25. Maki KC, Dicklin MR, Baum SJ. Statins and diabetes. Cardiol Clin 2015; 33: 233–43.
26. Szadkowska I, Stanczyk A, Aronow WS *et al*. Statin therapy in the elderly: a review. Arch Gerontol Geriatr 2010; 50: 114–8.
27. Williams B. The changing face of hypertension treatment: treatment strategies from the 2007 ESH/ESC hypertension guidelines. J Hypertens Suppl 2009; 27: S19–26.
28. Munther P, DeSalvo KB, Wildman RP, Raggi P, He J, Whelton PK. Trends in prevalence, awareness, treatment and control of cardiovascular disease risk factors among noninstitutionalized patients with a history of myocardial infarction and stroke. Am J Epidemiol 2006; 163: 913–20.
29. Farshad F, Mariedl MF, Gooarz D *et al*. National, regional and global trends in serum total cholesterol since 1980: systematic analysis of health examination surveys and epidemiological studies with 321 country-years and 3.0 million participants. Lancet 2011; 377: 578–86.
30. Ostchega Y, Dillon CF, Hugher JP *et al*. Trends in hypertension prevalence, awareness, treatment and control in older US adults: data from the National Health and Nutrition Examination surveys 1988 to 2004. J Am Geriatr Soc 2007; 55: 1056–65.

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The Multidimensional Prognostic Index predicts in-hospital length of stay in older patients: a multicentre prospective study

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Abstract

Background: prediction of length of stay (LOS) may be useful to optimise care plans to reduce the negative outcomes related to hospitalisation.
Objective: to evaluate whether the Multidimensional Prognostic Index (MPI), based on a Comprehensive Geriatric Assessment (CGA), may predict LOS in hospitalised older patients.
Design: prospective multicentre cohort study.
Setting: twenty Geriatrics Units.
Participants: patients aged 65 and older consecutively admitted to Geriatrics Units.
Measurement: at admission, the CGA-based MPI was calculated by using a validated algorithm that included information on basal and instrumental activities of daily living, cognitive status, nutritional status, the risk of pressures sores, co-morbidity, number of drugs and co-habitation status. According to validated cut-offs, subjects were divided into three groups of risk, i.e. MPI-1 low risk (value ≤0.33), MPI-2 moderate risk (value 0.34–0.66) and MPI-3 severe risk of mortality (value ≥0.67).

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Results: two thousand and thirty-three patients were included; 1,159 were women (57.0%). Age- and sex-adjusted mean LOS in patients divided according to the MPI grade was MPI-1 = 10.1 (95% CI 8.6–11.8), MPI-2 = 12.47 (95% CI 10.7–14.68) and MPI-3 = 13.41 (95% CI 11.5–15.7) days (*P* for trend <0.001). The overall accuracy of the MPI to predict LOS was good (C-statistic 0.74, 95% CI 0.72–0.76). Moreover, a statistically significant trend of LOS means was found even in patients stratified according to their International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM) main diagnosis.
Conclusions: the MPI is an accurate predictor of LOS in older patients hospitalised with the most frequent diseases.

Keywords: *older people, length of stay, Multidimensional Prognostic Index, mortality*

Introduction

Hospitalisation in older people is a dramatic event that can lead to complications and death more frequently than in younger subjects with consequences that may involve patients, their caregivers and the healthcare system. Indeed, older adults account for almost 50% of all inpatient hospitalisation days [1] and have a higher risk of disability in the activities of daily living (ADL) [2, 3], length of in-hospital stay (LOS) [4] and mortality during hospitalisation and after hospital discharge than young adult subjects [5].

The need for validated and reliable prognostic tools to improve clinical decision-making in older patients with different risk of negative health outcomes has been recently reported [6]. As expected, administrative instruments, such as the Diagnostic Related Groups (DRG), failed to correctly represent the complex clinical care and needs of the older patient. In fact, LOS and costs of hospitalisation were significantly higher in older than in young and/or adult patients grouped into the same DRG group [7, 8]. Indeed, adjusting the DRG for functional status, i.e. ADL [9], or the all patient refined-DRG system (APR-DRG) that includes into the system the disease severity and the mortality risk [10], may predict in-hospital LOS and costs better than standard DRG in older patients.

Recently, the Multidimensional Prognostic Index (MPI), a predictive tool of mortality based on a standardised Comprehensive Geriatric Assessment (CGA), has been developed and validated [11] in several acute and chronic clinical conditions of hospitalised older patients. As recently reported [12, 13], the MPI showed good accuracy, with C-statistics values reaching roughly 0.80 in the different cohorts studied, and excellent calibration with <10% of differences between predicted and observed mortality rates, in estimating both short- and long-term mortality in hospitalised older patients with the most common conditions leading to death [14]. Moreover, the MPI demonstrated significantly higher accuracy than three other frailty instruments, in predicting all-cause mortality both at 1 month and 1 year of follow-up in hospitalised older patients [15]. In addition, a recent study showed that MPI correctly estimates the probability of death in cognitive impairment outpatients during a maximum observation period of ∼4 years, and the probability of hospitalisation for acute events in the 12 months following the date of evaluation [16]. At present, however, it is not known whether the MPI may predict the in-hospital LOS in hospitalised older patients with different clinical diseases. The aim of this multicentre prospective study was to evaluate whether the MPI may predict in-hospital LOS in older patients admitted to geriatrics units for an acute disease or a relapse of a chronic disease.

Methods

Study population

This was a prospective multicentre cohort study conducted according to the Declaration of Helsinki and the guidelines for Good Clinical Practice. Prior to begin was approved by local Ethics Committee. All patients aged 65 and older admitted to the hospital due to acute disease or relapse of a chronic disease in 20 Italian Geriatric Wards from 1 February to 31 March 2008 were screened for eligibility. Inclusion criteria were: (i) age ≥65 years; (ii) ability to provide an informed consent or availability of a proxy for informed consent; (iii) a standardised CGA to calculate the MPI at the hospital admission. The main and secondary diagnoses at discharge from the hospital, coded according to the Italian translation of the International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM), were also recorded in all patients. Disease sub-groups were identified using the official major categories specifically designed to include a set of similar diseases. In-hospital mortality was also recorded in all patients.

Multidimensional Prognostic Index

The Multidimensional Prognostic Index (MPI) was calculated from the data derived from a standard CGA carried out using assessment instruments widely used in geriatric practice that included information on the following eight domains: functional status evaluated with the ADL [17] and the instrumental ADL (IADL) [18] scales; cognitive status evaluated by the Short Portable Mental Status Questionnaire (SPMSQ) [19]; nutritional status evaluated by the Mini Nutritional Assessment (MNA) [20], the risk of developing pressure sores evaluated by the Exton Smith Scale (ESS) [21]; co-morbidity was examined using the Cumulative Illness Rating Scale (CIRS) [22]; moreover, the number of drugs taken by patients at admission and the co-habitation status, i.e. alone, in family or in institute, were also recorded. For each domain, a tripartite hierarchy was used, i.e. 0 = no

problems, 0.5 = minor problems and 1 = major problems, based on conventional cut-off points derived from the literature for the ADL and IADL [23], SPMSQ [19], MNA [20] and the ESS [21] or observing the frequency of distribution of patients in the previous validation study for co-morbidities and number of medication [11]. (see Supplementary data, Appendix, available in *Age and Ageing* online.) The MPI value ranges between 0 (no risk) and 1 (higher risk) of mortality. Also, based on previously calculated cut-offs, the MPI was expressed as three grades of risk, i.e. MPI-1 (low risk MPI value ≤0.33), MPI-2 (moderate risk MPI value between 0.34 and 0.66) and MPI-3 (severe risk of mortality MPI value >0.66). Details on mathematical methods used to identify the best MPI cut-off points and validation of the algorithm have been reported elsewhere [11]. To calculate the MPI, a software for Windows may be downloaded (available for free) at the following address: http://www.mpiage.eu/home/about-mpi.

Statistical analysis

Patients' baseline characteristics were reported as mean ± standard deviation (SD) or frequencies and percentages for continuous and categorical variables, respectively. Baseline comparisons between men and women and between MPI grades were assessed using linear mixed-effects models, accounting for clustering due to centre effect. Rank analysis was performed for all continuous variables due to their skewed distributions. The overall in-hospital mortality rate was calculated as the number of death events per 100 person-months. Results were reported as hazard ratios (HRs) and 95% confidence intervals (95% CI). *Post hoc* pairwise comparisons of the estimated means between MPI grades were investigated through suitable contrasts, and *P* values were adjusted for multiple comparisons, following Hochberg's method.

Predicted risk probabilities were derived from the estimated Cox regression models. Models' calibration, i.e. the agreement between observed outcomes and predictions, was assessed using the survival-based Hosmer–Lemeshow (HL) goodness-of-fit test [24], a χ^2 test based on grouping observations into deciles of predicted risk and testing associations with observed outcomes. To evaluate the predictive role of the continuous MPI on patient's LOS, age- and sex-adjusted GLMMs (using Poisson distribution for modelling the response), accounting for clustering due to study sample effect, were also assessed. In addition, to evaluate the prognostic ability of continuous MPI to predict patients' long LOS, the well-established C-statistic was estimated using a logistic regression model, having dichotomised LOS considering values below and upper the third tertile (i.e. ≤10 versus >10 days). Such analyses were restricted to patients who survived during the hospitalisation only.

A *P* value of <0.05 was considered for statistical significance. All analyses were performed using SAS Release 9.3 (SAS Institute, Cary, NC, USA).

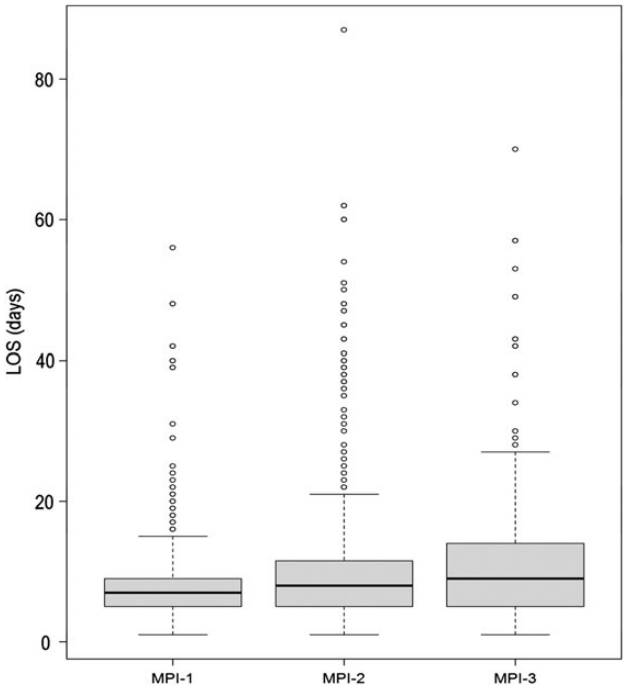

Figure 1. Box plot for LOS according to MPI grades for patients who survived during the hospitalisation only (*n* = 1,908).

Results

Characteristics of the study population

During the enrolment period, 2,322 consecutive patients were screened. One hundred and eleven subjects were excluded, because they were younger than 65 years, and 178 patients were excluded, because data collection was not completed. Thus, the final analysis was performed in 2,033 patients, 874 men (43%) and 1,159 women (57%), 851 (41.9%) in MPI-1, 743 (36.5%) in MPI-2, 439 (21.6%) in MPI-3, with a mean age of 79.8 ± 7.8 years. The baseline characteristics of the population stratified for MPI grade are shown in Table 1 along with pairwise comparisons. The overall in-hospital mortality rate was 19.7% for 100 persons-months, without significant differences between men and women. Considering MPI-1 as the reference group, the age- and sex-adjusted hazard ratios for in-hospital mortality were HR = 1.52 (95% CI = 0.79–2.92) for MPI-2 and HR = 5.69 (95% CI = 3.08–10.50) for MPI-3, respectively. At the median of 7 days of LOS, the in-hospital mortality prediction model that included continuous MPI only, yielded a survival C-statistic of 0.764 (95% CI = 0.707–0.821) along with a good calibration (HL *P* value: 0.833).Further details of the study population as well as the accuracy of the MPI in predicting 1-month and 1-year mortality, also in comparison with three other frailty instruments, have been previously reported elsewhere [15].

MPI and in-hospital LOS

For patients who survived during the hospitalisation (*n* = 1,908), estimates from Poisson models suggested that continuous

Table 1. Baseline characteristics of patients divided according to Multidimensional Prognostic Index (MPI) grades

Characteristics	Multidimensional Prognostic Index			*P* for trend[a]	Pairwise comparisons (*P* value[b])		
	MPI-1 (0–0.33)	MPI-2 (0.34–0.66)	MPI-3 (0.67–1)		1 versus 2	1 versus 3	2 versus 3
Patients (*n*, %)	851 (41.8)	743 (36.5)	439 (21.7)	–	–	–	–
Age (years)	76.63 ± 7.19	81.12 ± 7.36	83.68 ± 7.22	<0.001	<0.001	<0.001	<0.001
ADL score	5.75 ± 0.58	3.35 ± 2.20	0.60 ± 1.04	<0.001	<0.001	<0.001	<0.001
IADL score	6.50 ± 1.92	2.51 ± 2.32	0.44 ± 1.05	<0.001	<0.001	<0.001	<0.001
SPMSQ score	1.22 ± 1.39	2.93 ± 2.49	7.02 ± 3.30	<0.001	<0.001	<0.001	<0.001
Exton Smith score	18.55 ± 1.49	15.14 ± 2.47	10.70 ± 2.43	<0.001	<0.001	<0.001	<0.001
CIRS-CI score	2.39 ± 1.46	3.62 ± 1.81	4.64 ± 2.02	<0.001	<0.001	<0.001	<0.001
MNA score	24.62 ± 3.11	19.67 ± 4.12	13.40 ± 5.21	<0.001	<0.001	<0.001	<0.001
Drugs number	3.61 ± 2.56	5.02 ± 2.67	5.43 ± 2.70	<0.001	<0.001	<0.001	0.005
MPI value	0.19 ± 0.08	0.50 ± 0.09	0.76 ± 0.08	<0.001	<0.001	<0.001	<0.001
Case mix	1.33 ± 0.81	1.50 ± 1.25	1.64 ± 1.59	<0.001	<0.001	<0.001	<0.001
Length of stay (days)	7.89 ± 5.34	10.33 ± 9.88	11.38 ± 10.65	<0.001[c]	<0.001[c]	<0.001[c]	0.055[c]
In-hospital mortality rates (ev/pm, ir)[d]	14/220 (6.4)	31/252 (12.3)	80/164 (48.9)	<0.001[c]	0.040[c]	<0.001[c]	<0.001[c]

MPI-1, -2, -3: low, moderate and severe MPI grades, respectively.
[a]*P* values from linear mixed-effect models, accounting for clustering due to study sample effect.
[b]*P* values for pairwise comparisons between MPI grades, adjusted for multiple comparisons following Hochberg's method.
[c]*P* values from generalised linear mixed-effect models (using Poisson distribution for modelling the response), accounting for clustering due to study sample effect.
[d]ev/pm: events (deaths) divided by person-months; ir: events per 100 person-months.

Table 2. Age- and sex-adjusted length of stay (LOS) means, along with 95% CI, according to MPI grades and ICD-9-CM main diagnosis

ICD-9-CM main diagnoses	*n*	MPI grades	LOS in days (95% CI)[a]	*P* value[a]	C-statistic (95% CI)[b]
Circulatory system	228	MPI-1	9.7 (8.2–11.5)	<0.001	0.772 (0.725–0.819)
	162	MPI-2	12.5 (10.5–14.8)		
	79	MPI-3	11.3 (9.4–13.5)		
Respiratory system	118	MPI-1	12.7 (8.6–18.8)	<0.001	0.781 (0.725–0.837)
	117	MPI-2	15.3 (10.3–22.6)		
	61	MPI-3	15.8 (10.7–23.5)		
Cerebrovascular disease	108	MPI-1	8.0 (6.5–9.9)	<0.001	0.817 (0.761–0.872)
	122	MPI-2	10.5 (8.5–13.0)		
	50	MPI-3	11.3 (9.0–14.1)		
Digestive disease	104	MPI-1	11.6 (8.6–15.8)	<0.001	0.743 (0.661–0.826)
	71	MPI-2	13.0 (9.6–17.7)		
	28	MPI-3	15.5 (11.3–21.1)		
Nervous system	72	MPI-1	9.8 (7.4–13.0)	0.075	0.694 (0.588–0.801)
	76	MPI-2	10.3 (7.8–13.7)		
	47	MPI-3	10.7 (8.1–14.1)		
Other diagnoses	207	MPI-1	9.0 (7.5–10.8)	<0.001	0.735 (0.681–0.789)
	154	MPI-2	11.2 (9.4–13.5)		
	94	MPI-3	13.5 (11.2–16.2)		
Total	837	MPI-1	10.1 (8.6–11.8)	<0.001	0.740 (0.714–0.765)
	712	MPI-2	12.5 (10.7–14.6)		
	359	MPI-3	13.4 (11.5–15.7)		

The analysis was restricted to patients who survived during the hospitalisation (*n* = 1,908).
95% CI, 95% confidence interval.
[a]*P* values for linear trend from age- and sex-adjusted generalised linear mixed-effects model (using Poisson distribution for modelling the response), accounting for clustering due to study sample effect.
[b]C-statistic was computed to evaluate the prognostic ability of continuous MPI to predict the probability of LOS >10 days.

MPI was significantly associated with LOS. As shown in Table 2, age- and sex-adjusted LOS means according to different MPI risk categories were 10.10, 12.47 and 13.41 days in MPI 1, MPI-2 and MPI-3 risk groups, respectively (*P* value for linear trend: <0.001, regression coefficients: 0.210, 95% CI = 0.179–0.242 for MPI 2; 0.284, 95% CI = 0.245–0.323 for MPI 3 (Figure 1). MPI 1 was taken as the reference class into the age- and sex-adjusted multivariable model). All pairwise comparisons between LOS adjusted means were strictly statistically significant (age–sex adjusted, $P < 0.001$).

Dividing patients according to the main ICD-9-CM diagnoses, a progressive significant increase of mean LOS was observed with increasing of the MPI grade of risk in the

older patients affected from the most frequent ICD-9-CM diagnoses (i.e. Circulatory Diseases, Respiratory tract diseases, Cerebrovascular diseases, Digestive diseases and Nervous System diseases). As shown in Table 2, statistically significant trend of age- and sex-adjusted LOS means across MPI grades was found for all main diagnosis with the exception for Nervous system (probably due to low sample size with a consequently loss of statistical power).

Furthermore, continuous MPI resulted as an accurate predictor of long LOS (longer than 10 days) reaching a C-statistic equal to 0.740 (95% CI = 0.714–0.765). Consistent results were also found within ICD-9-CM diagnoses, separately (Table 2).

Discussion

This multicentre study demonstrated that the MPI is an accurate instrument to predict LOS in older patients admitted to a geriatrics unit, reaching a C-statistic equal to 0.740 (95% CI = 0.714–0.765) in the evaluation of long LOS (longer than 10 days). This predictive capability is preserved also stratifying patients according to the main diagnoses at discharge as grouped in ICD-9 principal disease categories. These results adjusted for age and sex remain clinically important and statistically significant indicating the goodness of the index used and the intrinsic capacity to capture a condition, frailty, that over than to be the first cause of death in the elderly [6] probably seems to be one of the most important factors in determining LOS [25]. However, the MPI in hospitalised elderly patients is also capable to predict in-hospital short- and long-term mortality in a large number of clinical conditions including gastrointestinal bleeding [26], pneumonia [27], heart failure [28], transient ischaemic attack [29] and chronic kidney disease [30]. Of noted recently, the MPI was also tested in outpatients setting on elderly affected of dementia considering as outcome also the hospitalisation risk reaching interesting results in term of prediction accuracy highlighting the versatility and solid theoretical basis of this index [16]. Previous studies reported that multiple factors were significantly associated with LOS, i.e. old age, polypharmacy, poor nutrition, depression, frailty, multiple co-morbidities, cognitive impairment, poor functional status, low socioeconomic status, lack of family support and/or living in a nursing home [23]. In agreement with the present study, however, other authors suggested that the above-mentioned individual factors seem to be not sufficient to accurately predict LOS in hospitalised older patients [31–33]. Actually, the multidimensional approach itself, i.e. by the CGA, seems to be an efficacious intervention to reduce LOS and adverse outcomes in hospitalised older patients [34, 35]. This last aspect is interesting in that a shorter LOS may result in improved patient outcomes, including lower risk for hospital-acquired infections and disabilities, and improved patient satisfaction [36, 37], according to a model of care tailored on the functional, cognitive and clinical needs of patients [38].

The study has some limitations. First CGA-based MPI is relatively time consuming and requires expertise that need to be implemented in non-geriatric settings. Second, since this multicentre study was performed in Italian hospitals, the findings might not be directly applicable to others healthcare systems [39]. Third, we had no economic data about the hospitalisation so an economic evaluation was not performed. Fourth, we have no data on how the implementation of MPI could have influenced the LOS in this population. Finally, in this study we have tested the LOS prediction accuracy of the MPI in a development cohort. It is clear that the establishment of a prediction model in clinical practice requires also an impact analysis and an implementation phase to be widely implemented so further studies are needed to assess these aspects [40]. The data about the number of patients that did not sign an informed consent were not available, and this could have determined a potential bias; moreover, we searched to reduce the errors through the appropriate use of statistical models.

In conclusion, this multicentre study demonstrates that the MPI is an accurate and valuable predictor of LOS in hospitalised older patients. The application of this widely validated instrument in addition to its capacity to predict short- and long-term mortality could lead to the development of tailored care plans finalised to reduce adverse outcomes of hospitalisation.

Key points

- Hospitalisation in older people is a dramatic event that can lead to complications and death.
- Administrative instruments failed to correctly represent the complex clinical care and needs of the older patient.
- The MPI is an accurate and valuable predictor of LOS in hospitalised older patients.

Conflicts of interest

None declared.

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Supplementary data

Supplementary data mentioned in the text are available to subscribers in *Age and Ageing* online.

References

1. Ahmed NA, Pearce SE. Acute care for the elderly: a literature review. Popul Health Manag 2010; 13: 4.
2. Boyd CM, Ricks M, Fried LP *et al*. Functional decline and recovery of activities of daily living in hospitalized, disabled older women: the women's health and aging study I. J Am Geriatr Soc 2009; 57: 1757–66.
3. Aditya B, Sharma J. Predictors of a nursing home placement from a non-acute geriatric hospital. Clin Rehabil 2003; 17: 108–13.
4. Bauer M, Fitzgerald L, Haesler E, Manfrin M. Hospital discharge planning for frail older people and their family. Are we delivering best practice? A review of the evidence. J Clin Nurs 2009; 18: 2539–46.
5. Levine SK, Sachs GA, Jin L *et al*. A prognostic model for 1-year mortality in older adults after hospital discharge. Am J Med 2007; 120: 455–60.
6. Gill TM. The central role of prognosis in clinical decision making. JAMA 2012; 307: 199–200.
7. Munoz E, Rosner F, Chalfin D. Age resource consumption and outcome for medical patients at an academic medical center. Arch Intern Med 1989; 149: 1946–50.
8. Rosental GE, Landefeld S. Do older Medicare patients cost hospitals more? Evidence from an academic medical center. Arch Intern Med 1993; 153: 89–96.
9. Chuang KH, Covinsky K, Sands LP *et al*. Diagnosis Related Groups adjusted hospital costs are higher in older medical patients with lower functional status. J Am Geriatric Soc 2003; 51: 1729–34.
10. Pilotto A, Franceschi M, Di Bari M *et al*. The ability of the all patient refined (APR) and centres for medicare (CMS) diagnosis related groups (DRG) systems to evaluate clinical and functional outcomes of hospitalized elderly patients: a multicentre, prospective study. J Pub Health Epidemiol 2011; 3: 248–53.
11. Pilotto A, Ferrucci L, Franceschi M *et al*. Development and validation of a Multidimensional Prognostic Index for 1-Year Mortality from the Comprehensive Geriatric Assessment in Hospitalized Older Patients. Rejuvenation Res 2008; 11: 151–61.
12. Siontis GCM, Tzoulaki I, Ioannidis JPA. Predicting death. An empirical evaluation of predictive tools for mortality. Arch Intern Med 2011; 171: 1721–6.
13. Yourman LC, Lee SJ, Schonberg MA *et al*. Prognostic indices for older adults. A systematic review. JAMA 2012; 307: 182–92.
14. Pilotto A, Panza F, Ferrucci L. A Multidimensional Prognostic Index in common conditions leading to death in older patients. Arch Intern Med 2012; 172: 594–5.
15. Pilotto A, Rengo F, Marchionni N *et al*. Comparing the prognostic accuracy for all-cause mortality of the Frailty Instruments: a multicentre 1-year follow-up in hospitalized older patients. PLoS One 2012; 7: e29090 (1–9).
16. Gallucci M, Battistella G, Bergamelli C *et al*. Multidimensional Prognostic Index in a cognitive impairment outpatient setting: mortality and hospitalizations. The Treviso Dementia (TREDEM) Study. J Alzheimers Dis 2014; 42: 1461–8.
17. Katz S, Downs TD, Cash HR, Grotz RC. Progress in the development of an index of ADL. Gerontologist 1970; 10: 20–30.
18. Lawton MP, Brody EM. Assessment of older people: self-maintaining and instrumental activities of daily living. Gerontologist 1969; 9: 179–86.
19. Pfeiffer E. A short portable mental status questionnaire for the assessment of organic brain deficit in elderly patients. J Am Geriatr Soc 1975; 23: 433–41.
20. Guigoz Y, Vellas B. The Mini Nutritional Assessment (MNA) for grading the nutritional state of elderly patients: presentation of the MNA, history and validation. Nestle Nutr Workshop SerClin Perform Progr 1999; 1: 3–11.
21. Bliss MR, McLaren R, Exton-Smith AN. Mattresses for preventing pressure sores in geriatric patients. Mon Bull Minist Health Public Health Lab Serv 1966; 25: 238–68.
22. Linn B, Linn M, Gurel L. The Cumulative Illness Rating Scale. J Am GeriatrSoc 1968; 16: 622–6.
23. Thomas VS, Rockwood K, McDowell I. Multidimensionality in instrumental and basic activities of daily living. J Clin Epidemiol 1998; 51: 315–21.
24. D'Agostino RB, Nam BH. Evaluation of the Performance of Survival Analysis Models: Discrimination and Calibration Measures. Handbook of Statistics, vol. 23. North Holland: Elsevier Science B.V., 2004.
25. Philp I, Mills KA, Thanvi B *et al*. Reducing hospital bed use by frail older people: results from a systematic review of the literature. Int J Integr Care 2013; 13: e048.
26. Pilotto A, Ferrucci L, Scarcelli C *et al*. Usefulness of the comprehensive geriatric assessment in older patient with upper gastrointestinal bleeding: a two year follow-up study. Dig Dis 2007; 25: 124–8.
27. Pilotto A, Addante F, Ferrucci L *et al*. The Multidimensional Prognostic Index (MPI) predicts short and long-term mortality in older patients with community-acquired pneumonia. J Gerontol A Biol Sci Med Sci 2009; 64A: 880–7.
28. Pilotto A, Addante F, Franceschi M *et al*. A Multidimensional Prognostic Index (MPI) based on a comprehensive geriatric assessment predicts short-term mortality in older patients with heart failure. Circ Heart Fail 2010; 3: 14–20.
29. Sancarlo D, Pilotto A, Panza F *et al*. A Multidimensional Prognostic Index (MPI) based on a comprehensive geriatric assessment predicts short- and long-term all-cause mortality in older hospitalized patients with transient ischemic attack. J Neurol 2012; 259: 670–8.
30. Pilotto A, Sancarlo D, Aucella F *et al*. Addition of the Multidimensional Prognostic Index to the estimated glomerular filtration rate improve prediction of long-term all-cause mortality in older patients with chronic kidney disease. Rejuvenation Res 2012; 15: 82–8.
31. Natalwala A, Potluri R, Uppal H, Heun R. Reasons for hospital admissions in dementia patients in Birmingham, UK, during 2002–2007. Dementia Geriatric Cognitive Dis 2008; 26: 499–505.
32. Zekry D, Loures Valle BH, Lardi C *et al*. Geriatrics index of comorbidity was the most accurate predictor of death in geriatric hospital among six comorbidity scores. J Clin Epidemiol 2010; 63: 1036–44.
33. Singh I, Gallacher J, Davis K *et al*. Predictors of adverse outcomes on an acute geriatric rehabilitation ward. Age Ageing 2012; 41: 242–6.
34. Ellis G, Whitehead MA, Robinson D *et al*. Comprehensive geriatric assessment for older adults admitted to hospital: meta-analysis of randomised controlled trials. BMJ 2011; 343: 1–10.
35. Harari D, Martin FC, Buttery A *et al*. The older persons' assessment and liaison team 'OPAL': evaluation of comprehensive geriatric assessment in acute medical inpatients. Age Ageing 2007; 36: 670–5.

36. Covinsky KE, Pierluissi E, Johnston CB. Hospitalization-associated disability: 'She was probably able to ambulate, but I'm not sure'. JAMA 2011; 306: 1782–93.
37. Carratala J, Fernandez-Sabe N, Ortega L *et al*. Outpatient care compared with hospitalization for community-acquired pneumonia: a randomized trial in low-risk patients. Ann Intern Med 2005; 142: 165–72.
38. Bakker FC, Robben SHM, Marcel GM, Rikkert O. Effects of hospital-wide interventions to improve care for frail older inpatients: a systematic review. BMJ Qual Saf 2011; 20: 680–91.
39. Carey MR, Sheth H, Braithwaite RS. A prospective study of reasons for prolonged hospitalizations on a general medicine teaching service. J Gen Intern Med 2005; 20: 108–15.
40. Adams ST, Leveson SH. Clinical prediction rules. BMJ 2012; 344: d8312.

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Association of increasing age with receipt of specialist care and long-term mortality in patients with non-ST elevation myocardial infarction

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Abstract

Background: observational studies suggest that older patients are less likely to receive secondary prevention medicines following acute coronary syndrome (ACS).
Objectives: to examine the association of increasing age with receipt of specialist care and influence of specialist care on long-term mortality in patients with non-ST elevation myocardial infarction (NSTEMI).
Design: a cohort study.
Setting: National ACS registry of England and Wales.
Subjects: a total of 85,183 patients admitted with NSTEMI between 2006 and 2010.
Methods: logistic regression analyses to assess receipt of secondary prevention medicines (ACE inhibitor, β-blocker, statin, aspirin) by age group; multivariate Cox regression models to examine longitudinal effect of cardiologist care on all-cause mortality by age group.
Results: mean age 72.0 years (SD 13.0 years), mean follow-up was 2.13 years. Older patients received less cardiologist care (70.2% of NSTEMI patients ≥85 years compared with 94.7% of patients <65) years and had more co-morbidity. Cardiologists prescribed more secondary prevention in all age groups than generalists, but this was mostly explained away by co-morbidity (receipt of statin crude OR 1.51 (1.27,1.80), fully adjusted OR 1.11 (0.92,1.33) in patients ≥85 years). Receiving cardiologist care compared with generalist care was associated with a decreased risk of death in all even after adjustment for co-morbidity, disease severity and secondary prevention; this benefit reduced incrementally with older age group (adjusted hazard ratio (HR) 0.58 (0.49,0.68) aged <65; 0.87 (0.82,0.92) aged ≥85).