The historical progression from ADL scrutiny to IADL to advanced ADL: Assessing functional status in the earliest stages of dementia

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Abstract

Background Decrements in instrumental activities (IADL) have been observed in the prodromal phase of dementia. Given the long pre-dementia stage in neuro-degenerative diseases, it has been proposed that subtle functional changes may precede clinical IADL impairment. Incorporating more challenging advanced ADLs (e.g., volunteer work) into the assessment process may increase the sensitivity of functional measures, thus expanding the window for monitoring or interventions.

Methods Longitudinal cohort study (follow-ups, 18-24 month), subjects aged >60 (n=3635). To elucidate the relationship between cognitive ability and functional status we employed an IADL scale with an extended range (ADL-extended; includes IADL but also more challenging advanced ADLs) that meets item response theory properties of dimensionality, monotonicity, and item hierarchy. Procedures involved: 1) a dynamic change model employed to inspect the temporal relationship between ADL-extended and cognitive status; 2) Cox proportional hazards to assess risk of incident dementia based on ADL-extended scores.

Results Growth curve modeling: baseline ADL-extended was significantly associated with all four cognitive domains investigated. Worse baseline ADL-extended was associated with more rapid declines in speed/executive function, and worse baseline memory was associated with more rapid declines in ADL-extended; a concurrent association was found for language and ADL-extended. Cox model: the risk of dementia was decreased for each additional ADL-extended item endorsed (HR, .85; 95% CI 0.81 to 0.90).

Conclusions An increased risk of dementia could be observed in the ADL-extended items, which reflects an area of the functional continuum beyond IADL competencies.

Kew words: Cognitive impairment, function, ADL-extended

INTRODUCTION

Due to their subjective reporting format, assessment of activities of daily living (ADL) have often been criticized in terms of reliability, or more accurately, reporting bias. However, what these self and proxy reports lack in accuracy, they make up for in predictive validity (1), as well as healthcare and research practicality (cost, time and subject burden). ADL questionnaire development began in the late 50s to describe functional status in relatively severe institutionalized populations (2; e.g., can subjects bathe or dress themselves). A decade later, instrumental ADLs questionnaires (IADL) were developed out of the need to describe a less severe, transitional independence stage (3); these activities were thought to be more complex and included, for example, activities related to shopping or personal finance. Now, with the growing consensus that preclinical dementia may begin one to two decades prior to diagnosis, it has prompted the need to describe function in another, earlier transitional stage, e.g., early prodromal dementia (mild cognitive impairment; MCI) or the transition from pre-clinical to prodromal dementia. Functional assessment in this range coincides with the recently revised dementia criteria (Alzheimer's type) that includes a preclinical dementia stage, that is, subjects that are minimally or non-symptomatic but at increased risk (based on biomarker evidence) of declining toward prodromal of frank dementia (4).

Evidence relating to functional difficulty in the prodromal stage of dementia continues to accumulate, usually presented in terms of IADL difficulty (5); Jutkowitz et al. (6) observed that IADL function, on average, decreased by nearly 15% eight years prior to dementia diagnosis. Luck et al. (7) reported that function and cognition were independent risk factors for incident dementia, with similar effect sizes (respectively, proportional hazards = 2.22 and 2.67); mean time to dementia for those with cognitive impairment only was 5.6 years, IADL impairment only 6.3 years, and combined impairment was 4.6 years. This independent relationship is supported by the finding that subtle functional difficulties, *prior to cognitive impairment*, are associated with Alzheimer's biomarkers, such as brain amyloid deposition (8) and neurodegeneration (i.e., baseline cortical thickness and worsening IADL impairment over time; 9).

It is unclear whether the emergence of difficulties in IADL tasks represents the limits of detectable functional change. In a review by Sikkes et al. (10), it was concluded that the psychometric properties of the commonly used IADL questionnaires either were unavailable or did not meet the standards of quality, citing large ceiling effects as one important example (content validity). Even in advanced age (mean age 79), reporting of IADL status presents with large ceiling effects (11). Finally, it has been noted that more sensitive tools were needed to identify the subtle functional changes that can occur in the early prodromal dementia stage (12).

Several approaches for detecting functional difficulty at the earliest stages of dementia are now being explored with increased fervor. Performance-based and observed IADLs in which subjects are asked to simulate everyday activities are thought be more objective measures, assessing one's actual functional performance, e.g., medication use; 13) or financial management tasks (14). Another promising format includes inquiries into compensatory strategies that may take place at beginning stages of IADL impairment (15). I third method relates to advanced (16) or extended ADL measures (17), terminology used to describe the level of functional competence beyond IADLs. Advanced ADLs (e.g., writing a letter, volunteer work, or technology use) are volitional with less automated skills, and increased potential for "effortful processing", which requires greater attentional resources. The term complex ADL has also been employed (e.g., functional activities questionnaire; FAQ), typically describing a cluster of tasks that include challenging IADLs (usually cognitive-type, such as personal finance), but also advanced ADLs, as well as what might be best described as subjective cognitive complaints (e.g., remembering appointments). It could be argued that the latter is less well-placed, based on the proposal that IADL or advanced ADLs should entail 'multiple cognitive processes' (10). This final point relates to the ambiguity of defining functional competence beyond the capacity to perform basic ADLs, which is discussed in the Limitations section. Finally, as this investigation is focused on self-report questionnaire data, it is worth noting that self-report and performance-based measures have shown to contribute unique variance to function (18; see Supplemental more detail).

This manuscript is novel in its effort to investigate function as continuum (Advanced ADL to IADL) and its relationship to cognitive impairment. Assessing advanced ADL appears to be gaining in popularity due to the interest in detecting the earliest alterations in daily functioning. In this manuscript we employed an ADL-extended scale to assess functional status, which includes four IADL tasks (e.g., medication use, traversing one's neighborhood, light housework, & shopping) and five advanced ADLs (visiting others, going to movies/restaurants/sporting events, attending clubs, volunteer work, & attending classes). Here we examine: 1) the temporal relationship between cognition and the ADL-extended measure; 2) the predictive validity of the ADL-extended scale in terms of incident dementia.

METHODS

Subjects and procedures

Subjects are Medicare beneficiaries living within three adjoining census tracts in the northern Manhattan (New York City) communities of Washington/Hamilton Heights and Inwood. The sample included individuals from several countries of origin and three broadly defined ethnic categories—Caribbean Hispanic, black, and non-Hispanic white of European ancestry. Those not speaking English or Spanish were excluded from participation. The study included longitudinal data from three separate recruitment periods: 1992, 1999, and 2009. Follow-ups were ongoing and occurred at 18-24 month intervals. The sampling strategies and recruitment outcomes of these three cohorts are described in previous publications (19). We employed growth curve analysis for examining change in our scale over time, and the relationship between changes in the scale and changes in cognition over time. We also used Cox analysis to explore the relationship between functional status and dementia.

Measures

Construct validity of the ADL-extended scale (ADL-x) was previously reported in this journal using item response theory methodology (IRT; 20). Figure 1 (bottom) depicts all nine items, as well as two theoretical models of the relationship between dementia course and function (4, 21). Briefly, we employed IRT Mokken scaling (22) to establish monotone homogeneity (i.e., unidimensionality, local independence, and monotonicity) for 11 advanced ADLs. Six items met the above IRT assumptions: reading books, visiting others, going to movies/restaurants/sporting events, attending clubs, volunteer work, attending classes. The same procedure was conducted for 9 traditional IADLs, resulting in seven activities that met IRT assumptions: trouble getting around the house, medication use, trouble getting around the neighborhood, paying bills, cooking meals, shopping, and light chores. An attempt was then made to combine the two scales; initially, this resulted in a poorly fitting model in terms of IRT assumptions. Three items were removed to improve the model, and to meet monotone homogeneity requirements: paying bills, trouble around the house, and reading books. Rasch IRT methodology further confirmed unidimensionality and local independence of the 10 remaining items. A final, rather stringent IRT assumption (double monotonicity) was employed to confirm a formal hierarchy of task difficulty. This assumption was met after the removal of the prepare meals item. This resulted in the final 9-item ADL-extended scale meeting the IRT assumptions of unidimensionality, local independence, and double monotonicity, with a sufficient Mokken Rho coefficient (comparable to Cronbach's Alpha) of .73.

The earliest proponents of advanced ADL assessment, noted in the introduction, considered the following tasks: reading newspapers or books, writing letters, going out socially, manage garden (advanced ADLs from their Nottingham Extended ADL scale) and visiting relatives or friends, participating in community activities, and taking care of other people (Functional Status Questionnaire). Advanced ADLs are also incorporated into the International Classification of Functioning, Disability and Health assessment. However, in all of these tools, advanced ADLs are examined as separate domains, with no attempt to construct a functional continuum. To the best of our knowledge, only one psychometrically validated scale (within the field of disability research) has devised a continuum of function from basic to advanced ADL, ranging from personal care needs & taking care of health (least difficult) to volunteer job & active recreation (23). Interestingly, the midway point/task for this scale is the same as our ADL-extended, namely, visit friends or family.

Neuropsychological evaluation: Assessed with a neuropsychological test battery grouped into four composite scores (memory, language, speed/executive, and visuospatial). See supplemental for a breakdown of composites. Diagnosis: A consensus diagnosis evaluating the presence or absence of Mild Cognitive Impairment (MCI) or dementia was conducted at a diagnostic conference of physicians and neuropsychologists (See supplemental).

Illness Burden: To quantify illness burden at each occasion, one point was assigned for the presence of each of the following conditions: heart disease, hypertension, stroke, diabetes, pulmonary disease, thyroid disease, liver disease, renal insufficiency, peptic ulcer disease, peripheral vascular disease, cancer, Parkinson's disease, Essential Tremor, Multiple Sclerosis, and arthritis. These points were summed to create an index of illness burden at each occasion.

Statistical analyses

Estimation of intercept and slope for ADL-x and cognitive composites

Longitudinal data were analyzed in Mplus version 7 (24) with latent growth curve (LGC) modeling, which is a special case of structural equation modeling that estimates average initial level (intercept) and rate of change (slope) in a measure for an entire sample (fixed effects), as well as individual differences in initial level and rate of change (random effects). For all models, time was parameterized in years from study entry. We simultaneously estimated growth curves for ADL-x and a cognitive composite, along with four covariates measured at baseline−gender, age, race, and education, and one time-varying covariate – illness burden.

Estimation of dementia risk

We employed Cox proportional hazards (25) to examine the association of ADL-x performance and the HR of incident dementia. In this paper HR is the ratio of the risk for cognitive impairment in the group exposed to the factor (advanced ADL participation), to the unexposed group (IADL tasks only). Here we are concerned with identifying the influence of ADL-x on future risk of dementia. For these analyses we chose to use the average ADL-x sum score as our metric of functional status due to the observed transient nature of disability in older adults (26).

For dementia cases, we assigned onset as the age of the first follow-up visit at which dementia was documented. The temporal component (x-axis) for the overall analyses was time (in years) to dementia. We calculated the association between ADL-x and HR of incident dementia in a complete Cox model that included all covariates: age, gender, ethnicity, education, occupation, depression, heart disease, hypertension, diabetes, stroke, arthritis, and COPD.

RESULTS

Longitudinal Examination−Latent Growth Curve Models

Intercepts for ADL-x and cognitive composites

The median age of first assessment was 73, with a range of 62 to 101 (See Table 1**.** for parameter estimates of growth curve modeling). The mean baseline ADL-x performance was 5.8, with a maximum value of 9 (higher scores equal more participation). There were significant positive associations between baseline ADL-x scores and baseline memory, language, speed/executive, and visuospatial abilities (see Supplemental Table 1)

Slopes for ADL-x and cognitive composites

In models allowing linear change (see Table 1.), ADL-x performance worsened over time (slope estimate = -.07; p <.001). On average, subjects scored worse on the z-score cognitive composites each year: substantially less decline was observed for language (verbal memory) and visuospatial domains, with yearly decrements of .3% and .9% respectively. However, memory performance saw a decline in z-score units per year of 5%, and speed of processing was 3%.

Multivariate (conditional) growth curves: lead, lag, and concurrent relationships

All possible associations between intercepts and slopes were estimated (details provided in Supplemental, Table 1.). Results show: 1) worse baseline ADL-x was associated with more rapid declines in speed/executive function. *The reverse, baseline speed/executive score predicting ADL-x change, was not observed*; 2) baseline memory was associated with change in ADL-x; 3) Concurrent change was observed for ADL-x performance and language (*p* = .058).

Demographic characteristics and Cox analysis

Of the subjects who had data available for advanced ADL status, 3,635 subjects were free of dementia at baseline. During the course of the study, 537 subjects became demented. Demographic variables and frequencies of medical conditions of subjects who did and did not become demented are presented in Table 2.

Risk of dementia conversion

When the mean ADL-x score was treated as a continuous variable in a Cox model, higher scores were associated with (p <.01) a hazard ratio for dementia (HR, .81; 95% CI 0.75 to 0.90). When age, memory performance, education, depression, and stroke were considered simultaneously in the Cox model, ADL-x sum score (continuous) still had a significant effect, with higher scores being associated with lower HR for incident dementia (HR, .85; 95% CI .84 to .93). For those subjects only endorsing IADL participation the hazard of dementia was twice as high, as compared to subjects preforming $\geq$ one advanced ADL (see Figure 2; HR, 2.2; 95% CI 1.80 to 2.6).

DISCUSSION

It has been proposed that, functional decline, like cognitive decline, exists on a continuum from healthy aging to dementia onset (27). Just as ADLs and IADLs have previously been shown to exist on a continuum (for a review see; 28), we speculated that IADL and advanced ADLs may also form a continuum. The ADL-extended scale employed in this investigation is reliable, uni-dimensional and adheres to a formal hierarchy. It was observed that average baseline performance for the entire sample was 5.8 on the ADL-x, an item location equivalent to "visit others" (advanced ADL item). Baseline ADL-x presented with positive correlations for all cognitive domains. We observed a significant decline for ADL-x status over time. After controlling for covariates, baseline ADL-x scores were associated with subsequent declines in performance on tests of speed/executive function (leading change in cognition). The reverse was observed for memory: baseline memory associated with decline in ADL-x. A concurrent association was observed between changes in ADL-x and language function. ADL-x function as an indicator of cognitive decline (speed/executive function) or the concurrent language association is consistent with the observation that functional difficulty can precede stroke (29),that is, post-stroke differences in IADL independence largely reflect pre-stroke disparities. Similarly, in a 3-year follow-up study it was observed that *cognitive IADL* status was predictive of global cognitive decline on subjects who later presented with delirium (30). The relationship between ADL-x status and executive function may also be explained by the well-established association between physical function (mobility) and cognition, as well as ADL status (31). We would also speculate that a good portion of the variance in the ADL-x/executive function relationship may be attributed to the construct of cognitive reserve (32), in which advanced ADLs serve to promote more efficient and adaptive neurological processes. Epidemiologic evidence for the influence of advanced ADL status on cognitive ability has been accumulating for three decades now. For instance, endorsing higher levels of advanced ADL performance (e.g., visiting family and friends) was related to less decline in executive function (33). Lovden et al. (34) reported that social-type advanced ADLs appeared to lead changes in speed of processing. Finally, in the current study involving older adults, better ADL-x scores were associated with a reduced HR of incident dementia; each additional activity endorsed on the ADL-x scale resulted in a 19% hazard reduction for dementia. It is important to note that only 5% of the entire sample presented with ceiling effects on the ADL-x instrument, thus allowing for a more comprehensive evaluation of functional status in older adults. This is particularly relevant if we consider that, despite deviations from the original definition of MCI, IADL difficulty has been observed in prodromal phase of dementia. Peres et al. (35) found that IADL difficulty could be detected in incident dementia cases 10 years prior to diagnosis. However, 65% (contrast with 5% in the current sample) of the 104 subjects that developed dementia did not present with difficulty at baseline, and an additional 17% presented with minor difficulties that did not translate into risk 10 years later. Thus, risk in terms of function could not be evaluated for a large majority of subjects. This is a problem relating to content validity and a restriction in the measurement of functional status.

The reporting of IADL impairment has been described as a ‘stepping stone’ towards Alzheimer’s disease (AD) diagnosis in subjects with prodromal dementia (12). However, it is more than likely that functional decrements may occur prior to their manifestation in traditional IADL performance (e.g., shopping), but historically, these “healthy” populations were not targets for investigation. Cognitive decline at an early stage seems first to be associated with advanced ADLs that present high cognitive demands; arguably, these kinds of activities require more cognitive resources than IADLs and are therefore more vulnerable to early cognitive changes than activities with relatively low attentional demand like preparing meals or housework (36).

Limitations

The sample is perhaps non-representative of the general population, e.g., the education level appears relatively low (nearly 50% of non-demented subjects have less than a high school degree), and only 23% of subjects with “high occupation”.

It could be argued that advanced ADLs are not a feature of disability, as they are nonessential functions, and thus should not be incorporated into the assessment of disability. We acknowledge this position, particularly as it relates to assessment at a single time point. However, when considering longitudinal trajectories and risk assessment, a functional continuum appears valid.

While the advanced social and cognitive leisure ADLs are nonessential functions, they have previously been conceptualized as a dimension of disability, for example, Nagi Disablement Model (elaborated on by Verbrugge and Jette; 37). These authors operationalized disability as a broad range of role behaviors that are relevant in most people's daily lives. Five commonly applied dimensions of disability evolved from this line of scientific inquiry: basic activities of daily living (e.g., basic personal care); instrumental activities of daily living (e.g., preparing meals & shopping); paid and unpaid role activities (occupation, & parenting); social activities (attending clubs); and leisure activities (attending museums & reading). While the performance of advanced ADLs are non-essential to the individual's immediate survival, they are increasingly recognized as essential to risk assessment in dementia care, as the neuropathology of the disease can occur decades prior to diagnosis, and thus, may be impacting function years before clinically relevant functional impairment (e.g., ADL difficulty such as bathing). For instance, the NIA/Alzheimer's Association workgroup noted the need to develop measures of very early functional changes (e.g., social interaction; 4). Similarly, it has been noted that that currently available functional instruments "are capable of detecting functional impairment in the MCI and AD stages, few of them capture the earliest functional deficits seen in preclinical AD (38, p. 859).

In its current format this IADL-x is relatively crude; the response options were a dichotomous yes/no format which reduced the amount of information to be obtained from each subject. A revised scale would include a polytomous-5-category response option. The dichotomous response format may have also had an adverse impact on the effect sizes in our growth curve estimates. However, it is not uncommon to observe significant but small effects using growth curves to model, for example, change in cognitive function (see Supplemental for more detail).

Conclusion

In this study a concerted effort was made to assess a fuller range of functional status (ADL-extended), from advanced-ADLs to instrumental activities (IADLs). Our dynamic change model showed that, function did decline across the study period, with the average baseline performance in the normal range of function. Also, our findings suggest a reciprocal relationship between ADL-x and cognition, whereby better language ability promotes activity engagement, and greater activity engagement promotes stability in cognition. Hazard assessments of dementia were two times lower for subjects performing advanced-ADLs, as compared to those whose status is limited to IADL performance.

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Conflicts of Interest

The authors have no conflicts to disclose.

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Table 1. Parameter estimates in the unconditional model

Unconditional univariate[a]	Intercept		Linear Slope		Quadratic slope	
	mean	SE	mean	SE		SE
IADL-x	5.8**	.031	-.070**	.007		
Memory	.215**	.001	-.050**	.006	.002*	.001
Language	.167**	.010	-.003	.004	-.003**	.001
Visuospatial	.219**	.010	-.009**	.002		
Speed	.281**	.020	-.033*	.014	-.005*	.002

Note: SE, standard error; [a] Parameters estimated in five separate univariate models;*p <.05; **p <.001

Table 2. Demographics, with/without Dementia

Demographics	No dementia	Incident dementia	*p* Value
Number of subjects	3098	537	
Age, mean, ± SD	76 (6.3)	79 (6.6)	<.001
Education years, low %	49	73	<.001
IADL-x, low, %	19	28	<.001
Sex, % woman	66	73	<.01
Occupation, high, %	23	8	<.01
Stroke, %	14	33	<.001
Hypertension, %	79	86	<.01
Heart disease, %	38	47	<.01
Diabetes, %	20	22	<.56
Depression, %	19	27	<.001
Race			
White%	28	12	<.01
Hispanic %	32	30	<.59

Black%	40	57	<.001

Note. SD= standard deviation. Low IADL-x= endorsing *no* advanced ADLs/cognitive leisure activities. Low education= ≤ 11 years.

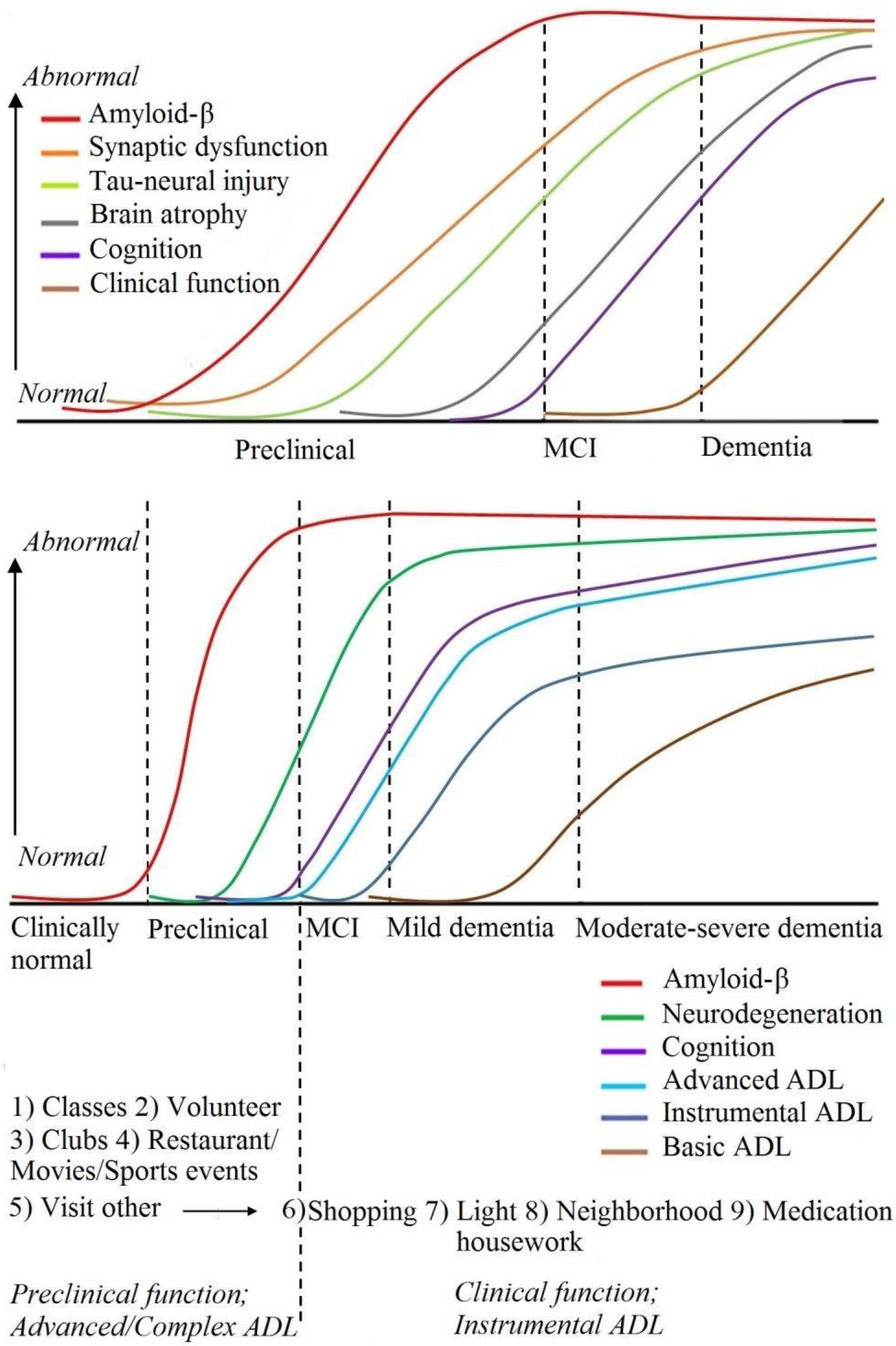
Figure 1. Functional status in preclinical dementia

The theoretical model (**top figure**) presents input from the NIA/Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease (adapted from 4). While the brown sigmoid curve was depicted primarily to contrast end-stage development, the authors briefly suggest: the need to develop measures of very early functional changes in other domains (e.g., social engagement); such measures would allow for a better link between pathological processes to the emergence of clinical symptoms, and may be particularly useful to monitor response to potential disease-modifying therapies in these very early stages. However, the **bottom figure** presents an extended ADL dynamic in which complex/advanced ADLs inhabit a range much closer to cognitive impairment (adapted from 21).

Figure 2. Cox model and incident dementia

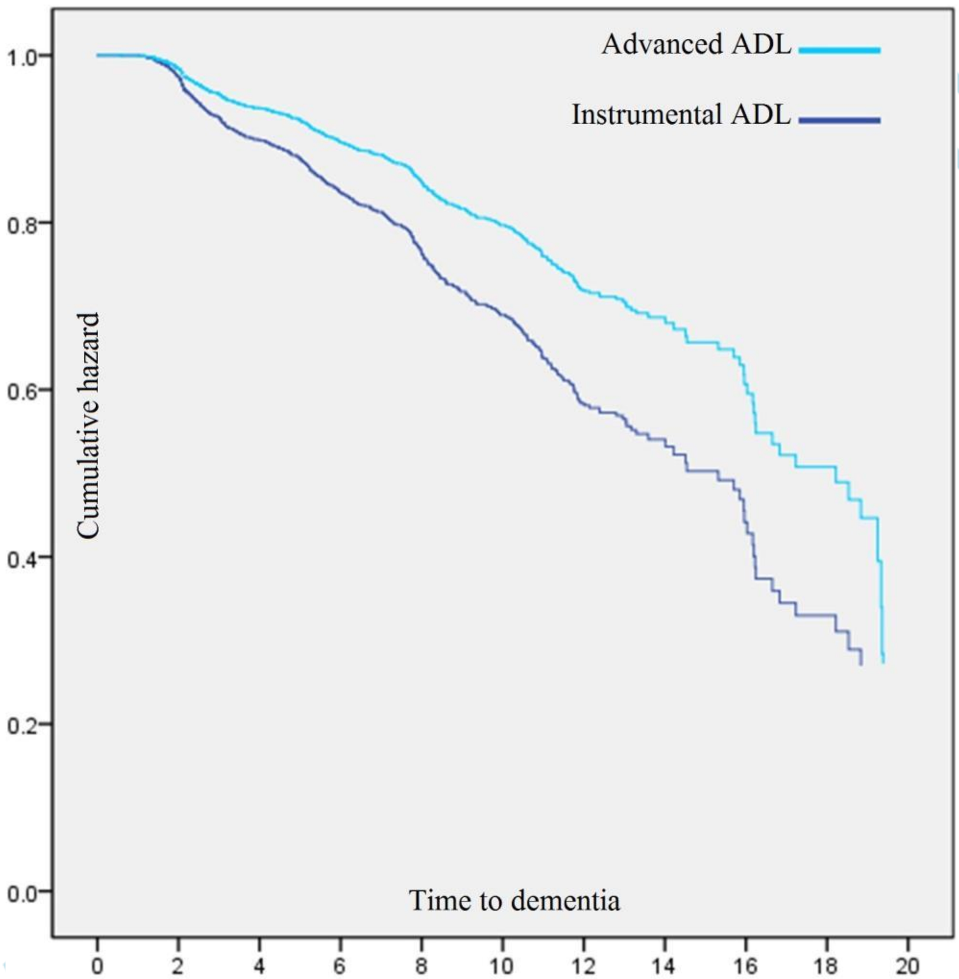
Survival curve based on Cox analysis comparing cumulative dementia incidence. The light blue line reflects the IADL-x of people performing at least one advanced ADL. The dark blue line also represents IADL-x performance, but restricted to people who only perform IADL tasks. The plot is adjusted for age, gender, memory, education, depression, and stroke.

Figure 1.



Abnormal
Amyloid-β
Synaptic dysfunction
Tau-neural injury
Brain atrophy
Cognition
Clinical function
Normal
Preclinical
MCI
Dementia
Abnormal
Normal
Clinically normal
Preclinical
MCI
Mild dementia
Moderate-severe dementia
Amyloid-β
Neurodegeneration
Cognition
Advanced ADL
Instrumental ADL
Basic ADL
1) Classes 2) Volunteer
3) Clubs 4) Restaurant/
Movies/Sports events
5) Visit other
6)Shopping 7) Light housework 8) Neighborhood 9) Medication
Preclinical function;
Advanced/Complex ADL
Clinical function;
Instrumental ADL

Figure 2.


Advanced ADL
Instrumental ADL
Cumulative hazard
Time to dementia
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
10
12
14
16
18
20