 1985). Tombaugh (2004) published a comprehensive set of norms for TMT for the first time based on data collected on healthy Canadian community-dwelling adults considering age, gender, and level of education (Tombaugh, 2004). TMT comprises parts A and B. In part A (TMT-A), the examinee is asked to connect twenty-five encircled numbers scattered on the paper in numerical order. Part B (TMT-B) contains scattered encircled numbers and encircled letters. The examinee must link the circles by alternating them numerically and alphabetically (Bowie & Harvey, 2006; Tombaugh, 2004). Performance is determined primarily through time to completion. Errors must be corrected during the task, which results in prolonged time scores. A discontinuation rule sets a maximum time limit for test administration at 180 seconds for TMT-A and 300 seconds for TMT-B or three mistakes (Bowie et al., 2006; Heaton et al., 2004; Strauss et al., 2006). This "classical" scoring method may result in a "floor effect" with many undifferentiated values of 300 sec. in the TMT-B in older patients with cognitive deficits. To solve this problem, Heaton and colleagues (2004) developed their revised comprehensive norms for an expanded Halstead-Reitan Battery and prorated TMT-B raw scores (TMT-Bpr) of patients who did not complete the test in 300 sec. using a formula, in which time (300 sec) is divided by the number of circles connected, and the result is multiplied by 25 (number of circles in TMT-B) (Heaton et al, 2004). This formula, as well as the "classical" scoring method, takes only time into account as a performance criterion without considering accuracy. Correia and colleagues (2015) proposed a formula for the TMT-B to "lower the floor" and avoid the floor effect, in which they considered accuracy as an additional performance criterion (TMT-B efficiency – TMT-Be). It is based on time to complete (300 sec), number of correct sequentially connected circles, errors of commission, errors of omission, and unattempted items. This valid metric captures performance variability within the range of severe cognitive impairment and dementia (Correia et al., 2015).

Performance in the Trail Making Test is influenced by age and education, whereas the influence of sex is controversial (Llinàs-Reglà et al., 2017; Specka et al., 2022; Tombaugh, 2004). Both parts A and B measure visuospatial abilities, such as visual scanning, speed of information processing, and motor speed, whereas TMT-B assesses additionally executive function, including working memory, mental flexibility, set-switching, and inhibition (Fernandez & Marcopoulos, 2008; Lezak et al., 2004; Llinàs-Reglà et al., 2017; Sánchez-Cubillo et al., 2009). Derived scores have been developed to "remove" the influence of visuospatial scanning and graphomotor speed of the TMT-B performance and give a "pure" measure of executive function. These include the difference between TMT-(B-A) and the ratio TMT (B/A) (Corrigan & Hinkeldey, 1987; Heaton et al., 1985). The former is considered a measure of executive

control (Sánchez-Cubillo et al., 2009), but similarly to raw scores, it is affected by age and education (Lamberty et al., 1994). The ratio is considered a pure measure of executive function in terms of working memory, inhibition, and set-shifting (Arbuthnott & Frank, 2000; Llinàs-Reglà et al., 2017; Sánchez-Cubillo et al., 2009) and is hardly affected by other cognitive or demographic factors (Christidi et al., 2015).

3.2.3. *Assessment of functional status: The Barthel-Index*

The Barthel Index (BI) measures activities of daily life (ADL) and detects functional deficits in persons with impaired independent living ability. It was developed by Mahoney and Barthel (1965) to assess the necessity of nursing care and functional change in patients with neuromuscular and musculoskeletal disorders with difficulties using their limbs under rehabilitation (Mahoney & Barthel, 1965). It has since been validated for more patient groups, including stroke patients (Duffy et al., 2013; Quinn et al., 2011). The BI examines ten domains of ADL in a self-care category, including feeding, bathing, grooming, dressing, using the toilet, and continence, as well as in a mobility category, including walking, climbing stairs, and transferring from a bed to a chair and vice versa. Each domain is scored on a three-point scale with values of 0, 5, or 10 in the original version of the test denoting total dependency, partial independence, or complete independence, respectively, with a maximum of 100 corresponding to outright independence (Hartigan, 2007; Mahoney et al., 1965). In the adapted version of BI, values of 0, 1, and 2 cover the range from total dependency to independence, with the latter corresponding to a maximal score of 20. The adapted version has been shown to enhance the test's sensitivity (Collins et al., 1988). The BI can be administered in four ways: by self-report, observation, or through testing by a nurse or physiotherapist. BI has shown excellent reliability with an agreement among the four rating modalities of 0.93, internal consistency of Cronbach's $\alpha = 0.96$, a high test-retest reliability, and interrater reliability of 0.99 for stroke patients. However, in patients with cognitive impairment, scores are less dependable when obtained by interview than through testing (Hartigan, 2007). In the case of older people, reliability remains partially uncertain, while validity is being questioned due to ceiling effects (De Morton et al., 2008; Sainsbury et al., 2005).

3.3. Study design, procedure, and independent variables

This is a clinical longitudinal observational study. A geriatric assessment with the CGA, including the calculation of the MPI, as well as a cognitive (MoCA, TMT-A and -B) and a functional (BI) evaluation of participants took place upon hospital admission (Median = 3 days). An assessment of functional status (BI) in 126 of 131 participants and an estimation of the MPI in a sample subgroup (n = 96) occurred at discharge, too. Data about mortality, hospital readmission, admission to LTCF, and falls were collected one and three months after discharge through a telephone interview.

Cognitive measures were treated as independent variables (factors). A metric and a categorical (ordinal) variable were defined for every cognitive test. The categorical variable for MoCA had three subgroups, namely “no cognitive deficit” (nCD), “mild cognitive deficit” (mCD), and “severe cognitive deficit” (sCD). For TMT-A and -B, only two subgroups were built due to a small number of participants in the mCD and the nCD subgroups, respectively, so that both latter subgroups were fused, resulting in a “no or mild cognitive deficit” (nCD) and a “cognitive deficit” (CD) subgroup.

Thirty-two of 131 participants did not complete MoCA, yet they were assessed, like all other participants, with the MMSE. Although the MMSE was not considered in the analyses, missing MoCA values were replaced through available data in the MMSE according to published data on matching MMSE to MoCA scores and vice versa (Fasnacht et al., 2022). A subset of the sample (n = 92), additionally to MoCA, was also evaluated with TMT-A and -B. The discontinuation rule at 300 seconds for both parts was used for the administration. Patients who did not complete the test within the time limit got a score of 300 sec. However, a floor effect was documented with many undifferentiated values of 300 sec, especially for part B. To address this problem, two different formulas to convert these values into prorated (TMT-pr) or efficiency values (TMT-e) were considered.

Although TMT-e gives more precise values, the formula has not been, to the author’s knowledge, validated in Germany to date. On the contrary, TMT-pr is measured in seconds and is, therefore, compatible with the available German norms. Consequently, the latter index was used in the analyses. The original values of the metric variable (in sec) were divided by ten to succeed in better presentability of regression analysis results and facilitate interpretation. This handling is not expected to have influenced the significance of the results.

3.4. Study outcomes

The study outcomes were treated as dependent variables and divided into two categories: outcomes at discharge and post-discharge. The first category included the functional status of patients assessed by the Barthel-Index and the risk of frailty/ poor prognosis estimated with MPI. Both variables had a metric and a categorical (ordinal) version. Because only a few participants scored in the normal range in both tests, subgroups for the ordinary and middle scores fused so that categorical variables included only two subgroups: “independence to moderate dependency” (61 – 100) vs “severe to total dependency” (0 – 60) for the Barthel-Index, and “low to moderate risk of frailty/ poor prognosis” (0.0 – 0.50) vs “high risk of frailty/ poor prognosis” (0.51 – 1.00) for the MPI. The original values of the metric variable of MPI were multiplied by one hundred to succeed in better presentability and interpretability of the results of regression analyses. This manipulation is not expected to have influenced their statistical significance.

Post-discharge trajectories included mortality, hospital readmission, admission to LTCF, and falls and were evaluated one- and three months post-discharge through telephone interviews. These were binary nominal variables (“yes vs no”-variables).

3.5. Statistical analyses

The IBM SPSS 28 was used for the statistical analyses. Categorical variables are described in absolute numbers or relative frequencies. Shapiro-Wilk analysis was applied to test for the normal distribution of metric variables. For normally distributed variables, the mean (M) and standard deviation (SD) are reported; otherwise, the median (Mdn) and interquartile range (IQR). A metric and a categorical variable with two or three groups were created for each cognitive test, covering a range of cognitive performance from ordinary to impaired. Statistical analyses included either the metric or the categorical variable. To investigate potential differences among cognitive groups in functional status and risk of frailty/ poor prognosis, Kruskal-Wallis (MoCA) or Mann-Whitney-U (TMT-A and -B) tests were applied depending on the number of groups of the cognitive variable. Hereby, BI and MPI were analysed as metric variables. The Chi-squared or Fisher’s exact test was used to search for any effect of cognition on post-discharge outcomes (nominal binary variables). Only variables that showed significance in the univariate comparison tests (Kruskal-Wallis, Mann-Whitney, Chi-square) were considered for further multivariable analyses to examine whether cognition predicts the outcomes of interest at discharge and post-discharge adjusted for potential co-factors. Multivariable regression models with backward selection were performed and adjusted for demographic co-factors, including gender, age, education, and MPI upon admission. The latter considers functional ability (ADL/IADL), nutritional status, pressure ulcers, multimorbidity (CIRS), medication and living conditions/cohabitation. In the case of metric outcomes, linear regression was chosen, while binary outcomes were analysed using binary logistic regression. The cut-off level of significance for all statistical analyses was set at $\alpha = 0.05$ two-tailed.

4. Results

4.1. Participants‘ characteristics

Several N = 131 patients were included in the analyses after excluding three patients for not meeting the inclusion criteria, four patients who did not complete the cognitive tests, and 12 patients who were lost to follow-up (Figure 1). Participants’ ages ranged from 65 to 96 years (M = 79.74, SD ±6.74), with 51.9% of the patients being between 75 and 84 years. Men comprised 54.2% of the sample. The median number of years of education was 12 (Mdn = 12.0, IQR = 3.25), with 51.2% of participants having completed a schooling period ranging from 10 to 14 years. All participants lived at home either with their family (51.9%), alone (43.4%), or under supporting care (4.7%). More than forty percent (41.5%) of participants had no level of care, while almost one-half had an intermediate level of care of two or three (26.0% and 22.8%, respectively). Polypharmacy (drugs ≥5) was the case in 91.6% of patients whose medication consisted of more than ten drugs on average (M = 10.36, SD ±4.45) (Table 1a). Of 131 participants, n = 121 (92.4%), as measured with MoCA, showed a global cognitive deficit upon admission. Of those, n = 48 (39.7%) had a previously undiagnosed mild cognitive deficit. Nevertheless, n = 73 (60.3%) showed a severe cognitive deficit, which in n = 67 cases (91.8%) was previously unknown, in one case was known as MCI and in n = 5 cases known as dementia. Cognitive data at discharge is available only for CGA-based SPMSQ. This test showed rates of cognitive deficit of 12.2% upon admission and a comparable rate of 11.1% at discharge. Specifically, a fourth of patients with cognitive deficits as measured with SPMSQ upon admission experienced deterioration at discharge, whereas only 6.25% of their counterparts without cognitive deficits showed some degree of decline. Accordingly, a quarter of patients with intact cognition upon admission improved at discharge, whereas only 12.5% of patients with cognitive deficits showed improved SPMSQ scores. Of all patients who experienced cognitive improvement at discharge, 94.11% were those with intact cognition upon admission, with a relation of 16:1 to those with cognitive deficits. This relation was drastically reduced to 2:1 regarding the rate of deterioration, with patients without cognitive deficit upon admission being still arithmetically more.

Variables with more than 10 percent of missing values were “education” (12,9%) and “three-months-LTCF-admission” (12.2%), whereas “one-month-LTCF-admission” and “three-moths-falls” had both 9.2%. “One-month-falls,” “one-” and “three-months-readmission” as well as “Barthel at discharge” had less than 5%. Due to small numbers, missing values were not replaced; instead, the original data basis was retained to avoid artificial data manipulation. TMT-A and -B were conducted in a sample subgroup (n = 92). MPI at discharge was also collected in a subgroup of participants (n = 96).

Table 1a. *Baseline sociodemographic, clinical, and cognitive data upon admission (N = 131).*

Participants' characteristics upon admission	Size (n)	Mean[ı] (±SD) or Median[‡] (IQR)	Percentage[*] (%)
Sex	131	-	100.0[*]
Male	71	-	54.2[**]
Female	60	-	45.8[**]
Age	131	79.7[ı] (±6.7)	100.0[*]
65 – 74	28	70.4[ı] (±3.0)	21.4[**]
75 – 84	68	79.4[ı] (±2.9)	51.9[**]
≥ 85	35	88.0[ı] (±2.7)	26.7[**]
Living condition prior to admission	129	-	98.5[*]
At home with family	67	-	51.9[**]
At home alone	56	-	43.4[**]
At home under supporting care	6	-	4.7[**]
Education	121	12.0[‡] (3.25)	92.4[*]
< 10 years	34	8.0[‡] (1.0)	28.1[**]
10 – 14 years	62	12.0[‡] (2.0)	51.2[**]
≥ 15 years	25	16.0[‡] (2.75)	20.7[**]
Medication upon admission	131	10.4[ı] (±4.5)	100.0[*]
0 – 2	3	0.0[ı] (±0.0)	2.3[**]
3 – 4	8	3.4[ı] (±1.0)	6.1[**]
≥ 5	120	11.1[ı] (±6.0)	91.6[**]
CIRS upon admission	131	6.0[‡] (3.0)	100.0[*]
Mild morbidity (CIRS = 0)	0	0.0[‡] (0.0)	0.0[**]
Moderate morbidity (CIRS = 1 – 2)	2	2.0[‡] (0.0)	1.5[**]
Severe morbidity (CIRS ≥ 3)	129	6.0[‡] (3.0)	98.5[**]
MPI upon admission	131	0.6[‡] (0.2)	100[*]
Low to moderate risk of frailty (0.0 – 0.50)	35	0.5[‡] (0.1)	26.7[**]
Moderate to high risk of frailty (0.51 – 1.0)	96	0.7[‡] (0.1)	73.3[**]
MoCA	131	19.0[‡] (10.0)	100.0[*]
No cognitive deficit (26 – 30)	10	28.0[‡] (3.0)	7.6[**]
Mild cognitive deficit (21 – 25)	48	23.0[‡] (1.8)	36.6[**]
Severe cognitive deficit (≤ 20)	73	14.0[‡] (8.5)	55.7[**]
TMT A	92	78.0[‡] (76.3)	70.2[*]
No cognitive deficit (≤ 54 sec.)	12	36.5[‡] (10.5)	13.0[**]
Cognitive deficit (≥ 55 sec.)	80	90.0[‡] (110.5)	87.0[**]
TMT B	92	885.5[‡] (3568.3)	70.0[*]
No cognitive deficit (≤ 144 sec.)	15	95.0[‡] (45.0)	16.3[**]
Cognitive deficit (≥ 145 sec.)	77	1071.0[‡] (3351.0)	83.7[**]

Abbreviations: SD, Standard deviation; IQR, Interquartile range; CIRS, Cumulative Illness Rating Scale; MPI, Multidimensional Prognostic Index; MoCA, Montreal Cognitive Assessment; TMT, Trail Making Test.

* Percentage related to the whole sample size (N = 131)

** Percentage related to the sample size of a variable (n = valid values)

ǂ Mean; ǂ Median

4.2. Significance of cognition in adverse outcomes at hospital discharge

4.2.1. *Functional status (Barthel-Index)*

In total, 40.5% of the sample was severe to utterly dependent on daily life activities at discharge (Barthel-Index < 60) (Table 1b). Kruskal-Wallis's test was used to compare the different cognitive subgroups of patients, based on their performance in MoCA upon admission (categorical variables: nCD vs. mCD vs. sCD), in terms of their functional status at discharge measured by Barthel-Index (metric variable). Analyses showed significant results ($p < .001$).

Table 1b. *Descriptive data related to outcomes at discharge and post-discharge (N = 131).*

Participants' characteristics	**Size (n)**	**Median (IQR)**	**Percentage* (%)**
Barthel-Index at discharge	126	70.0 (40.0)	96.2*
Independence to moderate dependency (61 – 100)	75	-	59.5**
Severe to total dependency (0 – 60)	51	-	40.5**
MPI at discharge	96	0.56 (0.2)	73.3*
Low to moderate frailty risk (0.0 – 0-66)	46	-	47.9**
High frailty risk (0.67 – 1.00)	50	-	52.1**
Survival		-	
1-month post-discharge (n = 131)	105	-	80.2**
3-months post-discharge (n = 131)	98	-	74.8**
No hospital readmission		-	
1-month post-discharge (n = 128)	100	-	78.1**
3-months post-discharge (n = 125)	76	-	60.8**
No LTCF admission		-	
1-month post-discharge (n = 119)	102	-	94.1**
3-months post-discharge (n = 115)	106	-	92.4**
No falls		-	
1-month post-discharge (n = 126)	116	-	92.1**
3-months post-discharge (n = 119)	101	-	84.9**

Abbreviations: SD, Standard deviation; IQR, Interquartile range; MPI, Multidimensional Prognostic Index; LTCF, Long Termi Care Facility.

* Percentage related to the whole sample size (N = 131),

** Percentage related to the sample size of a variable (n = valid values)

Pairwise comparisons conducted with the Mann-Whitney U-test revealed considerable differences between the nCD and sCD (z = -3.52, $p < .001$), as well as the mCD and sCD groups (z = -3.19, $p = .001$) of MoCA (Table 3a). Patients with better cognitive performance were functionally more often independent at discharge, demonstrating higher BI (100.0% of the nCD) compared to those with some degree of cognitive deficit (65.9% of the mCD, as well as 49.3% of the sCD, Table 2). Overall, BI median values among MoCA cognitive groups were higher in the nCD (Mdn = 90.0, IQR = 21.25) compared to the mCD (Mdn = 80.0, IQR = 35.0), which in turn were better than those of the sCD group (Mdn = 60.0, IQR = 47.5, Table 3a, Figure 2).

Table 2. *Absolute numbers and frequencies (n, (%)) of patients in outcome-subcategories classified by cognitive performance (N = 131).*

		Cognitive tests						
		MoCA			TMT-A		TMT-B	
Outcomes	Subgroup n, (%)	nCD	mCD	sCD	nCD	CD	nCD	CD
Barthel-Index	INDEP	10 (100%)	31 (65.9%)	34 (49.2%)	10 (83.3%)	45 (60.0%)	10 (76.9%)	45 (60.8%)
	DEP	0 (0.0%)	16 (34.1%)	35 (50.8%)	2 (16.7%)	30 (40.0%)	3 (23.1%)	29 (39.2%)
MPI	L/M RF	7 (100%)	20 (60.6%)	19 (33.9%)	3 (50.0%)	28 (45.9%)	6 (60.0%)	25 (43.9%)
	High RF	0 (0.0%)	13 (39.4%)	37 (66.1%)	3 (50.0%)	33 (54.1%)	4 (40.0%)	32 (56.1%)
1M-Survival	Yes	10 (100%)	37 (77.0%)	58 (79.5%)	10 (83.3%)	64 (80.0%)	11 (73.3%)	63 (81.9%)
	No	0 (0.0%)	11 (23.0%)	15 (20.5%)	2 (16.7%)	16 (20.0%)	4 (26.7%)	14 (18.1%)
3M-Survival	Yes	10 (100%)	33 (68.8%)	55 (75.3%)	9 (75.0%)	60 (75.0%)	10 (66.7%)	59 (76.6%)
	No	0 (0.0%)	15 (31.2%)	18 (24.7%)	3 (25.0%)	20 (25.0%)	5 (33.3%)	18 (23.4%)
1M-No-hospital-readmission	Yes	6 (60.0%)	37 (80.4%)	57 (79.2%)	8 (66.7%)	59 (75.6%)	8 (57.1%)	59 (77.6%)
	No	4 (40.0%)	9 (19.6%)	15 (20.8%)	4 (33.3%)	19 (24.4%)	6 (42.9%)	17 (22.4%)
3M-No-hospital-readmission	Yes	6 (60.0%)	26 (59%)	44 (61.9%)	7 (58.3%)	44 (57.9%)	7 (50.0%)	44 (59.5%)
	No	4 (40.0%)	18 (41%)	27 (38.1%)	5 (41.7%)	32 (42.1%)	7 (50.0%)	30 (40.5%)
1M-No-LTCF-admission	Yes	10 (100%)	37 (94.9%)	65 (92.9%)	12 (100%)	67 (91.2%)	12 (92.3%)	67 (93.1%)
	No	0 (0.0%)	2 (5.1%)	5 (7.1%)	0 (0.0%)	6 (8.8%)	1 (7.7%)	5 (6.9%)
3M-No-LTCF-admission	Yes	9 (100%)	35 (94.6%)	62 (89.9%)	10 (90.1%)	64 (91.4%)	12 (85.7%)	64 (92.8%)
	No	0 (0.0%)	2 (5.4%)	7 (10.1%)	1 (9.9%)	6 (8.6%)	2 (14.3%)	5 (7.2%)
1M-No-Falls	Yes	9 (90.0%)	43 (97.7%)	64 (88.9%)	11 (100%)	74 (94.9%)	14 (100%)	71 (94.6%)
	No	1 (10.0%)	1 (2.3%)	8 (11.1%)	0 (0.0%)	4 (5.1%)	0 (0.0%)	4 (5.4%)
3M-No-Falls	Yes	6 (75%)	38 (90.5%)	57 (82.6%)	7 (77.8%)	65 (87.2%)	10 (83.3%)	62 (87.3%)
	No	2 (25%)	4 (9.5%)	12 (17.4%)	2 (22.2%)	9 (12.2%)	2 (16.7%)	9 (12.7%)

Abbreviations: MoCA, Montreal Cognitive Assessment; TMT, Trail Making Test; nCD, No cognitive deficit; mCD, Mild cognitive deficit; sCD, Severe cognitive deficit; CD, Cognitive deficit; LTCF, Long Term Care Facility; INDEP, Independence to moderate dependency; DEP, Severe to total dependency; L/M RF, Low to moderate risk of frailty and poor prognosis; MPI, Multidimensional Prognostic Index; 1M-/ 3M-, 1-month-/ 3-months-

Mann-Whitney U-test was applied to examine whether cognitive groups in TMT-A and -B (categorical variables: nCD vs CD) differ regarding their Barthel-Index (metric variable). Results showed that both tests significantly discriminated between patients with vs. without functional deficits at discharge (z = -2.67, $p = .008$ and z = -2.99, $p = .003$ for TMT-A and TMT-B, respectively, Table 3a). Specifically, several patients without cognitive deficit screened with either test demonstrated functional independence compared to those with CD (83.3% vs 60.0% with TMT-A, 76.9% vs 60.8% with TMT-B, Table 2). Overall, BI median values between

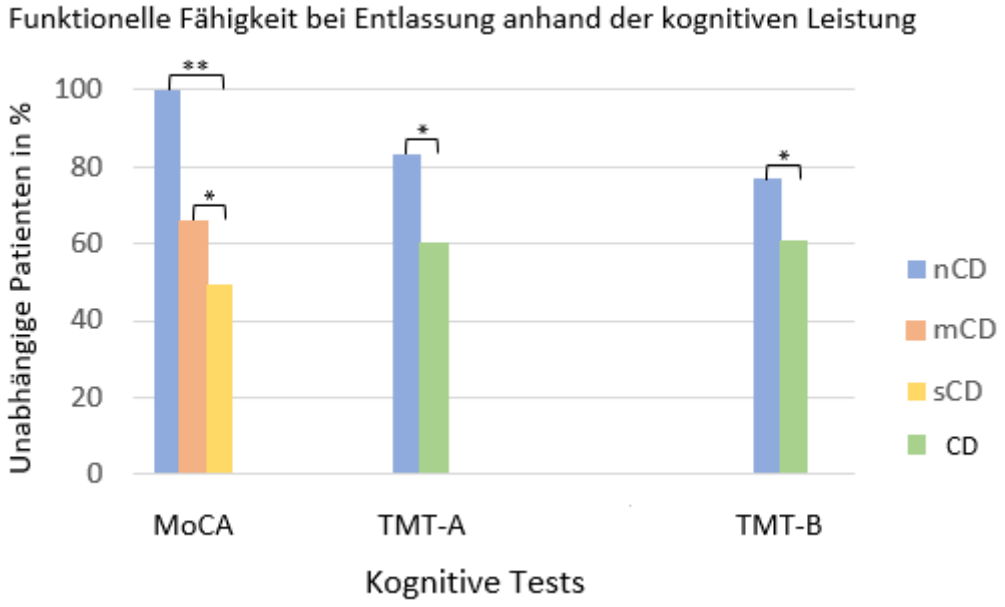
TMT-A cognitive subgroups were better in the nCD (Mdn = 90.0, IQR = 12.50) than in the CD group (Mdn = 70.0, IQR = 40.0). Similar results were found for TMT-B, too (Mdn = 90.0, IQR = 27.50 for nCD vs Mdn = 70.0, IQR = 40.0 for CD, Table 3a, Figure 2).

Table 3a. *Median score in BI as a measure of functional status at discharge classified by cognitive performance upon admission, and between-groups comparisons (N = 131).*

		Functional status at discharge – Barthel Index (Independence to moderate dependency > 60)					
Cognitive tests			**BI Mdn (IQR)**		**Pairwise comparisons**		
		n		***p***	$P_{1,2}$	$P_{1,3}$	$P_{2,3}$
MoCA		126		***<.001*** [a]	.063[b]	***<.001***[b]	***.001***[b]
	[1]nCD	10	90.0 (21.3)				
	[2]mCD	47	80.0 (35.0)				
	[3]sCD	69	60.0 (47.5)				
TMT-A		87		***.008*** [b]			
	nCD	12	90.0 (12.5)				
	CD	75	70.0 (40.0)				
TMT-B		87		***.003*** [b]			
	nCD	13	90.0 (27.5)				
	CD	74	70.0 (40.0)				

Abbreviations: BI, Barthel Index; Mdn, Median; IQR, Interquartile range; MoCA, Montreal Cognitive Assessment; TMT, Trail Making Test; nCD, No cognitive deficit; mCD, Mild cognitive deficit; sCD, Severe cognitive deficit; CD, Cognitive deficit; *P*, comparison of BI between cognitive subgroups; [a]Kruskal-Wallis test; [b]Mann-Whitney U-test; $P_{1,2,3}$, Pairwise comparisons between nCD, mCD, sCD.

Figure 2. *Percentage of patients with high Barthel-Index at discharge classified by cognitive performance upon admission.*



Percentage of patients with high Barthel-Index at discharge – A comparison among cognitive groups. Patients with nCD were significantly more often independent compared to other cognitive groups.

* Significance level at < .05

** Significance level at < .01

4.2.2. *Risk of frailty/ poor prognosis (MPI)*

More than half of the participants (52.1%) demonstrated a high risk of frailty/ poor prognosis (high MPI) (Table 1b). Kruskal-Wallis's analyses investigated whether cognitive performance in MoCA (categorical variables: nCD vs. mCD vs. sCD) influences patients' risk of frailty/ poor prognosis, as measured by MPI at discharge (metric variable).

Findings revealed that MoCA discriminated between patients with an increased risk of frailty/ poor prognosis (*p = .005*). The Mann-Whitney U-test was used for the pairwise comparisons and showed statistically significant differences between the nCD and sCD groups (z = -2.67, *p* = .006), as well as the mCD and the sCD groups in MoCA (z = -2.41, *p = .016,* Table 3b). Patients with no cognitive deficit showed more often decreased risk of frailty/ poor prognosis (nCD: 100.0%) compared to those with mCD (60.6%) or sCD (33.9%, Table 2) documented by lower MPI scores (Mdn = 0.44, IQR = 0.12 for nCD vs Mdn = 0.50, IQR = 20.0 for mCD vs Mdn = 0.56, IQR = 25.0 for sCD, Table 3b).

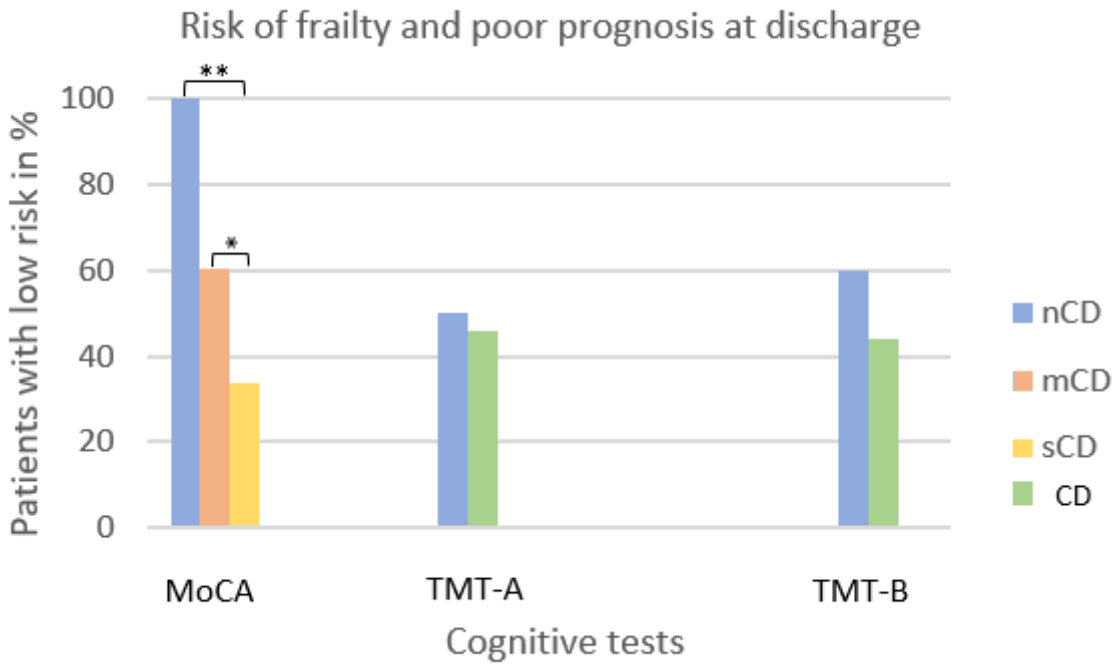
Table 3b. *Median score in MPI as a measure of risk of frailty at discharge classified by cognitive performance upon admission, and between-groups comparisons (N=96).*

Risk of frailty and poor prognosis at discharge – MPI (Low risk ≤ 0.50)							
Cognitive tests			**MPI Mdn (IQR)**		**Pairwise comparisons**		
		n		***p***	$P_{1,2}$	$P_{1,3}$	$P_{2,3}$
MoCA		96		***.005*** [a]	.218[b]	***.006***[b]	***.016***[b]
	[1]nCD	7	.44 (.12)				
	[2]mCD	33	.50 (.20)				
	[3]sCD	56	.56 (.25)				
TMT-A		67		.295 [b]			
	nCD	6	.50 (.23)				
	CD	61	.56 (.22)				
TMT-B		67		.161 [b]			
	nCD	10	.47 (.20)				
	CD	57	.56 (.25)				

Abbreviations: Mdn, Median; IQR, Interquartile range; MPI, Multidimensional Prognostic Index; MoCA, Montreal Cognitive Assessment; TMT, Trail Making Test; nCD, No cognitive deficit; mCD, Mild cognitive deficit; sCD, Severe cognitive deficit; CD, Cognitive deficit; *P*, comparison of MPI between cognitive subgroups; [a]Kruskal-Wallis Test; [b] Mann-Whitney U-Test; $P_{1,2,3}$, Pairwise comparisons between nCD, mCD, sCD.

Mann-Whitney U-test was implemented to search for differences between the TMT-A and -B cognitive groups regarding their MPI score at discharge. None of the tests showed statistical significance, but median MPI values were lower (i.e., better prognosis) in patients without cognitive deficit than in those with CD based on TMT-A (nCD: Mdn = 0.50, IQR = 0.23 vs. CD: Mdn = 0.56, IQR = 0.22) and TMT-B (nCD: Mdn = 0.47, IQR = 0.20 vs. CD: Mdn = 0.56 IQR = .25, Tables 2 and 3b). In general, patients screened with no cognitive deficit showed a decreased risk of frailty/ poor prognosis at discharge compared to those with some cognitive deficit (Figure 3).

Figure 3. *Percentage of patients with low MPI at discharge classified by cognitive performance upon admission.*



Percentage of patients with low MPI at discharge – A comparison among cognitive groups. Patients with nCD in MoCA were significantly more often at lower risk of frailty/ poor prognosis compared to other cognitive groups.

* Significance level at < .05

** Significance level at < .01

4.3. Significance of cognition in adverse post-discharge outcomes: Mortality, hospital readmission, admission to LTCF, falls.

One month after discharge, the overall percentage of mortality regardless of cognitive group was 19.8%, hospital readmissions 21.9%, admission to LTCF 5.9%, and falls 7.9%. At three-months-follow-up, all rates increased to a different extent, with mortality reaching 25.2%, hospital readmissions at 39.2%, admission to LTCF at 7.9%, and post-discharge falls nearly doubled to 15.1% (Table 1b).

The chi-squared test of independence or Fisher's exact test (in case of cell frequencies <5) was selected to investigate any potential influence of cognition on post-discharge outcomes. Findings showed no statistical significance of MoCA, TMT-A, or -B on any post-discharge outcomes for either follow-up time points (Tables 4a and 4b, as well as Figures 4, 5, 6, and 7).

Table 4a. *Frequency of adverse outcomes one-month post-discharge classified by cognitive performance upon admission, and significance of cognition (N = 131).*

	Adverse outcomes one-month post-discharge															
Cognitive tests		**Survival**				**No Readmission**				**No LTCF admission**				**No Falls**		
	N	**Yes**	**No**	***p***	**N**	**Yes**	**No**	***p***	**N**	**Yes**	**No**	***p***	**N**	**Yes**	**No**	***p***
MoCA	131	105 (80.2%)	26 (19.8%)	.249[a]	128	100 (78.1%)	28 (21.9%)	.348[a]	119	112 (94.1%)	7 (5.9%)	1.00[b]	126	116 (92.1%)	10 (7.9%)	.167[b]
nCD	10	10 (100%)	0 (0.0%)		10	6 (60.0%)	4 (40.0%)		10	10 (100%)	0 (0.0%)		10	9 (90.0%)	1 (10.0%)	
mCD	48	37 (77.0%)	11 (23.0%)		46	37 (80.4%)	9 (19.6%)		39	37 (94.9%)	2 (5.1%)		44	43 (97.7%)	1 (2.3%)	
sCD	73	58 (79.5%)	15 (20.5%)		72	57 (79.2%)	15 (20.8%)		70	65 (92.9%)	5 (7.1%)		72	64 (88.9%)	8 (11.1%)	
TMT-A	92	74 (80.4%)	18 (19.6%)	1.00[b]	90	67 (74.4%)	23 (25.6%)	.494[b]	85	79 (92.9%)	6 (7.1%)	.588[b]	89	85 (95.5%)	4 (4.5%)	1.00[b]
nCD	12	10 (83.3%)	2 (16.7%)		12	8 (66.7%)	4 (33.3%)		12	12 (100%)	0 (0.0%)		11	11 (100%)	0 (0.0%)	
CD	80	64 (80.0%)	16 (20.0%)		78	59 (75.6%)	19 (24.4%)		73	67 (91.2%)	6 (8.8%)		78	74 (94.9%)	4 (5.1%)	
TMT-B	92	74 (80.4%)	18 (19.6%)	.482[b]	90	67 (74.4%)	23 (25.6%)	.178[b]	85	79 (92.9%)	6 (7.1%)	1.00[b]	89	85 (95.5%)	4 (4.5%)	1.00[b]
nCD	15	11 (73.3%)	4 (26.7%)		14	8 (57.1%)	6 (42.9%)		13	12 (92.3%)	1 (7.7%)		14	14 (100%)	0 (0.0%)	
CD	77	63 (81.9%)	14 (18.1%)		76	59 (77.6%)	17 (22.4%)		72	67 (93.1%)	5 (6.9%)		75	71 (94.6%)	4 (5.4%)	

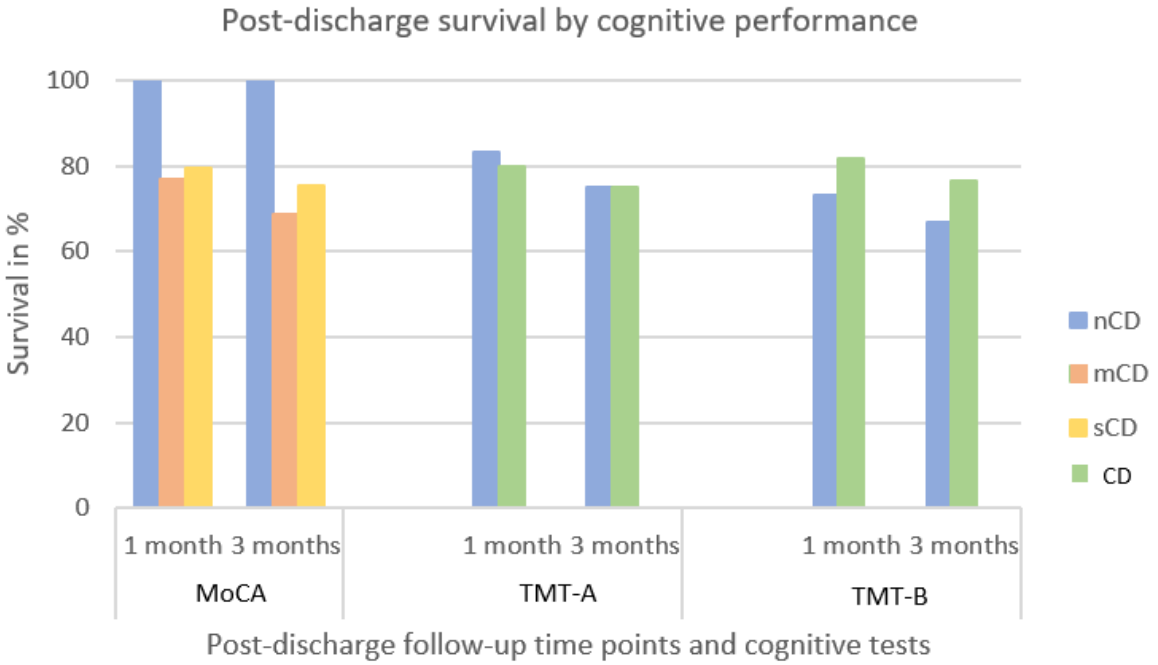
Abbreviations: MoCA, Montreal Cognitive Assessment; TMT, Trail Making Test; nCD, No cognitive deficit; mCD, Mild cognitive deficit; sCD, Severe cognitive deficit; CD, Cognitive deficit; LTCF, Long Term Care Facility; *P*, comparison of post-discharge outcomes between cognitive subgroups; [a] Pearson's Chi-squared (χ^2) test; [b] Fischer's exact test

Table 4b. *Frequency of adverse outcomes three months post-discharge classified by cognitive performance upon admission, and significance of cognition (N = 131).*

	Adverse outcomes three months post-discharge															
Cognitive tests		**Survival**				**No Readmission**				**No LTCF admission**				**No Falls**		
	N	**Yes**	**No**	***p***	**N**	**Yes**	**No**	***p***	**N**	**Yes**	**No**	***p***	**N**	**Yes**	**No**	***p***
MoCA	131	98 (74.8%)	33 (25.2%)	.116[a]	125	76 (59.3%)	49 (40.7%)	.952[a]	115	106 (92.2%)	9 (7.8%)	.650[b]	119	101 (84.9%)	18 (15.1%)	.385[a]
nCD	10	10 (100%)	0 (0.0%)		10	6 (60.0%)	4 (40.0%)		9	9 (100%)	0 (0.0%)		8	6 (75%)	2 (25%)	
mCD	48	33 (68.8%)	15 (31.2%)		44	26 (59%)	18 (41%)		37	35 (94.6%)	2 (5.4%)		42	38 (90.5%)	4 (9.5%)	
sCD	73	55 (75.3%)	18 (24.7%)		71	44 (61.9%)	27 (38.1%)		69	62 (89.9%)	7 (10.1%)		69	57 (82.6%)	12 (17.4%)	
TMT-A	92	69 (75.0%)	23 (25.0%)	1.00[b]	88	51 (57.9%)	37 (42.1%)	.977[a]	81	74 (91.4%)	7 (8.6%)	1.00[b]	83	72 (86.7%)	11 (13.3%)	.341[b]
nCD	12	9 (75.0%)	3 (25.0%)		12	7 (58.3%)	5 (41.7%)		11	10 (90.1%)	1 (9.9%)		9	7 (77.8%)	2 (22.2%)	
CD	80	60 (75.0%)	20 (25.0%)		76	44 (57.9%)	32 (42.1%)		70	64 (91.4%)	6 (8.6%)		74	65 (87.2%)	9 (12.2%)	
TMT-B	92	69 (75.0%)	23 (25.0%)	.515[b]	88	51 (57.9%)	37 (42.1%)	.511[a]	81	74 (91.4%)	7 (8.6%)	.276[b]	83	72 (86.7%)	11 (13.3%)	.657[b]
nCD	15	10 (66.7%)	5 (33.3%)		14	7 (50.0%)	7 (50.0%)		12	12 (85.7%)	2 (14.3%)		12	10 (83.3%)	2 (16.7%)	
CD	77	59 (76.6%)	18 (23.4%)		74	44 (59.5%)	30 (40.5%)		69	64 (92.8%)	5 (7.2%)		71	62 (87.3%)	9 (12.7%)	

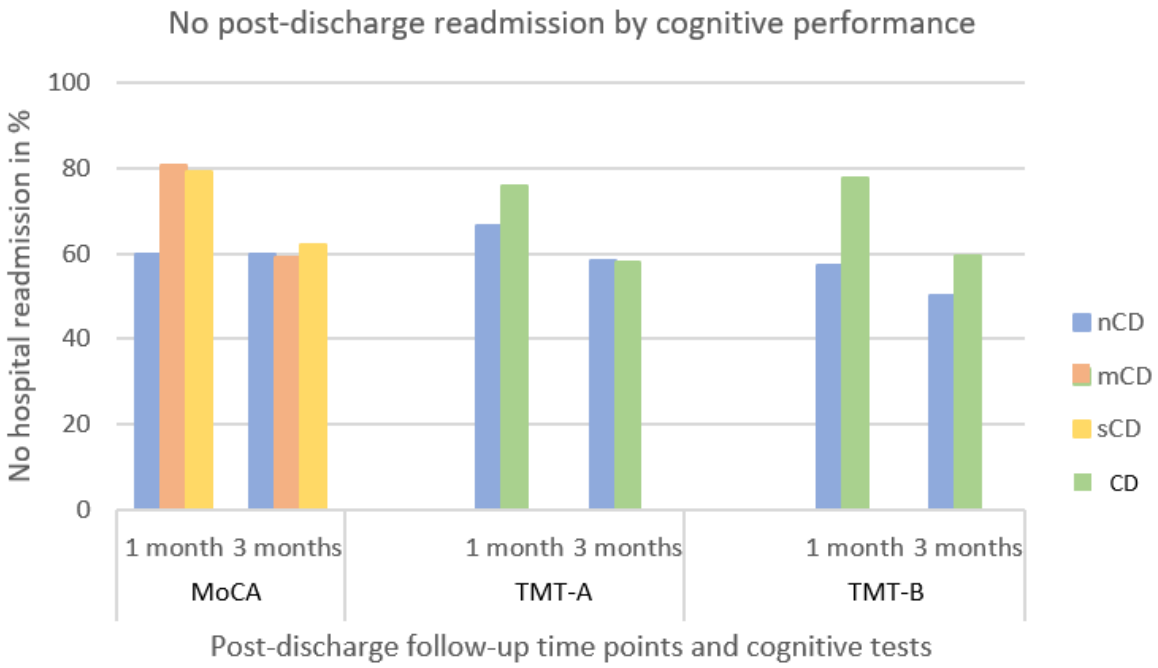
Abbreviations: MoCA, Montreal Cognitive Assessment; TMT, Trail Making Test; nCD, No cognitive deficit; mCD, Mild cognitive deficit; sCD, Severe cognitive deficit; CD, Cognitive deficit; LTCF, Long Term Care Facility; *P*, comparison of post-discharge outcomes between cognitive subgroups; [a] Pearson's Chi-squared (χ^2) test; [b] Fischer's exact test

Figure 4. *Percentage of patients still living at follow-up time points.*



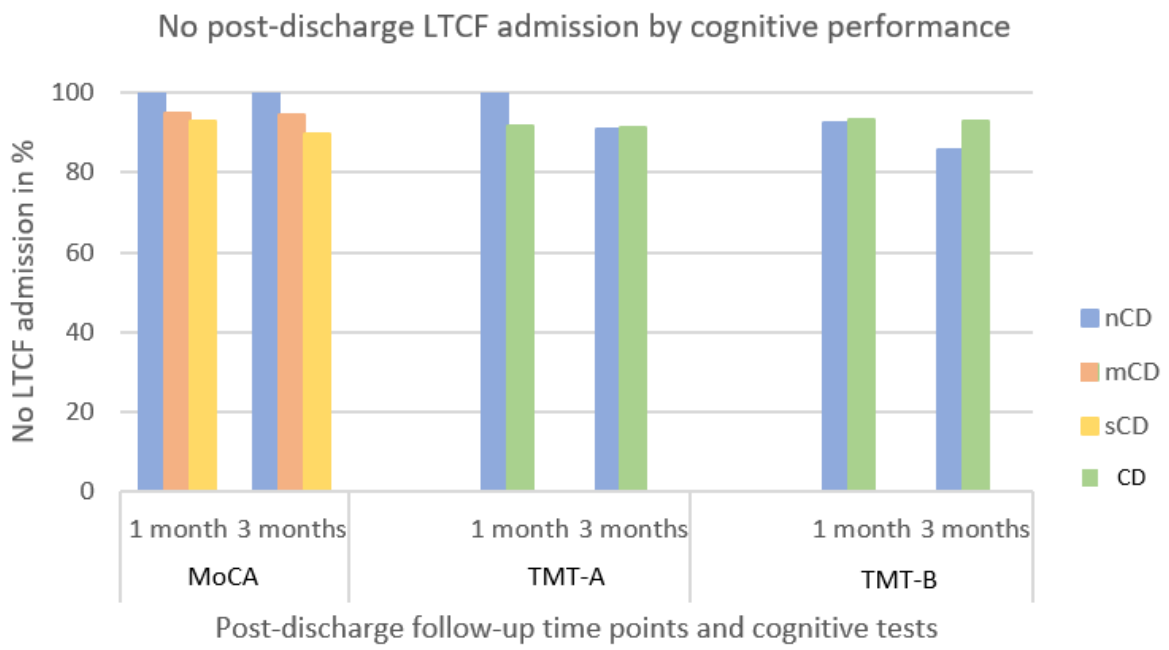
There is no significant protective effect of cognition on post-discharge mortality, as well as no clear trend, on whether better cognitive performance is associated with longer survival at follow-up. MoCA and TMT show contradictory results.

Figure 5. *Percentage of patients not readmitted to hospital at follow-up time points.*



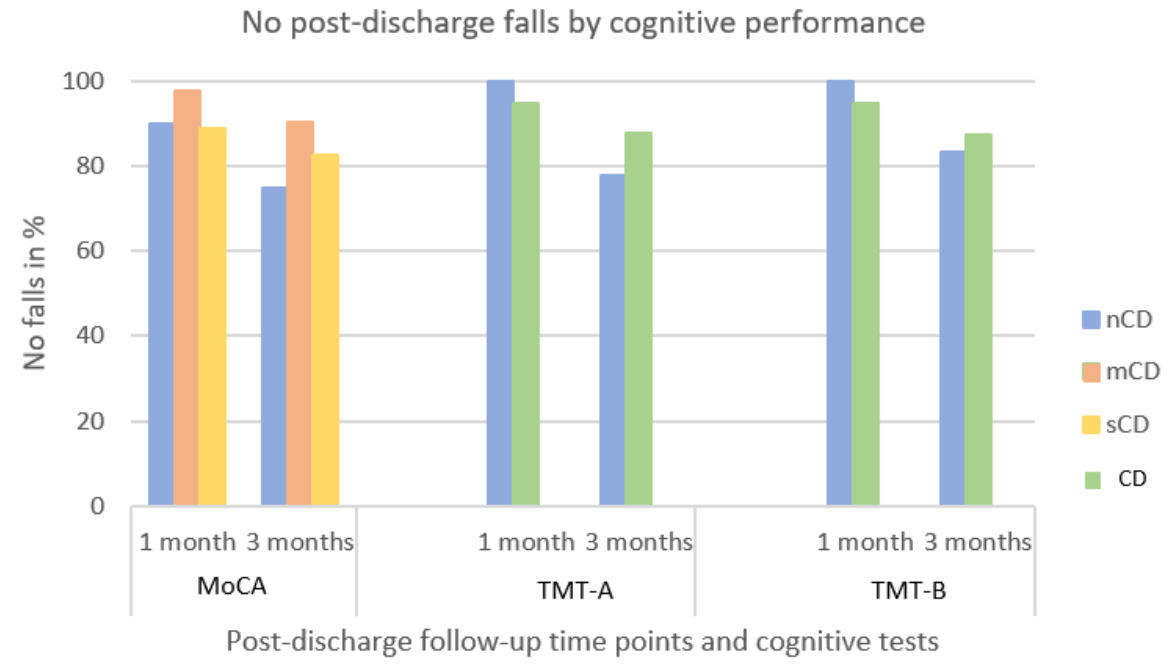
There is no significant protective effect of cognition on rehospitalisation. Patients with impaired cognition seem to be less often readmitted at hospital one month after discharge. This trend disappears at 3-months follow-up.

Figure 6. *Percentage of patients not admitted to a LTCF at follow-up time points.*



There is no significant protective effect of cognition on admission to a LTCF after discharge, as well as no clear trend, on whether better cognitive performance is associated with less frequent LTCF admission at follow-up.

Figure 7. *Percentage of patients with no falls at follow-up time points.*



There is no significant protective effect of cognition on post-discharge falls, as well as no clear trend, on whether better cognitive performance is associated with less frequent falls at follow-up.

4.4. Cognition as a predictor of adverse outcomes

Multivariable linear or binary regression models were used to investigate whether cognition predicts functional status and risk of frailty/ poor prognosis at discharge. Only variables that showed statistical significance in the univariate comparison tests (Chi-squared/ Fisher's test or Kruskal-Wallis/ Mann-Whitney U-test) were included in the regression analyses as metric or categorical variables. Demographic co-factors (gender, age, education, MPI upon admission) were controlled for in all cases.

MoCA showed a linear relationship with Barthel-Index (functional status) and MPI (risk of frailty/ poor prognosis) at discharge. Its predictive value was, therefore, analysed using backward multivariable linear regression, where factors and outcomes were metric. TMT-A and -B showed no linear relationship with BI. Therefore, backwards multivariable binary logistic regression analyses were applied. TMT-A and -B were included as metric variables, while BI was treated as a nominal binary variable ("dependency – no/yes").

No regression analyses were conducted for the association between TMT-A and -B with MPI at discharge because no significant influence was shown in the comparison tests. No post-discharge outcomes were included in the regression analyses due to the missing significance of cognition on these outcomes in the univariable comparison tests.

Results revealed that BI at discharge is predicted by MoCA and TMT-B independent of demographic factors (age, gender, education, MPI upon admission). MoCA explained 22.7% of the outcome variance [R^2 = .227, *p <.001*] and was positively associated with discharge BI (β = 1.19, *p < .002*). This finding shows that for each point of increase in MoCA score, the probability of a patient being functionally independent at discharge is higher (Table 5a). TMT-B was positively associated with BI [OR (95% CI) = 1.006 (1.002, 1.009), *p = .003*], where the possibility of functional deficit increased with an increase in TMT-B score. This model was significant (Omnibus-test: *p < .001*), with a Nagelkerkes of R^2 = 0.381, a mediocre sensitivity (60.0%), a rational specificity (87.3%) and an overall prediction accuracy of 77.6% (Table 5b). Cognitive tests predicted no further outcomes (MPI at discharge, post-discharge endpoints). Demographic co-factors (gender, MPI upon admission) showed statistical significance regarding the BI or MPI at discharge in the logistic regression, but this was not the case in the linear regression for the same outcomes. The focus of this text lies on cognitive factors. For more details on the influence of demographic factors, see Tables 5a, 5b, and 6.

Table 5a. *Final linear regression of global cognition (MoCA) upon admission on functional status (BI) at discharge adjusted for demographic co-factors.*

Functional status at discharge (Barthel-Index)					
	Multivariable model (n = 110)				
All Variables	**R^2 adjusted**	**F (df)**	**B (SE)**	**95%CI**	***p***
MoCA			1.193 (0.371)	0.457, 1.929	***.002***
Demographic co-factors					
Gender			-3.747 (4.484)	-12.638, 5.143	.405
Age			-0.135 (0.362)	-0.854, 0.583	.709
Education			0.448 (0.648)	-0.837, 1.733	.491
MPIx100 on admission			-0.519 (0.185)	-.887, -.152	***.006***
Constant			75.915 (15.825)	44.544, 107.286	*<.001*
Model	.227	17.037 (3, 109)			***<.001***

Abbreviations: df, degrees of freedom; SE, Standard error; CI, Confidence interval; MoCA, Montreal Cognitive Assessment; MPIx100, Multidimensional Prognostic Index – metric variable multiplied by 100.

Table 5b. *Binary logistic regression of executive function (TMT-B) upon admission on functional status (BI) at discharge adjusted for demographic co-factors.*

Functional status at discharge (Barthel-Index)			
	Multivariable model (n = 85)		
All variables		**OR (95% CI)**	***p***
TMT-B:10		1.006 (1.002, 1.009)	***.003***
Demographic co-factors			
Gender	Men	REF	-
	Women	3.268 (1.100, 9.711)	***.033***
Age		1.014 (0.938, 1.095)	.729
Education		.986 (0.840, 1.157)	.861
MPIx100 on admission		1.072 (1.024, 1.122)	***.003***
Model characteristics			
Overall significance (*P*)			***<.001***
Nagelkerkes R^2		0.381	
Overall correct prediction rate		77.6%	
Sensitivity		60.0%	
Specificity		87.3%	

Abbreviations: OR, Odds ratio; CI, Confidence interval; TMT-B:10, Trail Making Test – Part B – metric value divided by 10; MPIx100, Multidimensional Prognostic Index – metric variable multiplied by 100; REF, reference group.

Table 6. *Linear regression of global cognition (MoCA) upon admission on risk of frailty/ poor prognosis (MPI) at discharge adjusted for demographic co-factors.*

Risk of frailty and poor prognosis at discharge (MPI)					
		Multivariable model (n = 84)			
All variables	**R^2 adjusted**	**F (df)**	**B (SE)**	**95%CI**	***p***
MoCA			-0.278 (0.205)	-0.686, 0.130	.179
Demographic co-factors					
Gender			-0.075 (2.520)	-0.01, 0.0	.976
Age			-0.290 (0.185)	-0.658, 0.078	.121
Education			-0.134 (0.342)	-0.815, 0.547	.696
MPIx100 on admission			0.736 (0.091)	(0.554, 0.918)	***<.001***
Constant			9.481 (5.811)	-2.078, 21.040	.107
Model	.434	64.696 (1, 83)			***<.001***

Abbreviations: df, degrees of freedom; SE, Standard error; CI, Confidence interval; MoCA, Montreal Cognitive Assessment; MPIx100, Multidimensional Prognostic Index – metric variable multiplied by 100.

5. Discussion

5.1. Interpretation and integrative presentation of the findings

This study investigated the influence of cognition upon admission to the hospital, measured by MoCA, TMT-A, and -B, on functional ability and risk of frailty/ poor prognosis at discharge, evaluated with the Bathel-Index and MPI, respectively. Another focus was the association of cognition with survival/mortality, hospital readmission, admission to LTCF, and falls one and three months after hospital discharge. The population of interest was older multimorbid inpatients with undiagnosed cognitive deficits in Germany. To the author's knowledge, this is the first study to address this question in the German population, considering the aforementioned combination of instruments and outcomes. Results showed that performance in MoCA, TMT-A, and -B upon hospital admission discriminated functionally independent patients at discharge from those with deficits. MoCA also differentiated between patients with a low risk of frailty/ poor prognosis at discharge and those with a high. Significant predictors of functional ability at discharge were MoCA and TMT-B. None of the cognitive tests predicted any further outcomes.

Concerning the functional status at discharge, results showed, as hypothesised, that all cognitive tests differentiated functionally independent patients from those with functional deficits. However, only MoCA and TMT-B predicted BI at discharge, with better cognition being associated with higher functional abilities. MoCA explained almost one-fourth of the variable variance. Though this number is not very high, it is not negligible either, and the effect was significant. Further, the logistic regression model, which associated TMT-B with BI, showed a rational specificity but a moderate sensitivity. That means that good performance in TMT-B upon hospital admission could be used to exclude the possibility of someone demonstrating functional deficit at discharge, but low performance would not reliably predict functionally dependent patients. These findings denote that performance in MoCA and TMT-B upon admission provides valuable information about the functional status at discharge; hence, they should be interpreted in combination with further clinical findings.

These results are in line with previous research that associated global cognition with functional status in older adults (s. in De Saint-Hubert et al., 2014; s. Hartley et al., 2017; s. in Lafont et al., 2011; Pedone et al., 2005). Most of the research, though, delivered evidence from neurological patients, where MoCA has been associated with BI, ADL, or the FIM and was found to be an independent predictor of functional status at discharge (Saberi et al., 2020; Sanchez-Silverio et al., 2022; Toglia et al, 2011). In these studies, higher MoCA performance upon admission was associated with better functional status (Durant et al., 2016; Lim et al., 2018; Millan-Calenti et al., 2012). Further studies have reported an association of global cognitive impairment with functional deficits in personal and instrumental activities of daily

living in community-dwelling older adults too (Dodge et al, 2005; Lee et al., 2019; McGuire et al., 2006; Van Grootven & Van Achterberg, 2022). This study delivers, however, new evidence about the relationship between global cognition and functional status in a patient collective that, to the author's knowledge, has not been thoroughly investigated yet.

To the association of executive function with functional abilities of daily life research has mainly delivered evidence from community-dwelling older adults, stroke patients, or nursery home residents (Bell-McGinty et al., 2002; Ghaffari et al., 2021; Mansbach & Mace, 2019; Marshall et al., 2011; Verreckt et al., 2022). It has been shown that executive function predicts functional abilities. Specifically, inhibition has been associated with ADL and IADL, while cognitive flexibility and shifting with IADL (Jefferson et al., 2006; Verreckt et al., 2022). These findings are explained by the fact that ADL/ IADL demands a tremendous amount of independence in motility, functional mobility, and cognitive resources, including visuospatial scanning, speed of information processing (Bowie et al., 2006), and executive function such as cognitive flexibility and set switching (Ghaffari et al., 2021; Verreckt et al., 2022). These cognitive functions, besides contributing to motor coordination, walking, and standing, are prerequisites for performing ADL/ IADL (Bell-McGinty et al., 2002; Ghaffari et al., 2021; Hanks et al., 1999; Verreckt et al., 2022). The present study investigated the relationship of executive function with functional status using a different combination of instruments than previous studies for both cognition (MoCA, TMT-A, and -B) and functional status (Barthel-Index) and concentrated on a distinct population group so that it adds new evidence in the available literature.

Regarding the risk of frailty/ poor prognosis at discharge, findings showed, as hypothesised, that MoCA discriminated patients with low risk from those with a high risk of frailty/ poor prognosis. Contrary to the initial hypothesis, TMT-A and -B showed no significance. Furthermore, none of the above tests demonstrated any predictive value for MPI at discharge. However, an overall trend towards patients without cognitive deficit showing a lower risk of frailty/ poor prognosis at discharge compared to those with some degree of cognitive deficit was consistent irrespective of cognitive test. There is also previous evidence reporting an association of global cognition with risk of frailty/ poor prognosis, where hospitalised patients with dementia or outpatients with mild or severe cognitive deficit demonstrated higher MPI scores (Gallucci et al., 2014; Overbeek et al., 2022; Pilotto et al., 2009). Pilotto and colleagues (2018) showed that treatment with antidementiva positively influences prognosis and increases survival in dementia patients with low or moderate MPI estimated risk of mortality (Pilotto et al., 2018). The association of better cognition with better MPI scores may be explained by the fact that patients with intact or slightly impaired cognition understand, to a better extent, their deficits, as well as face no or fewer difficulties in reasoning and problem-solving, leading to better decision-making capacity during hospital residency. They take, therefore, fewer risks and are more compliant with therapy, which protects them from health deterioration, injury, and

death. This explanation is supported by evidence showing decreased decision-making capacity, memory deficits, and unawareness in patients with AD (Cosentino et al., 2011; Karlawish, 2008). Furthermore, Burton and colleagues (2012) found that patients with cognitive deficits performed worse in decision-making measures and that global cognitive impairment predicted low decision-making capacity (Burton et al., 2012). It has also been reported that individuals with cognitive deficits or dementia show lower rates of therapy adherence, ranging from 10.7 – 38% compared to individuals without (Smith et al., 2017) and that cognitive impairment is a risk factor for poor therapy compliance (Okuno et al., 2001). This study is, to the author's knowledge, the first to have investigated whether global cognition and executive function upon hospital admission, assessed by the implemented instruments, predict the risk of frailty/ poor prognosis measured with MPI in geriatric multimorbid inpatients in Germany. Given the significance of MoCA in the comparison tests, as well as the consistent trend throughout all cognitive tests towards clinically better cognition being associated with a lower risk of frailty/ poor prognosis at discharge, missing significance in regression analyses may be attributed to reduced statistical power due to small sample size in some of the cognitive subgroups (i.e., MoCA – nCD group).

With respect to the influence of cognition on adverse post-discharge outcomes, results showed no significant associations with any cognitive tests. Survival/ mortality rates showed no consistent trend as to whether patients without cognitive deficits die less often than those with impaired cognition after discharge. In some cases, the nCD group demonstrated a higher survival rate than other groups (e.g., MoCA at both follow-up time points). In other cases, however, the inverse relationship was documented (e.g., TMT-B at one- and three-month follow-up).

In hospital readmission, no clear trend towards patients without cognitive deficits being less often rehospitalised than others were documented for MoCA, TMT-A, and -B, but rather a mixed pattern. Similarly, LTCF showed no consistent trend across cognitive tests and subgroups concerning whether patients with no cognitive deficit were likely to be admitted to an LTCF less often than those with cognitive deficits in either follow-up time point. Specifically, in MoCA, patients in the nCD group were more often not admitted to LTCF than those in the mCD, and the latter were more often not authorised to an LTCF than those in the sCD for both one- and three-month follow-ups. This non-significant trend disappeared in TMT-A and -B, where nCD and CD groups showed similar LTCF non-admission rates. Post-discharge falls also showed no clear trend concerning whether patients with better cognition fall less often after discharge than those with cognitive deficits. In some cases, the nCD group showed higher rates of no-fallers (e.g., TMT-A and -B at one-month post-discharge), while in others, the inverse relationship was documented (e.g., TMT-A and -B at three months post-discharge).

These inconclusive results regarding the post-discharge outcomes reflect the current state of the research in this field. Findings are at present contradictory, with some authors reporting an association between cognition and post-discharge mortality (Agrawal et al., 2019; Huynh et al., 2016; Patel et al., 2015; Yao et al., 2020), hospital readmission (Huynh et al., 2016; Kim, 2020; Patel et al., 2015; Wang-Hansen et al., 2022) admission to LTCF (Von Bonsdorff et al., 2006), or falls (Mahoney et al., 1994), while others do not (Baztán, 2004; Hanna et al., 2020; Logue et al., 2016; Shami et al., 2019). The controversy in research findings may lie in the heterogeneity of the studies regarding design (prospective vs. retrospective), sample constitution and size, instruments, outcomes of interest, and follow-up time points. Some studies recruited geriatric patients, while others recruited heart or surgical patients. Some were community-dwelling participants, and others were out or inpatients of a clinic. Furthermore, authors used different instruments to measure cognition, such as MoCA, MMSE, or Mini-Cog, and assess the outcomes of interest, i.e., an interview, medical records, or a patient's diary. Moreover, authors often concentrated on different post-discharge outcomes and post-discharge time points. To the author's knowledge, this study is the first to have been conducted in Germany on this collective of patients using these instruments and showed that cognition upon admission does not predict adverse post-discharge outcomes. Alternatively, the small sample size may have influenced the study's statistical power, leading to failure to confirm the initial hypothesis. Because of the contradictory evidence in the literature, it is recommended that this study be repeated with a larger sample in a multicentre study to shed more light on the relationship between cognition and adverse post-discharge outcomes.

A further observation of this study was that several patients showed cognitive deficits to some extent. Based on MoCA, 92.4% of participants had some impairment of global cognition upon admission, while CGA-based SPMSQ showed a rate of 12.2%. Available SPMSQ data at discharge revealed a rate of cognitive deficit of 11.1%. Data from SPMSQ may seem contradictory to those from MoCA; hence, they showed that the cognitive function of cognitively impaired patients upon admission tends to deteriorate during a hospital stay. Patients with cognitive deficit upon admission showed more frequently cognitive impairments at discharge compared to their counterparts without cognitive deficits. Accordingly, patients with intact cognition upon admission improved or maintained their cognitive function to a greater extent at discharge than those with impairment. Moreover, of all patients who experienced cognitive improvement at discharge, the majority were those with intact cognition upon admission, with a relation of 16:1 to those with cognitive deficits. This relation was reduced to 2:1 regarding the rate of deterioration, with patients with intact cognition at baseline being still numerically more than those with cognitive impairment. This is attributable to the more substantial number of patients diagnosed as having no cognitive deficit at all with SPMSQ at both time points due to its potentially questionable sensitivity. These findings show that older multimorbid

hospitalised patients often face cognitive deficits and experience some degree of cognitive decline during the hospital stay as well and confirm previous literature reporting that hospitalisation serves as a risk factor for cognitive decline in older adults (James et al., 2019; s. in Chinnappa-Quinn, et al., 2020, 2022; s. in Mathew et al., 2014). James and colleagues (2019) found that nonelective hospitalisations of older adults resulted in an acceleration of cognitive decline compared to elective admissions or no hospitalisation (James et al., 2019). Chinnappa-Quinn and colleagues (2002; 2022) also reported that acute illness hospitalisation poses a risk factor and triggers a cognitive decline in older adults (s. in Chinnappa-Quinn et al., 2020, 2022).

5.2. Limitations of the study

Besides the new evidence provided by this study, there are some limitations to refer to. Firstly, the sample size was too small in some subgroups (e.g., nCD in MoCA: n = 10, nCD in TMT-A: n = 12), which may have decreased the statistical power of the analyses. This may have prevented the analyses from showing statistically significant associations between some of the cognitive tests and the outcomes. These differences were documented, therefore, as non-significant trends. Consequently, the findings of this study are to be interpreted with caution. Regarding the implemented instruments, MoCA had missing values replaced using the participants' scores in the MMSE. The score conversion occurred based on published data regarding matching MMSE to MoCA score and vice versa (Fasnacht et al., 2022). Although replacing original values may distort the precise outcome, Fasnacht and colleagues (2022) found a high Spearman's correlation (rs = 0.80, $p < .001$) between the MoCA and MMSE and a reliable conversion of values in the high and middle score ranges, so that it is assumed that replaced values highly reflect the original values. Furthermore, participants' performance in TMT-B showed a floor effect in the raw scores, so prorated TMT values were used in the analyses instead. Primary values would have covered participants' performance variance and potential differences in this case. Replacing raw values through prorated was, in the author's opinion, a methodologically decent decision in favour of uncovering group differences. Concerning statistical analyses, linear and binary regression models were adjusted only for demographics but not for motor co-factors, which may also influence patients' performance. What is more, the predictive value of TMT-B on the Barthel-Index was investigated using binary logistic regression due to missing linearity between factor and outcome. However, BI was, in fact, no nominal binary variable but rather ordinal with two subgroups. This may have potentially led to a limited loss of information, but in the author's opinion, it has not affected the analysis result in terms of significance.

5.3. Conclusions and recommendations for future research

Although the results of the present study should be interpreted with caution, it documented that cognition does influence functional status at discharge in older multimorbid hospitalised patients. Practical implications of these findings relate to standard diagnostic procedures in the clinical setting and post-discharge management policies aiming to take advantage of the protective role of intact cognition. So, for example, early cognitive testing and MPI calculation in multimorbid older inpatients contribute to uncovering undiagnosed cognitive deficits and dementia so that an appropriate therapy schema with cognitive training and antidementiva be timely started. Research has shown a beneficial effect of antidementiva therapy in older adults with low frailty/ poor prognosis risk, which resulted in prolonged survival rates (Pilotto et al., 2018). It has also been shown that simultaneous cognitive and physical training, nutrition optimisation, and reduction of cardiovascular risk in individuals with a risk of developing dementia may slow cognitive decline (see Frisoni et al., 2023). What is more, the differentiating and predictive value of cognitive performance upon admission on functional status at discharge could be taken advantage of to target during hospitalisation suitable patients (BI ≥60) for subsequent rehabilitation programmes after hospital discharge. Cognitive assessment may, therefore, be valuable in planning in-hospital therapeutic procedures, post-discharge management, and preventive strategies and should constitute an integral part of standard diagnostic schemata in geriatric settings.

Furthermore, this study raises additional questions on the complex relationship of cognitive performance with the investigated outcomes, such as which specific cognitive domains, except for executive functions, would be most relevant for these endpoints or the direction of causality between cognition and the investigated outcomes. For example, does impaired cognition lead to functional deficits, or is the inverse relationship the case? More longitudinal prospective studies or randomised controlled studies are warranted to answer such questions. Future research should investigate these issues with larger samples in the context of multicentre projects. Further matters of interest include the influence of cognition on adverse outcomes during hospitalisation in older multimorbid patients, such as in-hospital sarcopenia or risk of falls, as well as its association with the duration of hospitalisation, weekly MPI change during this time and the need for supporting nursing care at home after hospital discharge. Future research findings could contribute to establishing more efficient management policies for older multimorbid patients at risk of adverse events during hospitalisation and post-discharge and help reduce their incidence.

6. Literature

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7. Appendix

7.1. List of figures

7.2. List of tables