Role of a multidimensional prognosis in-hospital monitoring for older patients with prolonged stay

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Abstract
Objectives: The Multidimensional Prognostic Index (MPI) is a prognostic tool—amongst others—validated for mortality, length of hospital stay (LHS) and rehospitalisation risk assessment. Like the Comprehensive Geriatric Assessment (CGA), the MPI is usually obtained at hospital admission and discharge, not during the hospital stay. The aim of the present study was to address the role of an additional CGA-based MPI measurement during hospitalisation as an indicator of “real-time” in-hospital changes.

Study design and main outcome measures: Two-hundred consecutive multimorbid patients (128 M, 72 F, median age 75 (78-82)) admitted to an internal medicine ward of a German metropolitan university hospital prospectively underwent a CGA and a prognosis calculation using the MPI on admission and discharge. Seven to 10 days later, an intermediate assessment (IA) was performed for patients needing a longer stay.

Results: The median LHS was 10 (6-19) days. As expected, patients who received an IA had poorer prognosis as measured by higher MPI values (P = .037) and a worse functional status at admission than patients who had a shorter stay (P = .025). In case of prolonged hospitalisation, significant changes in the MPI were detected between admission and IA, both in terms of improvement and deterioration (P < .001). Different overtime courses were observed during prolonged hospitalisation according to the severity of prognosis (P < .001).

Conclusion: A CGA-based MPI evaluation during hospitalisation can be used as an objective instrument to detect changes in multidimensional health course. Prompt identification of the latter may enable quick tailored interventions to ensure overall better outcomes at and after discharge.

1 | BACKGROUND

The challenge of treating multimorbid older patients in order to achieve the best possible outcome is a central theme in medicine. It is widely known that hospitalisation itself is an additional risk factor for older patients regardless of their underlying disease. Possible sarcopenia, malnutrition, delirium and polypharmacy often complicate and prolong the hospital stay. For older people living alone, there is also a risk of longer hospitalisation time. Additionally, because of physiological age-related changes and frailty, adverse events after mild interventions occur more often than in younger adults and can lead patients into...
a downward spiral—the so-called geriatric cascade—at the end of which death occurs.⁴ Although hospitalisation–related risks in advanced age are well recognised,⁵ there is still a substantial lack of evidence about the actions to be taken in clinical routine to avoid poor outcomes.⁶ In general, the use of the Comprehensive Geriatric Assessment (CGA)⁷ is associated with the improvement of a number of key performance indicators including mortality, re-hospitalisation, onset of cognitive impairment and depression and admission in long-term care facilities.⁸,⁹ However, there are numerous barriers to the routine use of the CGA and related instruments in older multimorbid patients and its use is still largely confined to geriatric settings.¹⁰ There is a gap between knowledge of multidimensional needs of older persons with disease and actual organ-centred interventions in usual care. In fact, the geriatric team usually addressing psychosocial and functional aspects beyond (and often behind) the medical burden,⁹ remains to date the main instrument of geriatric medicine, not of the medicine of the older person. Accordingly, the CGA is used exclusively in geriatric settings, in its typical performance twice during hospitalisation: at admission and at discharge. However, recently the CGA-based Multidimensional Prognostic Index (MPI)¹¹ was shown to profoundly impact the characterisation of older multimorbid inpatients admitted to non-geriatric wards.¹²-¹⁴ In the setting object of our investigation—an acute internal medicine ward of a large German university hospital—admitted patients undergo highly specialised, technology-based, innovative clinical approaches which fall usually within the terminological frame of “high-performance medicine” or “high care”, but frequently display high potential for side effects in advanced age.⁴,⁵

The MPI has previously shown to enable the close monitoring of patients’ trajectories after hospitalisation and potentially during hospital stay.¹,¹⁵,¹⁶ As it is not known to date whether an additional in-hospital MPI calculation aids the clinical evaluation of older multimorbid patients, this study was aimed at measuring the MPI not only on admission and at discharge, but also during the stay of inpatients undergoing “high-performance medicine” in an internal medicine department of a German metropolitan university hospital.

2 | PATIENTS AND METHODS

The study was registered at the German Clinical Trials Register (DRKS00013791) and complies with the Declaration of Helsinki. The Ethical Committee of the University Hospital of Cologne approved the study. All patients (or proxy respondents, when medical record indicated incapacity to give informed consent) signed informed consent to participate.

2.1 | Patients

Two hundred patients were prospectively enrolled in the study between June 2017 and November 2018. Recruitment was carried out in the Department of Nephrology, Rheumatology, Diabetology and General Internal Medicine of the University Hospital Cologne. Inclusion criteria were age over 70 years, at least two chronic diseases and a hospitalisation period longer than four days. Exclusion criteria were a refusal to participate in the study, language barrier and a hospitalisation period of less than 4 days.

2.2 | Comprehensive Geriatric Assessment and Multidimensional Prognostic Index

All patients were enrolled to undergo a CGA with a prognosis calculation using the MPI¹¹ as previously described.¹²,¹³ Briefly, Activities of Daily Living (ADL),¹⁷ Instrumental Activities of Daily Living (IADL),¹⁸ Mini-Nutritional Assessment-Short Form (MNA-SF),¹⁹ Short Portable Mental Status Questionnaire (SPMSQ),²⁰ Cumulative Illness Rating Scale (CIRS)²¹ and Exton Smith Scale (ESS)²²—as well as the number of drugs taken by the patient and living conditions¹⁶,²³—were collected to calculate the MPI, which generates continuous values between 0 and 1. These can be divided into three risk groups, MPI-1 (0.00-0.33), MPI-2 (0.34-0.66) and MPI-3 (0.67-1.00), to inform low (MPI-1), medium (MPI-2) and high (MPI-3) risk of mortality, rehospitalisation, admission in long-term care facilities, increase of nursing needs amongst others, 1, 3, 6, 12 months after initial evaluation.¹,¹³,¹⁶,²⁴

For the purpose of this investigation, the CGA-based MPI was performed at admission and discharge as per standardised procedures in all patients¹,¹⁸,⁹,¹⁶ as well as at an additional timepoint after 7-10 days in patients needing a stay longer than one week (intermediate assessment, IA). If patients were about to be discharged on the 7th day of hospitalisation, the IA was not performed.
In all patients, main and secondary diagnoses, geriatric syndromes (including polypharmacy, instability, incontinence, inanition, immobility, irritability/depression, cognitive impairment, insomnia, impoverishment, swallowing disorders, chronic pain, sensorial impairment, irritable colon, iatrogenic disease, social isolation, fluid/electrolyte disorders and incoherence/delirium) and resources (physical resources, good living conditions, social, economic, competence-related, intellectual, spiritual, motivational, emotional and mnemonic resources) were also collected as previously described.13

2.3 Statistical analysis

The IBM SPSS 26 software was used for statistical analysis. Descriptive statistics are expressed using absolute numbers and relative frequencies for categorical variables and means (and standard deviation, SD) or medians (and interquartile range, IQR) for continuous variables. All continuous variables were tested for normal distribution using the Kolmogorov-Smirnov test and t-test or non-parametric tests were used for comparisons amongst groups. Only the number of drugs taken at admission was normally distributed, all other continuous variables were not normally distributed. Rates were compared by Chi-square test or Fisher’s exact test.

3 RESULTS

3.1 Study population

Of 200 patients, 36% were female. The median age was 78 (75-82) years and the average MPI at admission 0.52 (±0.19) points. The median length of hospital stay (LHS) was 10 (6-19) days and the mean number of medications taken was 9.4 (±3.7) per day. Diagnoses, other clinical characteristics including the most frequent geriatric syndromes observed in our sample are described in Table 1.

3.2 MPI-prognosis at admission

Sixty-one % of the patients did not receive an IA, as they were discharged after 7-9 days. Thirty-nine % received an IA after 7-10 days. As displayed in Table 1, and as expected, patients with an IA because of prolonged stay showed a significantly poorer multidimensional prognosis at admission with respect to patients with a shorter stay (0.55 IA vs 0.50, P = .037). Activities of daily living (ADL) were significantly more impaired and decubitus risk (ESS) significantly increased in patients who had to stay in the hospital for an extended period compared with patients discharged at one week (ADL: 5 (3-6) vs 3 (2-5), P = .006; ESS: 16 (13-18) vs 14 (10-17), P = .020). Patients in the long-stay group suffered from significantly more geriatric syndromes (5 (3-7) IA vs 6 (5-8), P = .001) than those in the short-stay group. Amongst the most frequent geriatric syndromes, immobility was significantly more common in the long-stay group (65.4% IA vs 44.3%, P = .004) than in the short-stay group. In line with these findings, significantly more patients with an IA received home care (33.3% IA vs 18.0%, P = .015).

3.3 MPI-Prognosis at discharge

While both patient groups displayed a mild overall health improvement at discharge, the mean MPI of patients without an IA was 0.48 significantly lower than for patients with an IA: 0.54 (P = .032). ADL values at the discharge of IA patients were significantly worse compared with those with a shorter stay (P = .001). The need for future rehospitalisation (52.8%, P = .004) and the number of requested home care services (13.9%, P = .002) after discharge were significantly higher in patients receiving an IA compared with patients who did not. MPI domains, distribution of the MPI risk groups and follow-up on discharge are displayed in Table 2.

3.4 MPI changes during hospitalisation in patients receiving an IA

To assess characteristics and possible reasons for MPI changes between admission and discharge, patients who received an IA were divided for the analysis into three groups: improvement, no change and worsening—referred to as the comparison of the MPI at admission with the MPI at discharge. Three patients were excluded from this analysis because the MPI at discharge was missing. Patients having no change in MPI were significantly older than patients with a change (84 no change vs 78 improvement vs 77.5 worsening, P = .017). According to the admission status, patients who had a worsening of MPI were significantly more likely to come as new admission (60% worsening vs 31.6% no change, vs 22.2% improvement, P = .001), while patients who entered the ward as an internal referral (i.e., admitted from an in-hospital department) had a significantly higher chance of having an improvement in MPI score at discharge than patients from an external ward (69.4% vs 2.8%, P = .001). Within the MPI domains, only for the ESS statistical significance could be found at the IA and discharge. Patients with a worsening of MPI had significantly lower ESS values at the IA than patients with an improvement (12.5 (10-16) worsening vs 16 (14.25-18) improvement, P = .016) and these values remained almost constant up until discharge (12.5 (10.25-15.75) worsening vs 16.5 (15.25-18) improvement, P = .002) (Table 3).

Patients whose MPI did not change between admission and discharge belonged mainly to MPI-2 (47.4%) and 3 (42.1%). The mean MPI at admission and discharge was 0.57, the IA showed a slight improvement to 0.54. This improvement, which was seen in 31.6% of the patients, was relativised until discharge (Figure 1).

Patients whose MPI improved between admission and discharge could be classified to MPI-2 (58.3%) and MPI-3 (41.7%), 77.1%
| Demographic | Total (N = 200) | No intermediate assessment (N = 122, 61.0%) | Intermediate assessment (N = 78, 39.0%) | P-value |
|-------------|----------------|------------------------------------------|---------------------------------------|---------|
| Age (y), median (IQR) | 78 (75-82) | 78 (74-82) | 78 (76-83.5) | .428 |
| Female, n (%) | 72 (36.0) | 41 (33.6) | 31 (39.7) | .378 |
| LHS, median (IQR) | 10 (6-19) | 6 (4.75-9) | 19 (13-28.50) | <.001* |
| Education (y), median (IQR) | 12 (10-15) | 12 (11-15) | 12 (10-13) | .235 |
| Level of Educational requirements, median (IQR) | 2 (2-3) | 2 (2-3) | 2 (1-3) | .674 |
| Admission status, n (%) | | | | .161 |
| New admission to hospital | 90 (45.0) | 62 (50.8) | 28 (35.9) | |
| Transferred from internal ward | 83 (41.5) | 47 (38.5) | 36 (46.2) | |
| Transferred from external ward | 21 (10.5) | 11 (9.0) | 10 (12.8) | |
| Missing | 6 (3.0) | 2 (1.7) | 4 (5.1) | |
| Reason for admission, n (%) | | | | .453 |
| Kidney failure | 79 (39.5) | 48 (39.3) | 31 (39.7) | |
| Acute infection | 45 (22.5) | 29 (23.8) | 16 (20.5) | |
| Respiratory disease | 12 (6.0) | 7 (5.7) | 5 (6.4) | |
| Bleeding/Aneamia | 9 (4.5) | 7 (5.7) | 2 (2.6) | |
| Cardiovascular disease | 10 (5.0) | 5 (4.1) | 5 (6.4) | |
| Endocrinologic disease | 8 (4.0) | 5 (4.1) | 3 (3.8) | |
| ≥2 diagnoses on admission | 127 (63.5) | 81 (66.4) | 46 (59.0) | .288 |
| MPI groups, n (%) | | | | .058 |
| MPI-1 | 39 (19.5) | 29 (23.8) | 10 (12.8) | |
| MPI-2 | 107 (53.5) | 66 (54.1) | 41 (52.6) | |
| MPI-3 | 54 (27.0) | 27 (22.1) | 27 (34.6) | |
| MPI-value, mean (SD) | 0.52 (0.19) | 0.50 (0.19) | 0.55 (0.17) | .037* |
| MPI domains, median (IQR) | | | | |
| CIRS | 5 (4-6) | 5 (4-6) | 5 (4-6) | .690 |
| ADL | 4 (2-6) | 5 (3-6) | 3 (2-5) | .006* |
| IADL | 4 (2-7) | 4 (2-7) | 4 (2-7) | .396 |
| MNA-SF | 9 (6-11) | 9 (6-11) | 8 (6-10) | .237 |
| SPMSQ | 1 (1-2) | 1 (1-2) | 1 (1-2) | .827 |
| ESS | 15 (12-17) | 16 (13-18) | 14 (10-17) | .020* |
| Number of medications | 9 (7-12) | 9 (7-12) | 10 (7-13) | .237 |
| Living conditions, n (%) | | | | .299 |
| With relatives (low risk) | 131 (65.5) | 85 (69.7) | 46 (59.0) | |
| Institutionalised/private attendant (moderate risk) | 17 (8.5) | 9 (7.4) | 8 (10.2) | |
| Alone (high risk) | 52 (26.0) | 28 (22.9) | 24 (30.8) | |
| Geriatric Syndromes, n (%) | | | | |
| Insomnia | 106 (53.0) | 63 (51.6) | 43 (55.1) | .630 |
| Polypharmacy (>6 drugs/d) | 171 (85.5) | 102 (83.6) | 69 (88.5) | .342 |
| Sensorial Impairment | 105 (52.5) | 61 (50.0) | 44 (56.4) | .376 |

(Continues)
experienced an improvement up until the IA. At discharge, 19.4% improved up to MPI-1 and 8.3% belonged to MPI-3 (Figure 1).

Patients whose MPI deteriorated between admission and discharge belonged to MPI-1 (35.0%) and MPI-2 (45.0%). In most (73.7%) patients, the prognosis worsened until the IA. At discharge, 60.0% of the patients were assigned to MPI-2 and 35.0% to MPI-3, none was in MPI-1 (Figure 1).

The Delta-MPI—thus the absolute changes in the MPI score—was statistically significant between the three time points (admission, IA, discharge, \( P < .001 \)).

From admission to IA there were major changes (−0.08 (±0.07) improvement, −0.02 (±0.06) no change, 0.08 (±0.11) worsening) compared with between IA and discharge (−0.03 (±0.05) improvement, 0.02 (±0.06) no change, 0.04 (±0.07) worsening) (Figure 2).

### 4 | DISCUSSION

The present study shows for the first time that the MPI detects inhospital changes in the multidimensional health of older multimorbid patients. This vigorously supports the evidence that the MPI can function as a monitoring tool during hospitalisation, especially for patients with a prolonged hospital stay. An IA after seven to ten days enables clinical professionals to monitor their patients not only on the basis of organ-related cut-offs, but multidimensionally, ie, related to the overall health. If any changes in the MPI are detected, actions can be taken in real-time in order to contrast any clinical deterioration. This observation is particularly relevant, for instance, in case of organ failure or acute infection (45.0% and 15.0%, \( P < .006 \)) and were mostly hospitalised for acute kidney failure or acute infection (45.0% and 15.0%, \( P = .679 \)). Patients who are admitted acutely to hospital often deteriorated in terms of activities of daily living, physical resources and social support. The fact that the deterioration was most evident in patients with the youngest chronological age shows that a stay in hospital is a high possibility of losing independence, especially for older people who have lived independently up to this point. In addition, this might suggest that chronological health is less critical for the risk of poor outcomes than the multidimensional frailty status, of which the MPI is an indicator and which is a surrogate marker of biological age. In the clinical routine, younger patients might be intuitively considered more robust and fit and this way they may get suboptimal functional training during the hospital stay. Although this group is assumed to be the group with lowest risk of poor outcomes, it is, indeed—based on our findings—the real-risk group. Therefore, a comprehensive evaluation and support of the patients during hospitalisation is highly important and should not be primarily based on chronological age. If an IA...
reveals deterioration in the MPI, immediate action can be taken. With respect to this, it should be noted that in the setting object of the present investigation, a nephrology department, an initial diagnosis of a nephrological disease is a frequent occurrence. This often represents an important turning point in patients’ lives and might contribute to the observed overall worsening, suggesting that not only known high-risk patients, but also apparently milder cases as new admissions should be promptly helped to cope with the new diagnosis.

Patients whose MPI remained stable were, as described above, the oldest patients (84 years, \( P = .017 \)) and belonged mainly to MPI-2 and -3 (47.4% and 42.1%, \( P = .006 \)). The most frequent reasons for admission were, again, acute kidney failure or acute infection (42.1% and 15.8%, \( P = .679 \)). Then why is not the prognosis of these patients worsening the same as the patients’ prognosis mentioned above? When explicitly looking at the eventual occurrence of any acute clinical events causing the MPI-worsening, it was not possible to detect any in-hospital events which occurred more frequently in the deterioration group than in the stable MPI.

### TABLE 2 MPI prognosis and follow-up on discharge

| MPI groups, n (%) | Total (N = 200) | No intermediate assessment (N = 122, 61.0%) | Intermediate assessment (N = 78, 39.0%) | \( P \)-value* |
|------------------|-----------------|------------------------------------------|------------------------------------------|-----------------|
| MPI-1            | 44 (22.0)       | 33 (27.0)                                | 11 (14.1)                                | .091            |
| MPI-2            | 108 (54.0)      | 61 (50.0)                                | 47 (60.3)                                |                |
| MPI-3            | 42 (21.0)       | 24 (19.7)                                | 18 (23.1)                                |                |
| Missing          | 6 (3.0)         | 4 (3.3)                                  | 2 (2.6)                                  |                |
| MPI-value, mean (SD) | 0.50 (0.18)  | 0.48 (0.18)                              | 0.54 (0.18)                              | .032*           |

### MPI domains, median (IQR)

| Domain       | MPI-1 | MPI-2 | MPI-3 | \( P \)-value |
|--------------|-------|-------|-------|--------------|
| CIRS         | 5 (4-6) | 5 (4-6) | 5 (4-6) | .279         |
| ADL          | 4 (3-6) | 5 (3-6) | 4 (2-5) | .001*        |
| IADL         | 4 (2-7) | 4 (3-7) | 3.5 (2-6) | .136         |
| MNA-SF       | 8.5 (3-11) | 9 (2-11) | 8 (3-11) | .585         |
| SPMSQ        | 1 (1-2) | 1 (1-2) | 1 (1-2) | .837         |
| ESS          | 16 (13-18) | 16 (14-19) | 16 (12-18) | .159         |
| Number of medications | 10 (8-12) | 9 (7-12) | 10 (7-13) | .315         |

### Follow-Up at discharge, n (%)

| Follow-Up at discharge | Total (N = 200) | No intermediate assessment (N = 122, 61.0%) | Intermediate assessment (N = 78, 39.0%) | \( P \)-value |
|------------------------|-----------------|------------------------------------------|------------------------------------------|--------------|
| Patient alive          | 184 (92.5)      | 112 (91.8)                               | 72 (93.5)                                | .763         |
| Fall during hospitalisation | 8 (4.4)      | 5 (4.5)                                  | 3 (4.2)                                  | 1.000        |
| Rehospitalisation planned | 73 (39.9)   | 35 (31.5)                                | 38 (52.8)                                | .004*        |
| Institutionalisation requested | 5 (2.7)       | 4 (3.6)                                  | 1 (1.4)                                  | .650         |
| Grade of Care requested | 9 (4.9)       | 4 (3.6)                                  | 5 (6.9)                                  | .486         |
| Home care requested    | 12 (6.6)        | 2 (1.8)                                  | 10 (13.9)                                | .002*        |
| Medical consultation requested | 163 (89.1) | 95 (85.6)                                | 68 (94.4)                                | .061         |

Note: \( P \)-value was calculated with non-parametric methods comparisons for continuous variables, rates were compared by Chi-square test or Fisher’s exact test, significant at 5% (*). Abbreviations: ADL, Activities of Daily living; CIRS, Cumulative Illness Rating Scale; ESS, Exton Smith Scale; IADL, Instrumental Activities of Daily living; LHS, Length of hospital stay; MNA-SF, Mini Nutritional Assessment-Short form; MPI, Multidimensional Prognostic Index; SPMSQ, Short Portable Mental Status Questionnaire.
| TABLE 3 | MPI changes during hospitalisation in patients receiving an IA |
|---------|-------------------------------------------------------------|
|         | Improvement N = 36 (46.1%) | No change N = 19 (24.3%) | Worsening N = 20 (25.6%) | P-value* |
| Demographic | | | | |
| Age, median (IQR) | 78 (74.25-82) | 84 (78-87) | 77.5 (74.25-82) | .017* |
| Female, n (%) | 11 (30.6) | 8 (42.1) | 12 (60.0) | .100 |
| LHS, median (IQR) | 17.5 (13-22) | 16 (13-26) | 24 (12.25-33.5) | .436 |
| Admission status, n (%) | | | | .001* |
| New admission | 8 (22.2) | 6 (31.6) | 12 (60.0) | |
| Internal ward | 25 (69.4) | 8 (42.1) | 3 (15.0) | |
| External ward | 1 (2.8) | 4 (21.1) | 5 (25.0) | |
| Missing | 2 (5.6) | 1 (5.2) | 0 (0.0) | |
| MPI-value, mean (SD) | | | | .073 |
| Admission | 0.58 (0.14) | 0.57 (0.17) | 0.44 (0.19) | |
| Intermediate assessment | 0.51 (0.16) | 0.54 (0.19) | 0.55 (0.19) | .684 |
| Discharge | 0.47 (0.14) | 0.57 (0.17) | 0.60 (0.17) | .026* |
| Delta-MPI, mean (SD) | | | | <.001* |
| Admission-intermediate assessment | -0.08 (0.07) | -0.02 (0.06) | 0.08 (0.11) | |
| Intermediate assessment-discharge | -0.03 (0.05) | 0.02 (0.06) | 0.04 (0.07) | <.001* |
| Admission-Discharge | -0.11 (0.06) | 0.00 (0.00) | 0.12 (0.07) | <.001* |
| MPI risk groups at admission, n (%) | | | | .006* |
| MPI-1 (low risk) | 0 | 2 (10.5) | 7 (35.0) | |
| MPI-2 (medium risk) | 21 (58.3) | 9 (47.4) | 9 (45.0) | |
| MPI-3 (high risk) | 15 (41.7) | 8 (42.1) | 4 (20.0) | |
| MPI risk groups intermediate assessment, n (%) | | | | .857 |
| MPI-1 (low risk) | 6 (16.7) | 4 (21.1) | 4 (20.0) | |
| MPI-2 (medium risk) | 19 (52.8) | 7 (36.8) | 9 (45.0) | |
| MPI-3 (high risk) | 11 (30.5) | 8 (42.1) | 7 (35.0) | |
| MPI changes until intermediate assessment groups, n (%) | | | | <.001* |

(Continues)
This underlines the advantage of a multidimensional view on patients with respect to the only physical health condition and clarifies the fact that in advanced age a clinical worsening of the general conditions is usually not related to an easily identifiable nosocomial event.6

Patients’ resilience might also play an important role. Resilience is the personal capacity to react to a stressor—eg, hospitalisation, an acute disease or a relapse of a chronic condition—and the ability to restore the original physical and mental state that the patient had before the stressor.32,33 Resilience, however, is a factor that is very difficult to quantify,34 which is why a CGA-based MPI during hospitalisation again seems to make sense in order to create an objective assessment of the patient’s condition—physical, psychological, social and functional9—for all the actors involved.

Patients whose MPI improved were most often admitted as an in-hospital transfer (69.4%, \(P = .001\)) and belonged only to MPI-2 and 3 (58.3% and 41.7%, \(P = .006\)). In this setting, these patients often were taken over from ICU. They might have received more attention from the very beginning from the doctors, nurses and especially therapists, who usually have accompanied these patients since their time in the ICU. An already formed team could be considered strong support for the patients and a motivation to keep on progressing.5

The benefit of everyday clinical practice that can be deduced from this study is relevant. The assessment of the patient’s overall potential, ie, physical, psychological, functional and social,9 is currently the responsibility of experienced doctors and nurses. Up to now, there has been—to our knowledge—no established screening instrument for changes during the hospital stay. A CGA-based MPI could fill this gap.10 Based on the findings of this study, the major changes show up already after 7-10 days (for improvement -0.08 to -0.11 in total, -0.02 of 0.00 in total for no change and 0.08 of 0.12 in total for worsening, \(P < .001\)), a multidimensional assessment only at admission and discharge might be not sufficient to catch deviations from the expected outcome during therapeutic management. An IA makes intervention possible, through, eg, occupational therapy, physiotherapy or social support and could enable patients to be discharged with multidimensionally improved health beyond “high-performance organ medicine.”

As a limitation of the study, it must be considered that the patient population is mostly nephrological patients, which are a particularly vulnerable population.30,35 They enter the hospital with a focus on this specialised organ-oriented therapy. The goal is to leave the hospital quickly. Thus, patients in this study seem to benefit greatly from the combination of multidimensional organic and functional treatment.10 In addition, the sample of patients who received an IA is 78 relatively low. In order to make precise statements on the improvement of prognosis in patients who have been hospitalised for a longer time, it must be investigated whether prompt identification through an IA during hospitalisation and the treatment of deterioration in multidimensional health of patients leads to improved outcome. The next step will, therefore, be large intervention studies that directly counteract patients when deterioration in group. This underlines the advantage of a multidimensional view on patients with respect to the only physical health condition and clarifies the fact that in advanced age a clinical worsening of the general conditions is usually not related to an easily identifiable nosocomial event.6
their multidimensional prognosis is detected. The outcome of these treated patients may be of great importance for the clinical care of older people.

5 | CONCLUSION

In conclusion, this study shows that the MPI can serve not only as a tool for long-term mortality, rehospitalisation and institutionalisation prediction, but also to dynamically monitor in-hospital changes in multidimensional health of older multimorbid inpatients. In-hospital clinical worsening is often—as outlined in this study—because of functional rather than disease-centred reasons in advanced age. Therefore, the fast uncovering of course change beyond organ cut-offs might enable tailored interventions to achieve the best possible outcome. Especially patients with a “young” chronological age at hospital admission are at risk of overall deterioration. Thus, the identification of patients’ frailty—as a predictor of patients’ biological age—and the prompt action if worsening of the multidimensional prognosis occurs might be crucial to avoid poor outcomes.

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DISCLOSURE

The authors declare that they have no competing interests. The results of this study have been presented in part in german at the annual Congress of the German Society for Internal Medicine (DGIM) in Mannheim (14th-17th of April 2018) and the annual congress of the

FIGURE 1  Course of the MPI during hospitalisation—subdivided for risk groups. Course of the MPI in patients who received an intermediate assessment. The course is shown separately for the three risk groups: MPI-1 (A, low risk, bottom graph, N = 9), MPI-2 (B, medium risk, middle graph, N = 41), MPI-3 (C, high risk, top graph, N = 27). The scores represent the means (± SD). *P-value <.001 for differences between MPI-risk groups (low, medium, high) and MPI at recruitment, MPI at IA and MPI at discharge

FIGURE 2  Course of the MPI during hospitalisation: improvement, no change and worsening. Course of the MPI in patients who received an intermediate assessment. The course is shown separately for the three possible courses between hospital admission and discharge: Worsening of MPI (X, bottom graph, N = 36), No change in MPI (Y, middle graph, N = 19), Improvement of MPI (Z, top graph, N = 20). The scores represent the means (±SD). The Delta-MPI values for X (P <.001), Y (P <.001) and Z (P <.001) are significant. This graph highlights that already at the time of the IA there is a trend towards improvement or deterioration in the multidimensional health of the patients
German Geriatric Society (DGG) in Cologne (7th-11th of September 2018), both as poster presentations.

AUTHORS CONTRIBUTIONS
Conceived and designed the clinical trial: LP, AMM, MCP. Performed the experiments: LP. Analysed the data: LP IB. Wrote the paper: LP. Conception of the manuscript: LP, AMM, MCP. IB. Critical revisions: LP, AMM, IB, AH, NN, PB, AP, TB, MCP.

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