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REVIEW ARTICLE

Predictors of Functional Decline in Hospitalized Elderly Patients: A Systematic Review

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Background. This article will systematically review the methodological characteristics and results of studies of variables and indices that predict functional decline in older hospitalized patients.

Methods. We restricted this review to original longitudinal studies of predictors of either physical functional decline or nursing home admission among patients aged 60 and older. Two reviewers independently abstracted information on methodological characteristics and substantive results.

Results. Thirty articles were identified, derived from 27 different studies, reporting on 33 substudies. Substantial variability was found with respect to study design, outcomes measured, period of follow-up, predictors investigated, and analytic methods. Multivariable predictive indices were significantly associated with adverse outcomes in the majority of studies that investigated them, as were the following variables: age, diagnosis, activities of daily living, cognitive impairment (including delirium), and residence.

Conclusions. The methodological heterogeneity of the studies identified limits quantitative synthesis of the results. Predictive indices for hospitalized elders appear to have moderate short-term predictive ability.

DISABILITY refers to limitation of function (usually of activities of daily living [ADLs]) or restriction of activities (1). Although disability tends to increase with advancing age, different change trajectories can be identified, including functional decline and recovery (2–4). For clinicians, the identification of predictors of functional decline can help with the targeting of interventions to high-risk groups, including secondary prevention (to reduce the incidence of disability among patients with impairments) and tertiary prevention (to reduce the incidence of handicap among patients with disabilities) (5). Examples of screening tools based on these predictors have been reported both for hospital inpatients and for elders in the community (6–9). Because both disability and functional decline are associated with increased risk of mortality, institutionalization, and service utilization, and with higher societal costs (2,10), the predictors of functional decline are of interest not only to clinicians, but also to patients and their family members, health services administrators, and health policy makers.

Most prior research has investigated functional decline and its predictors in community-dwelling elders (11). A recent synthesis of 78 studies of community-dwelling elders reported a wide range of predictors of functional decline including cognition, affect, comorbidity, health behaviors, and specific impairments (11). Hospitalized elders, who have been less well studied, appear to be at increased risk of functional decline, both during hospitalization and following discharge (12).

We undertook this systematic review to examine the methodological characteristics and results of studies of the predictors of functional decline in older hospitalized patients. We included studies that measured functional decline directly, by a reduced ability to carry out activities of daily living, or indirectly, by the need to transfer the patient to a nursing home or similar institution providing increased assistance with activities of daily living. In planning the review, we considered three types of study: the first type investigates a primary predictive variable, such as delirium, with all other predictive variables being considered as potential confounders; the second type investigates several potential predictors and then uses multivariable analyses to identify those that are independent predictors of functional decline; and the third type proceeds further to the development of predictive models and/or indices.

Methods

Search Strategy

The search strategy for relevant studies focused on published studies identified through computerized databases and hand searches of the bibliographies of relevant studies and review articles. The Medline database was searched from 1976 to 1998 to identify studies that were conducted on elderly patients, used a longitudinal design, and investigated one or more predictors of functional decline. The search strategy consisted of four sets of terms that were subsequently combined using the Boolean term "and." These sets were elderly (i.e., "aged," "elderly"), performance characteristics (i.e., "sensitivity," "specificity"), outcomes of interest (i.e., "mortality," "hospitalization"), and study design (i.e., "longitudinal studies," etc.). The complete search strategy is shown in the Appendix.

Screening of Articles

The abstract of each article identified through the search was screened, and a set of exclusion criteria was applied hi-

erarchically. Articles were excluded if they did not report data from an original study; they were restricted to a particular medical condition or procedure; the study population included patients younger than the age of 60 (unless the results for those aged 60 and older were presented separately); patients were not followed longitudinally; no predictive variable was investigated; a particular treatment or other intervention was the only predictor studied; the study outcomes did not include measures of either physical functional decline or nursing home admission; the study was conducted in a setting other than an acute-care hospital; or the study was written in a language other than English or French.

Data Extraction and Analysis

All the articles determined to be eligible were reviewed independently by two reviewers; the reviewers then met to discuss their findings with the first author (Jane McCusker), and a consensus review was completed. The data extracted included study setting (country, number and type of hospitals, admitting service); sample size at baseline and follow-up; characteristics of the study population (age, gender, residence, and level of disability at baseline); length of follow-up; definition and time of measurement of outcomes and predictors; statistical methods; and results (associations between predictors and outcomes, and performance characteristics of predictor variables or indices, if reported).

Simple descriptive techniques, including contingency table analyses, were used to analyze the data.

Results

Search for Articles

The Medline search yielded 1840 citations, of which 20 met eligibility criteria for this review. Excluded were 1056 articles that were restricted to particular conditions (e.g., a particular diagnosis, a surgical series, or patients admitted to an intensive care unit) and 307 studies that did not include outcome measures of either physical functional decline or nursing home admission. Other reasons for exclusion are shown in Figure 1. Hand searching of the eligible articles and personal files yielded 10 additional articles, for a total of 30 articles (6,13–41). These articles were based on 27 different studies; three studies each had two publications, dealing with different predictors and/or outcomes (15,16), different stages of follow-up (17,18), or separate reports on development and validation of a predictive index (31,32). Three other articles presented both development and validation components of a predictive index (6,21,35). Thus, for consistency, we considered development and validation components as separate substudies, giving a total of 33 substudies. Analyses were conducted either at the study (n = 27) or substudy (n = 33) level.

Methodologic Features of Studies

Some general and methodological characteristics of the 27 studies (33 substudies) are shown in Table 1, grouped into 21 studies that measured outcomes postdischarge and 12 that measured outcomes only at hospital discharge. Although functional decline was measured in different ways,

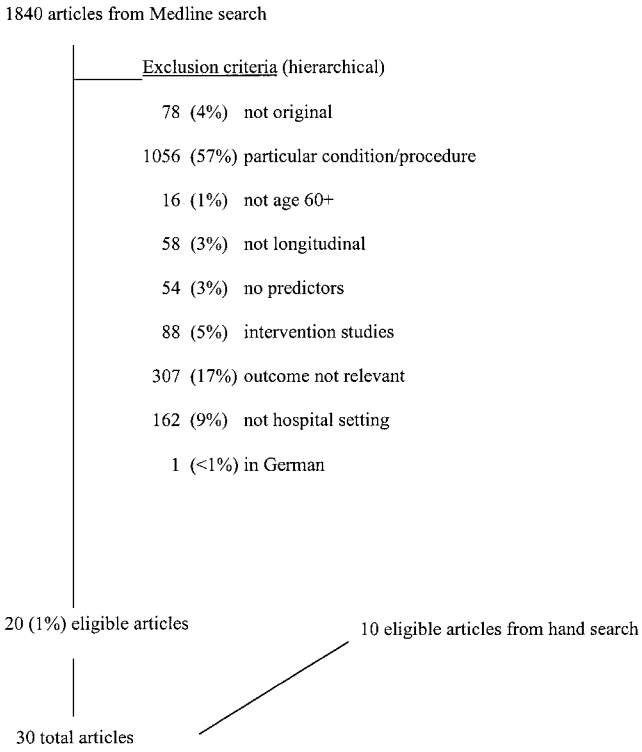

Figure 1. Screening of articles.

the majority of substudies included nursing home admission as an outcome. Those studies that measured functional status directly usually employed a measure of ADLs, and decline was defined as a binary variable (loss of independence in a given number of ADLs versus no loss). Other approaches included measures of lack of improvement (35) or of change in functional status over time using a continuous measure of ADLs and an ordinal change measure (better, same, worse) (25). Six substudies derived from five articles (17,21–23,41) employed a dichotomous, composite outcome variable, in which the outcome was defined as one or more of a group of adverse events. All five articles incorporated death and institutionalization into their composite outcome. Three also incorporated decline in ADL independence (17,22,41), and two incorporated a long hospital stay (22,41). There were also differences between studies in the "time zero" for measuring change, among those studies that measured change in ADL status either as a separate outcome or as part of a composite outcome variable. Some studies used a premorbid "time zero," usually defined as the functional status at 2 weeks before admission, while others used status at the time of (or soon after) admission.

Predictors examined included a single primary variable of interest in eight substudies (24%), multiple predictors in 18 substudies (55%), and a predictive index in seven substudies (21%). Selected results are also shown in Table 1, including the percentage of patients with an adverse outcome and statistically significant predictors (described further below).

Other study characteristics are not shown in Table 1. All studies used an observational cohort design, except for one

Table 1. Selected Characteristics of 27 Studies (33 Substudies)

Study	Year	Country	Mean Age (y)	% Female	Predictors	Baseline Function	Outcome(s)	Time of Outcome	No. of Subjects Analyzed	Outcome %	Analysis	Significant Predictors*
Studies With Follow-Up Post-Discharge												
Barberger-Gateau (13)	1990	France	82	60	Multiple	—	NH	Discharge	1133	10.9	Multivariable	
					Multiple	—	NH	1 mo. PD	1013	11.9	Multivariable	a, b, c, j, k, n
Covinsky A (15)	1997	USA	80	68	Depression	Admission	BADL status	Discharge	216	72.2	Multivariable	n
					Depression	Admission	BADL status	1 mo. PD	176	76.1	Multivariable	n
					Depression	Admission	BADL status	3 mo. PD	167	74.9	Multivariable	n
					Depression	Admission	IADL status	Discharge	276	71.4	Multivariable	n
					Depression	Admission	IADL status	1 mo. PD	253	63.6	Multivariable	n
					Depression	Admission	IADL status	3 mo. PD	230	66.5	Multivariable	n
Covinsky B (16)	1997	USA	81	68	ADL	Admission	NH	3 mo. PD	823	16.7	Multivariable	g
Francis A (17)	1990	USA	78	63	Delirium	—	NH	6 mo. PD	216	6.6	Multivariable	g, i
Francis B (18)	1992	USA	78	62	Delirium	Premorbid	Composite	24 mo. PD	190	35.5	Multivariable	a, e, i, k
George (19)	1997	UK	81	57	Delirium	—	NH	Discharge	266	9.4	Multivariable	i
					Delirium	—	NH	6 mo. PE	266	14.3	Multivariable	i
					Delirium	—	NH	12 mo. PE	266	17.3	Multivariable	i
Inouye (20)	1998	USA	79	60	Delirium	Premorbid	NH	Discharge	692	8.6	Multivariable	i
					Delirium	Premorbid	NH	3 mo. PD	600	12.8	Multivariable	i
					Delirium	Premorbid	ADL decline	Discharge	512	37.9	Multivariable	i
					Delirium	Premorbid	ADL decline	3 mo. PD	534	28.1	Multivariable	i
Mateev (23)	1998	Switzerland	NR	NR	Multiple	—	Composite	Discharge	198	42	Univariable	n
					Multiple	—	Composite	3 mo. PD	198	32	Univariable	n
McCusker (41)	1999	Canada	77	44	Index	Premorbid	Composite	6 mo. PA	509	50.5	Univariable	l
Murray (25)	1993	USA	81	67	Delirium	Admission	BADL decline	3 mo. PD	255	34.9	Multivariable	i, n
Narain (26)	1988	USA	77	3	Multiple	—	NH	Discharge	380	11.6	Multivariable	a, e, g, j, d
					Multiple	—	NH	6 mo. PD	396	8.7	Multivariable	a, e, g, j, d
O'Keeffe (27)	1997	Ireland	82	65	Delirium	Admission	ADL decline	Discharge	171	15.8	Multivariable	i
					Delirium	—	NH	6 mo. PD	225	21.2	Multivariable	i
Rubenstein A & B (35)	1984	USA	80	5	Multiple	—	NH	Discharge	98	15.3	Multivariable	c, e, g
					Multiple	—	NH	12 mo. PD	76	18.4	Multivariable	c, e, g
					Multiple	Admission	ADL improvement	Discharge	87	26.4	Multivariable	d, e
					Index	—	NH	Discharge	96	22.9	Multivariable	c, e, g
					Index	Admission	ADL improvement	Discharge	80	26.3	Multivariable	d, e
Rubenstein (33)	1986	USA	74	3	Index	—	NH	Discharge	742	20.4	Univariable	l
					Index	—	NH	12 mo. PA	742	11.99	Univariable	l
Rudberg (28)	1996	USA	79	32	Multiple	—	NH	Discharge	1240	8.5	Multivariable	a, c, g, m, n
					Multiple	—	NH	3 mo. PD	1112	7.8	Multivariable	a, c, g, m, n
Sager A & B (6)	1996	USA	79	63	Multiple	Premorbid	ADL decline	Discharge	448	22.5	Multivariable	a, h, j, l
					Multiple	Premorbid	ADL decline	3 mo. PD	448	14.3	Multivariable	a, h, j, l
			80	62	Index	Premorbid	ADL decline	Discharge	379	27.7	Multivariable	l
					Index	Premorbid	ADL decline	3 mo. PD	379	17.2	Multivariable	l
Sager (39)	1996	USA	79	62	Multiple	Admission	BADL decline	Discharge	1279	32	Multivariable	a, b, e, h
					Multiple	Admission	BADL decline	3 mo. PD	1072	19	Multivariable	a, e, j
					Multiple	Admission	IADL decline	3 mo. PD	1072	40	Multivariable	a, e, j
Satish (29)	1996	USA	71	0	Multiple†	—	NH	12 mo. PA	507	4	Multivariable	d, j, n
Winograd (30)	1997	USA	71	0	Multiple	Admission	IADL decline	12 mo. PA	382	53.7	Tree analysis	n
Studies With Follow-Up to Discharge Only												
Bonnefoy (14)	1998	France	83	69	Index	—	NH	Discharge	1066	55	Multivariable	l
Inouye A & B (21)	1993	USA	78	59	Multiple	Premorbid	BADL decline	Discharge	188	27	Multivariable	b, d, g, h, j
					Multiple	Premorbid	Composite	Discharge	188	18.6	Multivariable	l
					Index	Premorbid	BADL decline	Discharge	142	24	Multivariable	b, d, g, h, j
					Index	Premorbid	Composite	Discharge	142	25	Multivariable	l
Jarrett (22)	1995	Canada	78	54	Multiple	Premorbid	Composite	Discharge	193	46.1	Multivariable	a, b, d, e, n
Kane (36)	1983	USA	76	58	Multiple	—	NH	Discharge	23,557	8.9	None	a, b, d, e, n
Lamont (34)	1983	USA	82	60	Multiple	—	NH	Discharge	124	16.9	Univariable	a, j
McClaran (24)	1996	Canada	75	50	Multiple	—	NH	Discharge	495	6.9	Multivariable	a, k, e, n
Roudot-Thoraval (40)	1987	France	83	71	Multiple	—	NH	Discharge	125	31.2	Multivariable	b, n
Wachtel (37)	1984	USA	NR	57	Multiple	—	NH	Discharge	100[F]	18	Multivariable	n
Wachtel (38)	1987	USA	NR	67	Multiple	—	NH	Discharge	337	22	Multivariable	a, d, g, h
Zureik A (31)	1995	France	84	73	Multiple	—	NH	Discharge	417	40.5	Multivariable	a, c, e, g, h, j, l, n
Zureik B (32)	1997	France	84	73	Index	—	NH	Discharge	354	37.6	Multivariable	a, c, e, g, h, j, l, n

Notes: NH = institutionalization; BADL = basic activities of daily living; IADL = instrumental ADL; ADL = both basic and instrumental ADLs; "decline" = measure of change; "status" = not a measure of change; "improvement" = presence or absence of improvement; PD = postdischarge; PA = postadmission; PE = postenrollment; NR = not reported.

*Predictors with statistically significant association with outcome, either in univariable or multivariable analyses: a = age; b = gender; c = living alone; d = residence (institution); e = diagnosis; f = comorbidity; g = ADL; h = IADL; i = delirium; j = cognitive status; k = marital status; l = composite; m = race; n = other.

†Includes composite predictors.

case-control study that compared 50 patients discharged to a nursing home with 50 patients discharged home (38). Predictors were examined within 48 hours of admission only in 18 (55%) of the substudies; 14 (42%) included one or more predictors assessed later during the hospitalization (this information was not reported in one substudy). The most common exclusion criterion was nursing home residence at admission (42% of substudies); 18% of substudies ex-

cluded patients with cognitive impairment at time zero and those with a very short length of stay. Methods of analysis are shown in Table 2.

Substantive Findings: Predictors

The last column of Table 1 shows the statistically significant predictors ($p < .05$) that were reported for each study, in univariable and/or multivariable analyses, by the type of outcome and time of measurement of the outcome. Because of the methodological diversity between the studies, we decided to focus on the predictors of functional decline and related outcomes at the time of discharge, using (i) whether a statistically significant association at the .05 level between the predictor and the outcome was reported, in univariable and/or multivariable analyses, and (ii) the direction of the association (based on the expected direction of the association) (Table 3). The latter criterion was not used for diagnosis or race, because of the lack of a clearly expected direction of the association. In the case of regression tree analysis employed in one study (30), the formal test of statistical significance does not apply. However, for the purpose of this table, variables that were selected as useful to define "terminal nodes," that is, subgroups of patients with a distinctive prognosis, are considered "significant." Variables not selected as predictors in the regression tree were considered "nonsignificant."

Table 2. Methods of Analysis ($n = 33$ Substudies)

Characteristic	*n*	%
Handling of Deaths*		
Excluded	14	42
Analyzed separately	12	36
Incorporated into outcome	6	18
None occurred	1	3
Unknown	1	3
Handling of Withdrawals/Losses to Follow Up		
Excluded	16	48
Incorporated into outcome	1	3
None occurred	9	27
Unknown	7	21
Multivariable Analyses Carried Out		
No	6	18
Yes	27	82
Inferential Statistics		
p values only	10	30
Confidence intervals only	4	12
Both	16	48
Neither	3	9
Measure of Association*		
Odds ratio	17	52
Risk ratio	6	18
Regression coefficient only†	3	9
Area under the ROC curve‡	2	6
Regression tree analysis	1	3
Comparison of proportions only	6	18
None of the above§	1	3
Performance Characteristics Reported		
No	19	58
Univariate only	7	21
Multivariate‖	5	15

Note: ROC = receiver operating characteristic.

*Substudies employed more than one method, thus total does not equal 33.

†One from linear regression, one from discriminant function analysis, and one from logistic regression. Three studies that presented both odds ratios and regression coefficients are not included.

‡Ability of predictive index to predict composite outcome.

§No numerical measure of association.

‖Includes predictive indices.

Table 3 presents the effects of specific predictors using the study level of analysis ($n = 27$) for those predictors with results reported in a minimum of five studies. Eight studies examined multivariable predictive indices, all of which were significantly associated with one or more outcomes of interest. Among the single variable predictors, age was the most frequently examined predictive variable: in 12 (63%) of 19 studies, older age was a statistically significant predictor of one or more adverse outcomes (Table 3). In the seven other studies, there was no significant association between age and adverse outcomes in six studies and a significant association in the opposite direction from that expected in one study (35). Several other predictors had significant results in the majority of studies that investigated them: diagnosis, cognitive impairment, ADLs, instrumental ADLs (IADLs), residence in an institution, and delirium. Most of these significant results were for the prediction of nursing home admission; the small number of studies reporting on other outcomes did not allow us to determine whether some variables predicted one outcome systematically better than another. Most of the studies reporting significant results for diagnosis reported that neurological or mental diagnoses were associated with institutional placement (24,26,36,37). Cancer was reported to predict functional decline (39) and a composite adverse outcome variable (22). Finally, a diagnostic classification of "atypical" presentation (defined as syndromes not consistent with the classic medical model, including delirium, falls, immobility, incontinence, functional decline, or breakdown of social supports) predicted a composite outcome (22). Among the 13 studies reporting on cognitive impairment other than delirium, six (46%) used the Mini-Mental State Examination (MMSE). Variables that were usually not significant predictors of adverse outcomes included comorbidity, which did not predict adverse outcomes in any of the studies; living alone, which predicted only nursing home admission and not functional decline; gender; race; and marital status.

Several other significant predictor variables are not presented in Table 3 because they were examined in fewer than five studies. Other predictors of nursing home admission included attitudinal factors (patient and/or caregiver wish for patient not to return home [31,32,40], or expectation of referring physician that patient would be discharged to a nursing home [35]); informal support factors (primary caregiver was patient's child [26], lack of relative at home to assist [37,38], not having children [24], receipt of professional services at home [31,32,38]); and miscellaneous medical and other factors (greater number of medications [29,37], prolonged bed rest and visual impairment [29], previous admissions [37], admission to surgical service [24], longer hospital stay [40], and geographic area of residence [28]). Other predictors of functional decline included depression (15,21); lack of social activity and support (21); longer hospital stay (6); and other measures of physical function (30). Other predictors of composite outcomes included functional

Table 3. Statistically Significant Associations With Outcomes for Predictors Reported in 5 or More of 27 Studies

Predictor (Hypothesized Direction)*	Nursing Home Admission			Functional Decline			Composite Outcome			Any Adverse Outcome		
		Significant‡			Significant‡			Significant‡			Significant‡	
	n†	n	(%)	n†	n	(%)	n†	n	(%)	n†	n	(%)
Composite Variables	3	3	(100)	2	2	(100)	3	3	(100)	8	8	(100)
Single Variables												
Age (older)	12	8	(67)	4	2	(50)	3	2	(67)	19	12	(63)
Diagnosis§	8	6	(75)	3	1	(33)	2	2	(100)	13	9	(69)
Cognitive impairment‖ (worse)	8	5	(63)	4	3	(75)	1	1	(0)	13	8	(62)
Gender (female)	7	3	(43)	3	1	(33)	2	1	(50)	12	5	(42)
ADL (more dependent)	10	7	(70)	3	1	(33)	—	—	—	12	8	(67)
Marital status (unmarried)	5	2	(40)	3	0	(0)	2	1	(50)	10	3	(30)
Living arrangement (alone)	5	4	(80)	4	0	(0)	—	—	—	9	4	(44)
IADL (more dependent)	4	2	(50)	4	3	(75)	—	—	—	8	5	(63)
Residence (institution)	4	4	(100)	2	1	(50)	1	1	(100)	7	3	(86)
Race§	3	1	(33)	3	0	(0)	1	0	(0)	7	1	(14)
Comorbidity (higher)	3	0	(0)	2	0	(0)	1	0	(0)	6	0	(0)
Delirium (present)	4	4	(100)	4	3	(75)	1	1	(100)	6	5	(83)

Notes: ADL = activity of daily living; IADL = instrumental activity of daily living.

*Category associated with higher risk of adverse outcome.

†Number of studies that reported a given predictor.

‡Statistically significant association in the hypothesized direction at $\propto = .05$ significance level, or 95% confidence interval. Excluding null value, reported either from univariate or multivariate analyses.

§No hypothesized direction of association.

‖Excluding delirium.

decline at admission, defined as a change in the ability to perform personal and/or instrumental ADLs before admission (22,41).

Performance Characteristics

Table 4 shows the performance characteristics of multivariable predictive indices and models. The predictive indices included five developed from multivariate analyses, either logistic regression (6,21,32,41) or discriminant function analysis (35); one index based on clinical targeting criteria (23); and one computed from a set of *ad hoc* algorithms (26). Two studies reported the area under the curve (AUC); these were similar and indicated moderate predictive performance (AUC 0.65 and 0.66, respectively) (6,41). Four studies (26,32,35,41) reported sensitivity and specificity, and two studies that did not explicitly report sensitivity and specificity provided sufficient data for computation of these measures (21,23). In general, these results indicated moderate performance. The best performance characteristics were for the hand-developed algorithm (26), with both sensitivity and specificity of more than 80%.

Discussion

The main finding in this systematic review of the predictors of functional decline in hospitalized elders is the considerable methodological variability between studies, which limits comparisons of their results and formal meta-analysis.

Conceptual and Methodological Issues

The studies reviewed here were heterogeneous in their goals, some focusing on a primary predictor, others on multiple predictors, and some of the latter proceeding to the development of a predictive model or index.

The conceptualization and measurement of functional decline was diverse. Most investigators have focused on nursing home admission, an indirect but easily measured outcome. However, the decision to admit to a nursing home involves cultural and social issues, in addition to functional decline itself (10). Thus, the predictors of nursing home admission more often included social and psychological variables such as living alone and residential preferences of the patient and/or family.

The use of a composite outcome measure, combining functional decline, death, nursing home admission, and/or other outcomes into a single, dichotomous outcome variable, is appealing, first because these outcomes may share some (but not all) predictors (as shown, for example, in Table 3). Second, in populations with a nonnegligible death rate, the exclusion of deaths poses problems in interpretation (42). Third, multiple tests of statistical significance are avoided when a single outcome variable is used. However, there are also some arguments against using composite outcome variables. First, differences in associations between a given predictor and different outcomes will not be identified. For example, men tend to have higher death rates than women, whereas women tend to have higher rates of functional decline than men (3). Thus, use of a composite outcome combining death and functional decline might result in finding no predictive effect of gender. A related problem is that differences in the effects of predictors on different outcomes may induce spurious differences in the results of various studies using the same composite outcome, if the proportions of specific outcomes vary across the studies.

Table 4. Performance Characteristics of Predictive Models and Indexes

First Author (Study Reference)	Predictive Index or Model	Outcome	*n*	Cut-point	Sensitivity (*n*)	Sensitivity %	Specificity (*n*)	Specificity %	AUC (95% CI)
Inouye (21)*	Index of four predictors: decubitus ulcer, cognitive impairment, premorbid functional impairment, low social activity	(D) Functional decline	188	≥1/4	(51)	92.2	(137)	35.7	—
				≥3/4		33.3		92.7	
		(V) Functional decline	142	≥1/4	(34)	88.2	(108)	53.7	—
				≥3/4		29.4		98.1	
		(D) Nursing home admission or death	188	≥1/4	(35)	91.4	(153)	32.7	—
				≥3/4		31.4		89.5	
		(V) Nursing home admission or death	142	≥1/4	(36)	83.3	(106)	52.8	—
				≥3/4		22.2		96.2	
Mateev (23)*	Clinical targeting criteria	(V) Death or nursing home admission at discharge	198	≥2	(83)	66.3	(115)	65.2	—
		(V) Same, 3 months after discharge	198	≥2	(63)	63.5	(135)	59.3	—
McCusker (41)	Index of six self-reported predictors (ISAR): impaired function, functional decline, recent hospitalization, impaired memory and vision, and polymedication	(V) Death, nursing home admission, or functional decline 6 months after admission	509	≥2/6	(223)	70	(286)	62	0.66 (0.61, 0.71)
				≥3/6		41		83	
				≥4/6		22		94	
Narain (26)	Algorithm based on residence, ADLs, mental status score, and primary diagnosis	(D) Nursing home admission	366	NA	(33)	83.7	(333)	83.3	—
Rubenstein (35)	Discriminant analysis of expected discharge location by referring physician and diagnostic category	(D) Nursing home admission	96	NA	(74)	95.9	(22)	63.9	—
		(V) Nursing home admission	101	NA		93.8		57.1	—
		(D) Functional impairment	80	NA	(59)	91.5	(21)	57.1	—
		(V) Functional impairment	76	NA		86.5		54.2	—
Sager (6)	Hospital Admission Risk Profile index derived from age, MMSE, and IADLs	(V) Nursing home admission	507	—	—	—	—	—	0.65
Zureik (32)	Index of six predictors: principal carer's wish, chronic condition, dependent in toileting, aged older than 85, lives alone, cannot name place	(V) Nursing home admission	354	≥4/6	(133)	74.4	(221)	63.8	—

Notes: AUC = area under the receiver operating characteristic curve; CI = confidence interval; (D) = development; (V) = validation; ISAR = Identification of Seniors At Risk; ADL = activity of daily living; MMSE = Mini-Mental State Examination; IADL = instrumental activity of daily living.

*Sensitivity and specificity were not reported but computed from data in the article.

Thus, the decision of whether to use a composite outcome variable will depend upon the goals and context of the study.

There was also heterogeneity in both the "time zero" and follow-up period used for measuring functional decline; some studies measured decline from the premorbid status while others measured decline from admission (or shortly after admission). The former studies conceptualize functional decline more broadly, as related to the episode of illness or injury that led to the hospital admission, while the latter studies focus upon functional decline that may result more specifically from processes and events during the hospitalization. The distinction is important because functional decline before admission was a strong predictor of outcome in the two studies that assessed it (26,41). The time frame for follow-up varied, with many studies having no postdischarge follow-up. Because of trends toward shorter hospital stays and differences in the average length of stay in different health care systems, assessment of functional decline over a standard time period from admission rather than at the time of discharge would facilitate comparisons between studies.

The specific predictors examined in these studies were diverse. At the study level ($n = 27$), the most frequently examined predictors included age and diagnosis, while important predictors such as baseline disability and cognitive status were reported only in a minority of studies. Studies also varied in whether they included only baseline (admission) predictors or postbaseline predictors, such as length of stay or level of disability at discharge.

Substantive Findings

The considerable methodological differences between studies limited our ability to draw substantive conclusions.

First, we were able to employ only a very crude measure to compare study results, that is, the statistical significance of specific effects (or confidence interval that excluded the null value) reported either from univariate or multivariate analyses. Second, most predictors (except for age and diagnosis) were examined and reported only in a minority of studies. Nevertheless, certain tentative conclusions can be drawn from our results. First, predictive indices (including clinically and empirically developed indices) were more consistent than individual predictor variables in their ability to predict adverse outcomes. Second, there appear to be similarities and differences between the predictors of nursing home admission and functional decline. Common predictors for these two outcomes (found in the majority of studies that examine them) include age, institutional residence, IADLs, delirium, and other cognitive impairment. On the other hand, living alone and patient/family preferences were more useful in the prediction of nursing home admission than of functional decline. Third, gender, marital status, and race were only significant in a minority of studies and appear to be less useful as predictors. Fourth, several other variables that have been examined in fewer than five studies but found to be significant may be worth assessing in future research. These include social activities and support, functional decline at admission, depression, visual impairment, and number of medications. Indeed, three of these variables (functional decline at admission, visual impairment, and polymedication) were among the strongest predictors of functional decline in one study and were subsequently incorporated into the six-item Identification of Seniors At Risk (ISAR) predictive index (41).

These results may be useful for clinicians looking for a screening tool to identify hospitalized elders who are at greatest risk of adverse outcomes, to help in the targeting of geriatric evaluation and management interventions. In general, the performance characteristics of predictive indices reported (or computed from reported data) indicate moderate predictive ability, with an area under the receiver operating characteristic curve of approximately 0.66. An exception was an ad hoc algorithm (26), which had values for both sensitivity and specificity of more than 80%. This algorithm was developed from data in a single study and needs to be validated independently. Apart from this algorithm, the various indices presented in Table 4 appear to perform similarly, despite differences in the variables that compose each index. Thus, easily measured indices, such as those derived from information readily available or from simple self-reported questions, may be preferable. It should be noted that some of these indices were studied in samples that excluded deaths, so that the predictive ability is conditional on survival and may be difficult to interpret. The results in Table 4 also indicate that the choice of a cut-point should depend on the goals of screening and the resources available. For example, the use of a cut-point of 3 versus 2 for the ISAR screen reduces the sensitivity but also reduces the proportion of patients with a positive result (41). Thus, a hospital with fewer resources may wish to adopt the higher cut-point to increase the specificity of the screen and, hence, the predictive value of a positive result. Finally, a thorough evaluation of the benefits and costs of screening requires information on the relative effectiveness of interventions among patient populations at different levels of risk of adverse outcomes.

Suggestions for Future Research

Based on the findings of this review, we would like to make suggestions for future research on the predictors of functional decline in hospitalized elders in order to facilitate comparison of their results. Regarding outcomes, the use of nursing home admission as the sole outcome should be avoided; at least one (and preferably several) postdischarge measure of functional status should be made. It is recommended that composite outcome variables be used that incorporate death, possibly using methods described by Diehr and colleagues (42). Regarding predictors, studies should include at least a basic set of variables that appear to have predictive value in most studies: age, residence, physical function (basic ADL and IADL), and cognitive status (preferably the MMSE, the most commonly used measure). These should be included in the multivariate analyses to ensure appropriate adjustments in studies that investigate additional predictive effects of other variables of interest. It would also be useful if the coding of these predictor variables were standardized (e.g., by using standard cut-points for continuous predictors and standard grouping of categorical predictors). Regarding analytic methods, the results of both univariate and multivariable analyses should be reported, and both affect measures (odds ratios, etc.) and confidence intervals presented. Validation of predictive indices and estimation of their performance characteristics should be done on independent samples. Finally, the reporting on methods, including statistical analyses, should be detailed enough to allow other researchers to replicate these methods.

In addition to these suggestions, synthesis and comparison of study results would be facilitated by the standardization of various methodological aspects of studies (e.g., measures of functional decline, the main inclusion/exclusion criteria, and duration of follow-up and timing of assessments).

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Appendix

Medline Search Strategy

001 exp aged/
002 exp aging/
003 age:.tw,sh,ab.
004 aging:.tw,sh,ab.
005 elder:.tw,sh,ab.
006 or/1-5
007 roc curve:.tw,sh,ab.
008 sensitiv:.tw,sh,ab.
009 specific:.tw,sh,ab.
010 exp prognosis/
011 predict:.tw,sh,ab.
012 or/7-11
013 exp activities of daily living/
014 exp quality of life/
015 exp hospitalization/
016 exp institutionalization/
017 exp mortality/

018 institutionali:.tw,sh,ab.
019 quality of life.tw.
020 activities of daily living.tw.
021 mortality.tw.
022 death.tw.
023 exp accidental falls/
024 functional decline.tw.
025 or/13–24
026 exp longitudinal studies/
027 exp cohort studies/
028 exp follow-up studies/
029 longitudinal:.tw.
030 prospective:.tw.
031 follow up.tw.
032 or/26–31
033 and/6,12,25,32
034 limit 33 to "aged <65 and over>"
035 exp intervention studies/
036 exp child/
037 exp middle age/
038 or/35–37
039 34 not 38