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Complementarity of the Mini-Nutritional Assessment and Activities of Daily Living for predicting follow-up mortality risk in elderly Taiwanese

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Abstract

Physical functional ability and nutritional status are two major indicators for predicting the risk of mortality in older adults. The present study examined the complementarity of the Activities of Daily Living (ADL) and the Mini-Nutritional Assessment (MNA) for predicting follow-up 4-year all-cause mortality risk in elderly Taiwanese. We analysed data of the 'Survey of Health and Living Status of the Elderly in Taiwan', a population-based longitudinal cohort study which involved 2872 men and women of ≥65 years old at baseline (1999). We rated their functional dependency with the ADL scale and nutritional status with the MNA (both the long form, LF and the short form, SF) at baseline, and analysed the complementarity of the two scales in predicting follow-up 4-year all-cause mortality with Cox regression analysis and the net reclassification improvement (NRI) to quantify the improvement. The results showed that both ADL and MNA offered improvement in predicting follow-up mortality risk beyond that predicted by either one alone according to the Akaike information criterion and the NRI. The MNA-SF was nearly as effective as the MNA-LF in improving the predictive ability of the ADL. The present study suggests that the MNA (especially the SF because of its simplicity and time-saving feature) together with the ADL scale might be of value for predicting the mortality risk of frail elderly living in various settings.

Key words: Mini-Nutritional Assessment: Activities of Daily Living: Mortality: Functional status: Elderly

Physical functional ability and nutritional status are two major indicators for predicting mortality risk in older adults. A decline in functional status is a profound predictor of mortality[1]. The death rate increases from 8 % in individuals with no disability, to 15 % with one or more Instrumental Activities of Daily Living (IADL) disabilities, to 21 % in persons with one or two ADL dependencies, and up to 37 % in those with five or six ADL dependencies during a 2-year period[2]. On the other hand, nutritional status is also a strong predictor of mortality. Numerous studies have shown that death rate is much higher for the elderly who are malnourished than those who are well nourished[3–7]. In a recent study, we have shown that the relative mortality risk is about seven times for individuals who are malnourished and 2·5 times for those who are at risk of malnutrition compared with those who are normal when rated with the Mini-Nutritional Assessment (MNA)[8]. The two indicators have been shown to be highly correlated, but the complementary effect between the two has not been well studied. Hence, the study was aimed to determine the extent to which the two tools (functional status and nutritional assessment) together can improve the ability to identify those who otherwise would not be identified by either one alone.

Methods

Data and subjects

The present study analysed datasets of the 'Survey of Health and Living Status of the Elderly in Taiwan' (SHLSET), a population-based longitudinal cohort study conducted by the Bureau of Health Promotion of Taiwan. The goal of the survey was to gain an understanding of the role of demographic, socio-economic, environmental, lifestyle and healthcare factors on health, well-being and quality of life of older Taiwanese[9]. The SHLSET employed a three-stage national probability sampling method. Stage 1 stratified the Taiwanese population into 361 primary sampling units and (after excluding thirty lightly populated mountainous primary sampling units)

Abbreviations: ADL, Activities of Daily Living; LF, long form; MNA, Mini-Nutritional Assessment; NRI, net reclassification improvement; SF, short form; SHLSET, Survey of Health and Living Status of the Elderly in Taiwan.

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randomly selected fifty-six primary sampling units for further sampling. Stage 2 was a proportional-to-size random selection of blocks from the selected primary sampling units and the final stage was a random selection of two eligible persons from each of the selected blocks. A total of 4412 men and women aged 60 years or older were drawn with this process and, among them, 4049 completed the first interview in 1989. A second sample of 2462 subjects, 50–66 years old, was drawn from the population with the same procedure in 1996 to maintain/extend the age of the cohort. Subjects in the combined cohort were interviewed with a structured questionnaire for eliciting demographic, socio-economic, lifestyle and health or healthcare-related data every 3 or 4 years (in 1989, 1993, 1996, 1999, 2003 and 2007). The completion rates ranged from 79·1 to 91·8 %. The 1999 survey had a special emphasis on diet and nutrition and the questionnaire included most items in the MNA, meeting the need of the present study and thus was chosen as the baseline of this analysis. The method and procedure were reviewed and approved by government-appointed representatives. The detailed sampling process of the survey has been described previously[10]. The present study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the ethics committee. Written informed consent was obtained from all subjects.

The Mini-Nutritional Assessment

We graded the nutritional status of each subject with both the long form (LF) and short form (SF) of the MNA which is well recognised as a simple, easy-to-use, reliable and non-invasive tool for screening/assessing the risk of malnutrition in older adults. The MNA is a two-part and two-stage scale. The LF includes eighteen items and evaluates four aspects of nutritional status (dietary, anthropometric, global and self-view)[11]. The elderly who are suspected of malnutrition are first screened with the SF consisting of six key questions. Those who are rated as at risk of malnutrition are further evaluated with the rest of the LF (additional twelve questions) to complete the diagnosis[12]. Under most conditions, the SF predicts the LF well and can function independently as a screening tool.

Measurements

Because of population-related differences, we rated the nutritional status of subjects in the present study with a slightly modified version (Taiwan version-2) of the MNA. The MNA-Taiwan version-2 adopted the Taiwanese-specific anthropometric cut-off points[13] and also replaced item R (calf-circumference) for item F (BMI)[14]. The MNA-Taiwan version-2 has been shown to perform better or at least equal to the MNA-Taiwan version-1 (a normalised version by adopting population-specific anthropometric cut-off points). Data for all items in the MNA-LF, except items I (pressure sore/skin ulcers) and M (fluid intake), were available in the survey database. So, the MNA was based on fifteen items with a maximum score of 28 points, rather than seventeen items for 30 points. However, the total score was proportionately adjusted on the full-score basis. A final score of ≤16·5 suggests malnourishment; 17–23·5, at risk of malnutrition; and 24 or more, normal. All MNA-SF items were available in the questionnaire. The MNA-SF has a maximum score of 14. A score of 0–7 indicates malnourished; 8–11, at risk of malnutrition; and 12–14, normal[12].

Functional status was assessed using a self-report questionnaire containing the ADL adapted from the 1984 National Health Interview Survey Supplement on Aging[15]. The following two types of scores could be derived from the scale: one measured difficulty in carrying out the items (the method used in the present study) and the other measured the degree of difficulty in performing each of the six items (bathing, dressing, transferring, eating, walking or toileting). An item that one ‘cannot do independently’ is considered ‘dependent’ for that item. The number of items that one ‘cannot do’ was then totalled[16]. Mortality data were obtained from records maintained by the SHLSET project and confirmed with records of the Universal Health Insurance Program and the National Household Registration.

Statistical analysis

Subjects’ baseline characteristics, nutritional status, number of ADL dependencies and follow-up 4-year mortality were computed with simple statistics. We used Cox regression analysis (with the Akaike information criterion) and the net reclassification improvement (NRI)[17] to quantify the improvement offered by the two markers, the MNA and the ADL, in predicting follow-up 4-year all-cause mortality. In Cox regression analysis, we calculated the lengths of survival time for subjects who died during the follow-up 4 years according to records maintained by the SHLSET project and took 48 months as the censoring time for subjects who survived, and we used the changes in Akaike information criterion values to indicate the improvement in predictive abilities. In an adaptation[18] of NRI analysis[17], we computed the differences in proportions of upward and downward reclassifications in the fatality groups minus the differences in proportions of upward and downward reclassifications in the survivor groups after the inclusion of the MNA ratings to the ADL ratings[17]. We considered the number of ADL dependencies (0, 1–2 or ≥3) to be the base risk, whereas the augmented risk function was the combination of the number of dependencies with the MNA ratings. For each ADL stratum, we defined upward reclassification as nutritional status worse than normal (at higher risk) and downward as normal nutritional status (at lower risk). All statistical analyses were performed with the SAS statistical software package (SAS Institute, Inc.). Statistical significance for all analyses was accepted at $\alpha = 0{\cdot}05$.

Results

Table 1 shows the characteristics of the subjects. The sample included slightly more men, which reflected the composition of the age group. More than half (64·9 %) of the subjects

Table 1. Characteristics of the subjects at baseline (*n* 2872)

Parameters	Before weighting (*n*)	After weighting (%)
Sex		
Men	1570	54·5
Women	1302	45·5
Age (years)*		
65–74	1622	64·9
75–84	1057	29·7
≥ 85	193	5·4
Formal education (years)		
≤ 6	2269	78·6
7–12	449	16·1
≥ 13	154	5·3
Living arrangement		
With spouse or sibling	2430	84·7
Alone	324	10·9
Institutions†	118	4·1
Smoking		
Yes	726	25·0
Drinking (times/week)		
< 1	2465	85·9
≥ 1	407	14·1
Physical activity (times/week)‡		
≤ 2	1299	44·8
≥ 3	1573	55·2

* Average age 73·04 (SD 6·11) years.
† Or with non-family members.
‡ Classified according to answers to questions that asked about the frequency and length of doing routine physical exercise. The cut-off was >30 min/time.

were 65–74 years of age and the rest were over 75 years; only 21·4 % of the subjects had more than 6 years of formal education; 11 % lived alone; 25 % were current smokers; 14 % drank once or more per week and 55 % exercised more than three times per week.

Table 2 shows the classification of ADL status and the follow-up 4-year mortality according to the nutritional status rated at baseline. The MNA-LF rated 2·7 % as malnourished, 12·7 % as at risk and 84·6 % as normal, while the MNA-SF rated 3·5, 19·0, and 77·5 %, respectively. Greater proportions of subjects who were malnourished or at risk of malnutrition had higher numbers of ADL dependency. Applying the MNA and ADL ratings simultaneously identified additional elderly with increased follow-up 4-year mortality risk who would otherwise be missed by either scale alone. Compared with the MNA-LF, the MNA-SF showed relatively good ability in predicting follow-up 4-year mortality risk.

Table 3 shows that both MNA (both forms) and ADL presented significant independent mortality-predictive abilities and complemented each other in predicting follow-up 4-year mortality risk (all $P<0·001$). It also exhibits the improvement in predicting the follow-up mortality according to the changes in Akaike information criterion values by adding nutritional status and/or ADL status to the models. The MNA-LF showed greater improvement than the MNA-SF.

Table 4 shows the cross-classification according to the ADL and MNA ratings for subjects who died and for those who survived during the 4-year follow-up. Among those who died, 205 subjects were reclassified in a higher risk and 374 in a lower risk by the MNA-LF; among those who survived, 238 subjects were reclassified in a higher risk and 2055 in a lower risk. The unstratified NRI was estimated to be 0·51 ($P<0·001$), which suggested a significant improvement after the inclusion of the MNA-LF. The MNA-SF showed comparable improvement (unstratified NRI = 0·53, $P<0·001$). The stratified NRI after the inclusion of the MNA-LF were 0·33 (SE 0·042, $P<0·001$), 0·24 (SE 0·254, $P=0·355$) and 0·05 (SE 0·193, $P=0·790$) for 0, 1–2 and ≥3 ADL dependencies, respectively. The MNA-LF improved the mortality prediction of the ADL alone for those with 0 dependencies, but not for those with 1–2 or ≥3 dependencies. The stratified NRI after the inclusion of the MNA-SF were 0·38 (SE 0·047, $P<0·001$), 0·28 (SE 0·255, $P=0·260$) and 0·08 (SE 0·191, $P=0·688$), similar to that observed with the MNA-LF. The stratified NRI shows that most of the improvement in classification over the ADL alone arises within the people with 0 dependencies, and little or no improvement in classification occurs in the people with ≥3 dependencies.

Table 5 shows the cross-classification of the results rated with the MNA-SF *v.* that rated with the MNA-LF. Among the 101 elderly rated as malnourished by the SF, thirty-nine were rated as at risk by the LF; among 545 rated as at risk by the SF, sixteen were rated as malnourished and 241 as normal by the LF; and among 2226 rated as normal by the SF, thirty-eight were rated as at risk by the MNA-LF.

Fig. 1 shows the follow-up 4-year Cox regression curves stratified by the number of ADL dependencies and nutritional status (rated with the MNA-LF and MNA-SF, respectively) adjusted for sociodemographic (age, sex and education), lifestyle (smoking, drinking and exercise) and health (hypertension, heart disease, diabetes, stroke and cancer) variables. The impact on follow-up 4-year survival by malnutrition and functional decline reached statistical significance ($P<0·05$) in most cases.

Discussion

Predicting mortality

Healthcare providers often rely heavily on measures of functional status such as the ADL to get an idea of the risk of mortality in the frail elderly. However, that approach may miss a significant proportion of the vulnerable individuals. Assessing nutritional status (with the MNA) in addition to measuring physical functional status (with the ADL) may add useful information. The present results suggest that measuring both ADL and MNA provides a more accurate indication of mortality risk than assessing either one alone. When the general older adults were graded into three levels of both nutritional and ADL status and the relative mortality risk was calculated, people who were malnourished had a markedly elevated risk of mortality in individuals seemingly functionally independent (those without any dependency). Subjects who had a greater number of ADL dependencies and poorer nutritional status were associated with a greater follow-up mortality risk. These results suggest that the MNA can improve the ability of the ADL to predict follow-up mortality risk in frail elderly.

The MNA has long been shown to predict the risk of mortality of the elderly living in various settings. van Nes *et al.*[19] observed that elderly hospital in-patients with poor nutritional status as rated with the MNA were associated

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Table 2. Distribution of Activities of Daily Living (ADL) status and follow-up 4-year mortality according to nutritional status classified at baseline in elderly Taiwanese (*n* 2872)*

(Number of subjects and percentages)

			Nutritional status rated with the MNA-LF						Nutritional status rated with the MNA-SF					
	Total		Malnourished		At risk		Normal		Malnourished		At risk		Normal	
Items	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Nutritional status†	2872	100	78	2·7	365	12·7	2429	84·6	101	3·5	545	19·0	2226	77·5
By the number of ADL dependencies														
0	2715	94·5	33‡	42·3	299	81·9	2383	98·1	54	53·5	475	87·2	2186	98·2
1–2	61	2·1	6	7·7	23	6·3	32	1·3	7	6·9	27	5·0	27	1·2
≥ 3	96	3·3	39	50·0	43	11·8	14	0·6	40	39·6	43	7·9	13	0·6
Follow-up 4-year mortality§														
Total	579	20·2	63	80·8	142	38·9	374	15·4	68	67·3	185	33·9	326	14·6
By the number of ADL dependencies														
0	469	17·3	20	60·6	101	33·8	348	14·4	24	44·4	141	29·7	304	13·9
1–2	32	52·5	6	100	11	47·8	15	46·9	7	100	13	48·1	12	44·4
≥ 3	78	81·3	37	94·9	30	69·8	11	78·6	37	92·5	31	72·1	10	76·9

MNA, Mini-Nutritional Assessment; LF, long form; SF, short form.
* Baseline nutritional status was rated with the LF and SF of MNA Taiwan-version-2. Values are weighting-adjusted.
† *n* and (%) of the total sample.
‡ *n* and (%) of subjects within the nutrition category.
§ *n* and (%) of death within the ADL dependency–nutrition category.

with a longer length of stay and increased in-hospital mortality. Similarly, Donini *et al.*[5] observed that a low MNA score was predictive of a greater incidence of adverse clinical events during hospitalisation and of higher follow-up mortality in elderly patients. Beck *et al.*[3] found that an MNA score ≤23·5 points predicted mortality risk in a group of 70–75-year-old Danes. In a prospective follow-up study, Persson *et al.*[4] observed that the MNA was able to predict 3-year follow-up mortality risk in geriatric patients.

The MNA is a multidimensional and multifunctional scale. Both the LF and SF scales evaluate multi-aspects of nutritional health. The MNA has been shown to have the ability to predict functional status, hospital cost and mortality risk, in addition to nutritional status[8,20–23]. Thus, it is not surprising that the MNA can enhance the ADL in predicting the risk of mortality in the elderly.

Our regression models suggest that nutritional status and ADL dependency are two major independent predictors of follow-up mortality risk in elderly persons. The models also show that the MNA-SF is comparable with the MNA-LF in improving the ability of ADL in predicting follow-up mortality risk. Because the SF is much simpler and time-saving to administer than the LF, it is often much more desired in routine practice. Although the MNA-LF is stronger than the MNA-SF in predicting nutritional risk, the SF appears as effective as the LF in predicting follow-up mortality risk.

The results also show that among the 101 elderly rated as 'malnourished' by the MNA-SF, the MNA-LF 'clarifies' that thirty-nine of these (39 %) are actually at lesser risk (at risk). Among the 545 rated as 'at risk' by the MNA-SF, almost half (241) are relabelled as 'normal'. Thus, among those in whom any action should be taken, the LF shows that a lesser action would suffice in 280 (43 %) out of 646 individuals. Changes to a diagnosed greater risk state are less frequent, only fifty-four people. Thus, the MNA-SF has a great deal of similar signal to the MNA-LF, but certain classifications

Table 3. Cox regression models evaluating the ability of the Mini-Nutritional Assessment (MNA) scores and/or the Activities of Daily Living (ADL) scores to predict the follow-up 4-year all-cause mortality in elderly Taiwanese (*n* 2872)*

(Hazard ratios (HR) and 95 % confidence intervals)

	MNA-LF at baseline				MNA-SF at baseline			
Variables in the model	AIC	HR	95 % CI	*P*	AIC	HR	95 % CI	*P*
CV† only	8574·0				8574·0			
CV+MNA score‡	8447·1	0·879	0·861, 0·897	< 0·001	8464·1	0·823	0·796, 0·852	< 0·001
CV + ADL score‡	8482·5	1·099	1·080, 1·119	< 0·001	8482·5	1·099	1·080, 1·119	< 0·001
CV + MNA and ADL scores	8422·3				8427·5			
MNA score		0·904	0·882, 0·926	< 0·001		0·859	0·827, 0·892	< 0·001
ADL score		1·058	1·036, 1·080	< 0·001		1·067	0·046, 1·089	< 0·001

LF, long form; SF, short form; AIC, Akaike Information Criterion; CV, control variables.
* All models are weighting-adjusted.
† All models were controlled for demographic (age, sex and years of formal education), lifestyle (smoking status, alcohol drinking and routine physical activity) and health-related (hypertension, diabetes, heart disease, stroke and cancer) variables.
‡ MNA score was rated with the MNA-LF and MNA-SF, respectively, and ADL score was rated with the ADL scale. Both variables were tested as continuous parameters (MNA score or number of ADL dependencies).

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Table 4. Analysis with the Net Reclassification Improvement (NRI) to evaluate the ability of the Mini-Nutritional Assessment (MNA) and Activities of Daily Living (ADL) to improve the prediction of follow-up 4-year death events in elderly Taiwanese: adding nutritional (MNA) classifications to ADL classifications* (*n* 2872)

		According to the MNA							
According to the ADL	Total	Malnourished	At risk	Normal	Proportion upward†	Proportion downward†	Stratified and unstratified NRI	SE‡	*P* for non-zero NRI
Long-form MNA									
Participants of events (dead)									
Total	579	63	142	374					
0 dependency	469	20	101	348	0·258	0·742	0·33	0·042	< 0·001
1–2 dependencies	32	6	11	15	0·531	0·469	0·24	0·254	0·355
≥ 3 dependencies	78	37	30	11	0·859	0·141	0·05	0·193	0·790
Participants of non-events (alive)									
Total	2293	15	223	2055					
0 dependency	2246	13	198	2035	0·094	0·906			
1–2 dependencies	29	0	12	17	0·414	0·586			
≥ 3 dependencies	18	2	13	3	0·833	0·167			
Unstratified NRI							0·51	0·042	< 0·001
Short-form MNA									
Participants with events (dead)									
Total	579	68	185	326					
0 dependency	469	24	141	304	0·352	0·648	0·38	0·047	< 0·001
1–2 dependencies	32	7	13	12	0·625	0·375	0·28	0·255	0·260
≥ 3 dependencies	78	37	31	10	0·872	0·128	0·08	0·191	0·688
Participants of non-events (alive)									
Total	2293	33	360	1900					
0 dependency	2246	30	334	1882	0·162	0·838			
1–2 dependencies	29	0	14	15	0·483	0·517			
≥ 3 dependencies	18	3	12	3	0·833	0·167			
Unstratified NRI							0·53	0·044	< 0·001

* The analysis of adding ADL classifications to MNA classifications is shown in Appendix A.

† Subjects were identified as upward reclassification if their nutrition status was worse than normal and downward if they were normal. The proportion of reclassified upward (downward) was the number of upward (downward) divided by the total in each ADL category.

‡ The standard error of the NRI was computed as the square root of $(2 \times (p_{up,event}\, q_{up,event}/n_{event} + p_{up,nonevent}\, q_{up,nonevent}/n_{non\text{-}event}))$, where $q = 1 - p$; p_{up} is the proportion reclassified upward; and n is the total number of subjects in each ADL category.

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Table 5. Mini-Nutritional Assessment (MNA)-long form (LF) and MNA-short form (SF) cross-tabulation test

	According to the MNA-LF							
	Malnourished		At risk		Normal		Total	
According to the MNA-SF	*n*	%	*n*	%	*n*	%	*n*	%
Malnourished	62	2·2	39	1·4	0	0	101	3·5
At risk	16	0·6	288	10·0	241	8·4	545	19·0
Normal	0	0	38	1·3	2188	76·2	2226	77·5
Total	78	2·7	365	12·7	2429	84·6	2872	100
Weighted κ	0·686							
95 % CI	0·655, 0·716							

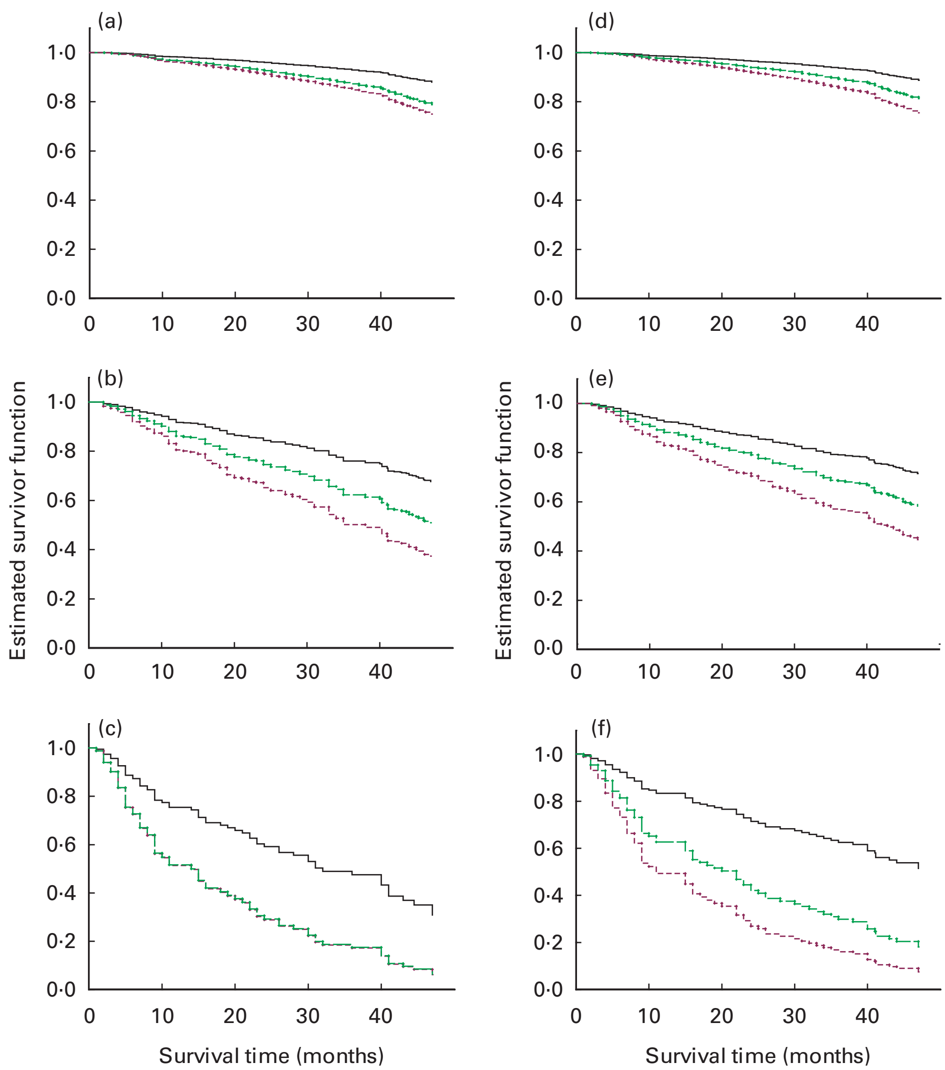

Fig. 1. Cox regression analyses of the follow-up 4-year survival curves stratified by the number of Activities of Daily Living (ADL) dependencies and nutritional status (rated with the Mini-Nutritional Assessment (MNA)-long form ((a) normal, (b) at risk and (c) malnourished)) and the MNA-SF ((d) normal, (e) at risk and (f) malnourished)), respectively) adjusted for demographic (age, sex and education), lifestyle (smoking, drinking and exercise) and health-related (hypertension, heart disease, diabetes, stroke and cancer) variables. Sets of data presented as hazard ratios and 95 % CI for 1–2 dependencies (HR1;-----) and ≥3 dependencies (HR2;········) using the ‘ADL-intact’ group (—) as the referent are as follows: (a) HR1 = 1·85 (1·14, 3·01), HR2 = 2·24 (1·23, 4·07); (b) HR1 = 1·73 (0·95, 3·14), HR2 = 2·52 (1·59, 3·99); (c) HR1 = 2·35 (0·82, 6·73), HR2 = 2·37 (1·19, 4·72); (d) HR1 = 1·74 (1·00, 3·01), HR2 = 2·36 (1·31, 4·25); (e) HR1 = 1·61 (0·93, 2·78), HR2 = 2·41 (1·54, 3·76) and (f) HR1 = 2·57 (1·06, 6·26), HR2 = 3·90 (1·97, 7·72). In the Cox regression analysis, lengths of survival time were calculated according to the records maintained by the Survey of Health and Living Status of the Elderly in Taiwan project for subjects who died during the 4-year follow-up, and took 48 months as the censoring time for subjects who survived.

are different in many people. Whether this matters depends on the cost of further diagnosis or intervention action. The 241 individuals who are rated as at risk by the MNA-SF but as normal by the MNA-LF are probably those who are having emerging nutritional problems.

The complementarity can also be demonstrated by adding the ADL classifications to the MNA classifications (Appendix A). With any dependency taken as upward reclassification and no dependency taken as downward reclassification, the unstratified NRI is 0·34 (SE 0·033, $P<0·001$), while the stratified NRI are 0·12 (SE 0·027, $P<0·001$) for those who are rated as normal by the MNA-LF, 0·35 (SE 0·087, $P<0·001$) for those who are rated as at risk, and 1·10 (SE 0·211, $P<0·001$) for those who are rated as malnourished. Similar results are obtained by adding the ADL classifications to the MNA-SF classifications. Thus, addition of the ADL classifications to the MNA classifications leads to significant reclassification improvement, particularly in the malnourished subgroup.

Strengths and limitations

A major strength of the study is that the data were from a longitudinal cohort study involving a relatively large population-representative sample. Baseline physical functional (ADL) and nutritional (MNA) status can infer a causal relationship with the follow-up mortality risk. However, there are also limitations. (1) Despite a relatively large sample size, when classified by the ADL and MNA simultaneously, the number of observation is relatively small in some classifications. (2) Most data were obtained through interviews. In individuals who were cognitively impaired, data were mostly obtained through proxies. The quality of such data might be compromised. (3) No biochemical data were available in the datasets to support the present findings. Thus, confirmation of the nutritional status graded with the MNA with biomarkers is not possible.

Conclusion

Using Cox regression analysis and the NRI, we have conclusively shown that nutritional (MNA) and functional (ADL) ratings complement each other in predicting the follow-up 4-year mortality risk in the elderly. Rating the elderly with both tools simultaneously can provide a more accurate prediction of mortality risk than with either one alone. The MNA and ADL are two simple and non-invasive scales that can be easily administered to the elderly living in almost any setting. Simultaneous application of the MNA and ADL appears to be an effective and economical way of identifying those elderly who are in need of intervention.

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Appendix A. Analysis with the net reclassification improvement (NRI) to evaluate the ability of the Mini-Nutritional Assessment (MNA) and Activities of Daily Living (ADL) to improve the prediction of follow-up 4-year death events in elderly Taiwanese: adding ADL classifications to nutritional (MNA) classifications (*n* 2872)

		According to the ADL							
According to the MNA	Total	0 dependencies	1–2 dependencies	≥3 dependencies	Proportion downward*	Proportion upward*	Stratified and unstratified NRI	SE†	*P* for non-zero NRI
Long-form MNA									
Participants of events (dead)									
Total	579	469	32	78					
Malnourished	63	20	6	37	0·317	0·683	1·10	0·211	<0·001
At risk	142	101	11	30	0·711	0·289	0·35	0·087	<0·001
Normal	374	348	15	11	0·930	0·070	0·12	0·027	<0·001
Participants of non-events (alive)									
Total	2293	15	29	18					
Malnourished	15	13	0	2	0·867	0·133			
At risk	223	198	12	13	0·888	0·112			
Normal	2055	2035	17	3	0·990	0·010			
Unstratified NRI							0·34	0·033	<0·001
Short-form MNA									
Participants with events (dead)									
Total	579	469	32	78					
Malnourished	68	24	7	37	0·352	0·647	1·11	0·015	<0·001
At risk	185	141	13	31	0·762	0·238	0·33	0·068	<0·001
Normal	326	304	12	10	0·933	0·067	0·12	0·028	<0·001
Participants of non-events (alive)									
Total	2293	2246	29	18					
Malnutrition	33	30	0	3	0·909	0·091			
At risk	360	334	14	12	0·928	0·072			
Normal	1900	1882	15	3	0·991	0·009			
Unstratified NRI							0·34	0·033	<0·001

* Subjects were identified as upward reclassification if they had any dependency and downward if they had no dependency. The proportion of reclassified upward (downward) was the number of upward (downward) divided by the total in each MNA category.

† The standard error of the NRI was computed as the square root of $(2 \times (p_{up,event}\, q_{up,event}/n_{event} + p_{up,nonevent} q_{up,nonevent}/n_{nonevent}))$, where $q = 1\text{-}p$; p_{up} is the proportion reclassified upward; and n is the total number of subjects in each MNA category.