THE FUNCTIONAL AUTONOMY MEASUREMENT SYSTEM (SMAF): A CLINICAL-BASED INSTRUMENT FOR MEASURING DISABILITIES AND HANDICAPS IN OLDER PEOPLE

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The SMAF (Functional Autonomy Measurement System) is a 29-item scale developed according to the WHO classification of disabilities.It measures functional ability in 5 areas: activities of daily living (ADL) [7 items], mobility [6 items], communication [3 items], mental functions [5 items] and instrumental activities of daily living (IADL) [8 items]. For each item,the disability is scored on a 5-point scale:0 (independent), -0.5 (with difficulty), -1 (needs supervision), -2 (needs help), -3 (dependent). Resources available to compensate the disability are also evaluated, and a handicap score is deducted. Stability of the resources is also assessed. A disability score (on -87) can be calculated, together with sub-scores for each dimension. SMAF must be administered by a health professional (nurse or social worker) who scores the subject after obtaining the information, either by questioning the subject and proxies, or by observing and even testing the subject.This instrument was submitted to many validity and reliability studies. It is responsive to interventions, and a change of 5 points or more should be considered the minimal metrically detectable change and clinically significant. Correspondence of the SMAF score with the required nursing-care time and the cost of long-term care, either at home or in different institutional settings,has been established.It has been utilized in many epidemiological and evaluative studies.It is also used in the clinical setting for assessment and follow-up of elderly disabled patients in the institution, in the community and in rehabilitation programs.

Key words: Disability, handicap, rating scale, cost of care, nursing time, outcome variable

In order to intervene with the elderly or disabled, we need to improve our knowledge of the subject's condition by going beyond the usual symptomatic, etiological and physiopathological diagnoses and doing a functional diagnosis. This diagnosis provides information on the impact of the disease on how the person functions and guides the clinician or manager in what interventions to focus on, in order to rehabilitate the individual or provide appropriate care and services to alleviate the disabilities. When this kind of diagnosis can be obtained through the practitioner's clinical evaluation, it is often useful to quantify and standardize it, in order to compare different subjects or the same subject over a period of time, or to summarize the functional status of a group of individuals in a management or research context. The **Functional Autonomy Measurement System** *(SMAF: Système de mesure de l'autonomie fonctionnelle)* was designed for this purpose. This instrument was developed in 1984 by a team from the Community Health Department at Hôtel-Dieu in Lévis and revised in 1993 by researchers and clinicians at the Sherbrooke University Geriatric Institute, and has been the subject of many validation studies in the past 15 years. This paper presents the conceptual framework that guided its development and summarizes how it is used. It also includes a summary of the studies of its reliability, validity and responsiveness.

CONCEPTUAL FRAMEWORK AND DEVELOPMENT

The development of the SMAF was based on the concepts of disabilities and handicaps (or disadvantages) described in the World Health Organization's Classification of impairments, disabilities and handicaps.[1,2] This classification is based on a functional concept of disease involving three levels: *impairment*, *disability* and *handicap*. Disability results from an impairment that limits individual functioning or activities. Handicap is more related to social disadvantages resulting from the disability, taking into account the requirements imposed on the individual and the available physical and social resources to alleviate this disability. In this sense,

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handicap represents the *gap* between disabilities and resources.[3]

To generate a handicap measure, the SMAF provides a semi-quantitative assessment of individual disabilities and a clinical assessment of whether the available physical and social resources are adequate to compensate for the disabilities.[4] Disabilities are measured using a scale comprising 29 items covering five basic aspects of functional abilities: activities of daily living (ADL), mobility, communication, mental functions, and instrumental activities of daily living (IADL). These items more or less tally with the WHO's classification of disabilities (Table 1), excluding those items less applicable to the elderly.

A review of the numerous instruments published since the *Index of Activities of Daily Living* proposed by Katz and colleagues in 1963[5] was used to develop the different items.[4,6] The scoring criteria

Table 1. List of SMAF items and corresponding sections in WHO classification of disabilities

SMAF Items	WHO Classification Disabilities
A. Activities of daily living	
1. Eating	
2. Washing	Section 30: *Personal*
3. Dressing	*disabilities*
4. Grooming	Section 60: *Dexterity*
5. Urinary continence	*disabilities*
6. Fecal continence	
7. Using the bathroom	
B. Mobility	
1. Transfers	
2. Walking inside	
3. Walking outside	Section 40: *Locomotor*
4. Putting on prosthesis or orthosis	*disabilities*
5. Moving around in a wheelchair	
6. Using the stairs	
C. Communication	
1. Seeing	
2. Hearing	Section 20: *Communication*
3. Speaking	*disabilities*
D. Mental functions	
1. Memory	
2. Orientation	
3. Understanding	Section 10: *Behavior*
4. Judgement	*disabilities*
5. Behavior	
E. Instrumental Activities of Daily Living	
1. Cleaning the house	
2. Preparing meals	
3. Shopping	
4. Doing the laundry	Section 50: *Body*
5. Using the telephone	*disposition disabilities*
6. Using public transportation	
7. Taking medications	
8. Managing the budget	

for these items were standardized using 4-point scales according to the following general rule:
- Level 0: autonomous
- Level 1: needs supervision or stimulation
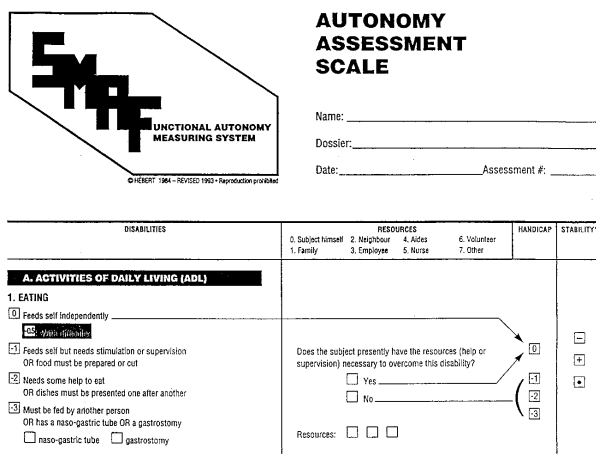- Level 2: needs help
- Level 3: dependent

When the instrument was revised in 1993, an intermediate level (-0.5) was added to most of the items to indicate a function done autonomously but with difficulty. For each item, the general rule for each level is worded precisely and specifically to make scoring easier, avoid interpretation errors and take some particular situations into account. The rater must score the individual's actual performance (what he does), not his potential (what he could or should be able to do). The rater uses all available information to do the rating: questions the subject or his family or close friends, observes the subject and his environment, and even tests the subject. Therefore, he has to use his clinical judgement to synthesize the available information.

It could be claimed that when assessing subjects' actual performance, the SMAF introduces a bias, especially for domestic tasks, related to men of the current generation of elders who do not do some of these functions because their wives do them. Although these disabilities are cultural, they are still real because a man who loses his wife – an important resource – often finds himself with a serious handicap that only institutionalization can compensate for.

In addition, for each item, the assessment scale evaluates if the available physical and social resources compensate for the observed disability. If they do or if no disability is measured for this function, the handicap is zero. If the resources do not completely compensate for the observed disability, the handicap is equal to the disability score. If the disabilities are partially alleviated, this score overestimates the handicap.[7,8] The rater must also indicate what resources are in place and their short-term stability. Figure 1 shows a sample of the scale, based on which a profile of the individual's disabilities and handicaps is obtained. A manual detailing the scoring and administration procedure for the SMAF is available.[9]

METROLOGICAL STUDIES

The interrater **reliability** of the SMAF was first verified in a study of 150 community-dwelling sub-

Figure 1. Sample of SMAF autonomy assessment scale.

jects who were evaluated twice within 24 hours by two different raters.[10] The ten pairs of raters were selected from two different professional groups (nurses and social workers) practising in community or institution settings. The objective was to check if the rater's profession or usual practice environment influenced the reliability of the rating. The raters had attended a 3-hour information session on the instrument. The subjects were randomly drawn from lists of home support services clients and people waiting for a place in a residential facility. The results showed that the raters agreed on the score in 75% of the cases and that the scale presented a mean weighted kappa coefficient of 0.75. Table 2 presents the results for each dimension. These reliability indicators did not vary according to the raters' profession or practice environment. A detailed analysis of the results for each of the 29 functions showed agreement percentages of 61% to 94%, with satisfactory weighted kappa coefficients ranging from 0.47 to 0.81 (p<0.01). Only two functions presented weaker coefficients (speaking: 0.38; behaviour: 0.37) despite respective agreement percentages of 84% and 73%. Finally, a comparison of

the reliability of the first and last assessments done by the same pair of raters showed that there was no significant learning effect.[11]

When the instrument was revised in 1993 and the -0.5 level was added to most of the items, the reliability of the scale was tested again.[12] This time, the stability of the overall score was also examined with a view to using the tool for epidemiological or evaluative research purposes. For this study, 90 subjects were randomly recruited from nine different living environments ranging from community-dwelling to long-term care institutions. Half the subjects were evaluated twice by the same nurse at a 2-week interval (test-retest reliability), while the other half were evaluated by two different nurses over the same time interval (interrater reliability). The results are shown in Table 3. The agreement percentages and weighted kappa for the interrater reliability were comparable to those measured in the first study. For the total score, the intraclass correlation coefficient (ICC) was estimated to be 0.95 (95% confidence interval: 0.90 to 0.97) for test-retest reliability and 0.96 (95% confidence interval: 0.93 to 0.98) for interrater reliability.

This study also determined the minimal metrically detectable difference on the total SMAF score.[13] This is the random error produced by the reliability limits of the instrument. This difference is 5 points and represents the lower limit of a clinically significant difference between two groups of subjects or between the same group of subjects at two different times. This 5-point limit has been used to determine a significant loss of autonomy in epidemiological studies[14,15] and in effectiveness studies where the loss of functional autonomy is the outcome variable.[16]

The content **validity** of the SMAF was first estab-

Table 2. Interrater reliability of the SMAF in a study of 150 community-dwelling subjects assessed by 10 pairs of professionals (nurses and social workers) from different practice environments (home or institution)[10]

Dimension	Percentage agreement	Weighted kappa
Activities of daily living	72.7	0.66
Mobility	78.4	0.74
Communication	79.0	0.53
Mental functions	68.3	0.58
Insturmental activities of daily living	75.5	0.76
Total	75.3	0.75

Table 3. Test-retest (n=39) and interrater (n=45) reliability of the revised SMAF[12]

| Dimensions	Test-retest			Interrater		
	% agreement	MWK	ICC	% agreement	MWK	ICC
Activities of Daily living	70	0.74	0.96	76	0.81	0.95
Mobility	78	0.74	0.91	79	0.73	0.93
Communication	78	0.59	0.78	85	0.72	0.74
Mental Functions	61	0.57	0.87	65	0.61	0.84
Instrumental Activities of Daily Living	80	0.69	0.95	87	0.75	0.96
Total score	79	0.73	0.95	73	0.68	0.96

MWK: Mean weighted kappa
ICC: Intraclass correlation coefficient

lished by its development, based on a recognized conceptual framework and the selection of the items based on the WHO classification of disabilities, and a review of the scales previously published and validated in this field. The validity of the SMAF has also been the subject of several empirical studies. The first study compared the SMAF score obtained with 99 institutionalized subjects with a measure of required nursing care time using the instrument PLAISIR 84 (*Planification informatisée des soins infirmiers requis* [Computerised planning of required nursing care]). A correlation coefficient of 0.88 (p<0.001) was observed between the two instruments.[10] This study was recently replicated with a larger sample (1,997 subjects), including subjects living at home and in different types of institutions.[17,18] In this study, nursing care time was measured using the modified instrument CTMSP (*Classification par type en milieux de soins prolongés* [Classification by type in long-term care settings]).[19,20] The correlation coefficient was 0.92, with the SMAF explaining 85% of the variance in the required nursing care time (Figure 2). The regression equation used to predict the nursing care time based on the SMAF score was as follows:

Log (required nursing care time + 1) = 0.118 + [0.0213 X SMAF]

Thus, for a SMAF score of 20, the log (required nursing care time + 1) would be 0.544 for an antilog of 1.723 and required nursing care time of 0.723 hours or 43.4 minutes per day.

The same study also linked the SMAF score to the total cost of the services received by the subjects including care, supervision, infrastructure (furniture and facilities), operations (meals, maintenance, etc.) and administrative support. Table 4 presents the regression equations used to estimate the cost from the SMAF score for three environments, namely the subject's home, intermediate resources (family-type residences and pavilions) and long-term care institutions. With these data, the SMAF
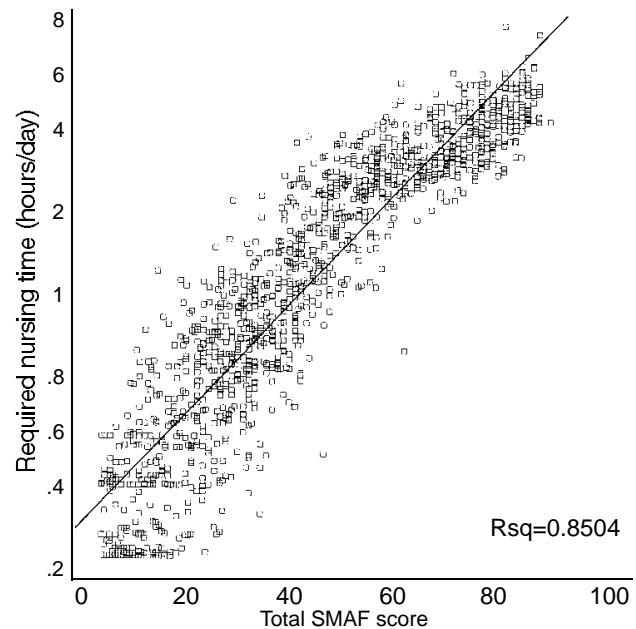
Figure 2. Correlation between required nursing care time (in hours per day) on a logarithmic scale and the total SMAF score (n=1,345).

can be used in cost-benefit studies because the financial benefits can be calculated from the differences in the observed SMAF scores.[18]

This same study done with a representative sample of subjects also provided reference data on the distribution of the SMAF scores in the clienteles in these three living environments. The median total SMAF score was 13.5 (semi-interquartile interval: 6.5) at home, 29.0 (7.5) in intermediate resources and 55.0 (13.5) in long-term care institutions.[19,20] Figure 3 presents these distributions for each dimension of the SMAF for which the partial scores were reduced to a standard three-point scale in order to facilitate interpretation and comparison of the dimensions.

These results confirmed the SMAF's ability to distinguish between clienteles with different needs, which supports the discriminant construct validity of the instrument. A similar study[21] had been done previously with a sample of 38 subjects residing in

Table 4. Regression equations predicting the cost of service (in 1995 Canadian dollars) based on the SMAF score[18]

Living environment	Equation for the metropolitan area Log (cost) =	Correction factor for urban areas	Correction factor for rural areas	95% confidence interval of the estimate (in $)	% of the variance in the cost explained (R^2)[1]
Community-dwelling	3.368 + 0.042 SMAF	0.88	0.77	± 1.39	57.2
Intermediate resources	3.560 + 0.007 SMAF	0.96	0.88	± 1.12	21.7
Long-term care facilities	4.388 + 0.126 SMAF	1.04	0.96	± 1.05	70.0

[1]Adjusted for the area
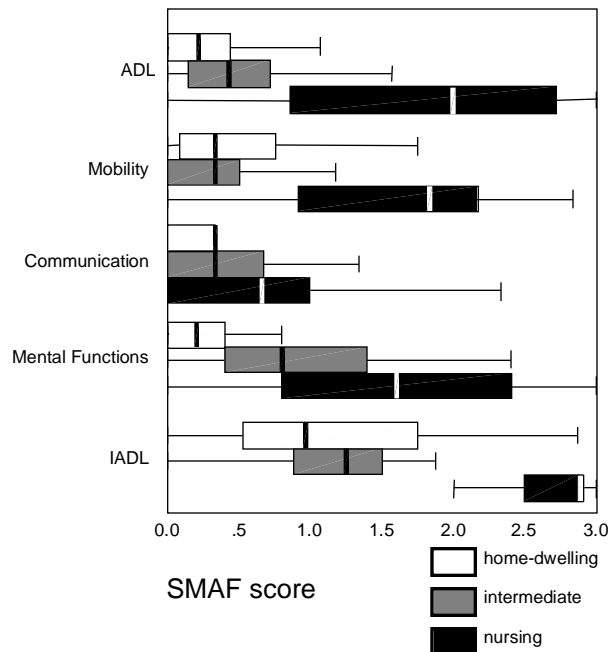
Figure 3. Distribution of the SMAF scores on each dimension for a representative sample of individuals living at home (n=300), in intermediate resources (family-type residences, pavilions) (n=271) and in long-term care institutions (nursing homes) (n=774).

pavilions, 135 subjects in nursing homes and 58 subjects in a long-term care unit at a time when these three types of establishments had complementary mandates and different clienteles. The study showed significant differences on the total SMAF score and for two of the four dimensions of the SMAF (domestic tasks were excluded), namely ADL (p<0.01) and mobility (p<0.01). For communication and mental functions, although a difference was observed between the subjects in the pavilions and those in the other two types of establishments (p<0.01), there was no difference between the subjects in the nursing homes and those in the long-term care unit.

A study done with 80 subjects admitted to an active rehabilitation unit and in long-term care institutions matched for age, sex and initial SMAF score compared the SMAF to two other disability measures: the Barthel Index and the Functional Independence Measure (FIM).[22] The objective was to document the **responsiveness** of these three scales by comparing the difference in scores between leaving and being admitted to the active rehabilitation unit in subjects in the active process of functional recovery and that observed over a similar period in subjects whose autonomy was stable. The studies showed that the Guyatt Index,[23] a mea-

sure of responsiveness, was 14.5 (95% confidence interval: 9.6 to 19.5) for the SMAF, 13.7 (9.0 to 18.4) for the FIM and 12.8 (8.8 to 16.8) for the Barthel Index. The difference between these indexes was not statistically significant. This study also showed correlation between the SMAF and FIM (r=0.94) and between the SMAF and Barthel Index (r=0.92), which represents concomitant construct validity.

USES OF THE SMAF

The SMAF was designed for clinical use in connection with a home support program or for admission and monitoring of clienteles in geriatric services and residential facilities. In this context, the SMAF completed medical, medication, nursing and social data to provide valuable information on the needs for care and services. To make the SMAF easier to use, a case-mix classification system (ISO-SMAF profiles) was generated. These profiles determine homogeneous needs corresponding to specific service plans.[24] The SMAF is the basis of assessment instruments currently used in Quebec in home support programs and for admission to residential institutions.

The prescribing of home support services is based primarily on the handicap profile, which identifies disabilities not alleviated by appropriate resources or unstable situations where the resources are exhausted or declining. In these cases, home support services must eliminate the handicaps by reducing the disabilities (through medication and rehabilitation services), by mobilizing more resources in the environment, or by compensating for the disabilities not alleviated by additional care or home help services.

When an individual can no longer be kept at home and a residence is being considered, the disability profile becomes more useful, since institutional resources are substitutive, not complementary. The individual's ISO-SMAF profile can then be compared to the admission profiles of institutions in the region, to determine which institutions can provide the services required by the subject.[11]

After admission to an institution or geriatric services, the SMAF also facilitates the subject's daily care. A care chart has been developed to guide the caregivers in their daily interventions. This chart assesses the same functions as the disability scale using the same criteria. However, domestic tasks

are excluded and colour-coded stickers (green, blue, yellow, red) replace the numeric code (0, -1, -2, -3) (Figure 4). When this schematic assessment is placed at the patient's bedside or in the nurses' file, the caregiver just needs to glance at it to know the resident's capacities and needs, in order to meet them appropriately without handicaps or mothering. It is also used to develop the daily care plan and, during multidisciplinary team meetings, to help refine the overall intervention plan and concerted action by the health workers. It may also be an educational and motivational tool for the resident and his family, by helping them to understand the intervention objectives. There is also a training program for caregivers in residences based on the SMAF which makes them aware of the importance of stimulating the residents' autonomy.[25] The care chart also shows several successive evaluations, which illustrate the subject's improvement or deterioration and enable monitoring of his progress.

The SMAF has been computerized for home support services by a team in the Bois-Francs region, in connection with a pilot project for an integrated services network for the elderly. This prototype is

Figure 4. SMAF care chart.

included in a single computerized file which can be accessed by all the health and social workers in the region, whether they are at a CLSC, hospital or private doctor's office. Thus, SMAF can be updated regularly as successive reassessments are done. The SMAF will soon be computerized for assessment and follow-up of institutionalized clienteles and coordinating admissions to residential facilities.

In terms of management, the SMAF provides information on the clienteles of different services and institutions. It can then be used to develop new services to meet the needs of a particular group of clients appropriately. It can be used to distribute resources between services, institutions and regions equitably. The correspondence of the SMAF with the costs of services can be a valuable tool to determine the financial impact of clinical decisions or regional orientations in regard to socio-health services. It is possible to plan the resources for continuous monitoring of clienteles. Thus, clinical information can be used directly and continuously by managers without collecting additional data.

Finally, because of the SMAF's reliability and validity, it can be used in research to evaluate the effectiveness of a treatment or intervention, or in epidemiological research to quantify the functional autonomy of groups of individuals or to compare different groups. For example, it has been used to document the functional autonomy and needs of the elderly in a given region,[26-28] to examine the incidence and risk factors for loss of autonomy,[14,15] to analyse the relationships between functional autonomy and other social and health variables,[29-33] and as an outcome measure or a confounding variable in experimental studies.[16,34-37]

CONCLUSION

The SMAF is an instrument which synthesizes and systematizes the various scales proposed to measure the functioning of the elderly or disabled. This comprehensiveness and standardization make it useful in various types of activities and different clinical settings. When it was developed, the first objective was to provide a diagnostic instrument for clinicians. It is simple and easy to use by various types of professionals with a reasonable amount of training. It can be used to assign home support services, allocate residential resources, plan the daily interventions of caregivers in institutions, and manage community and institutional services. It also provides an element of continuity in the assessment and monitoring of dependent clienteles, by avoiding unnecessary reassessments and providing a dynamic, up-to-date table

of the individual's condition. Scientific demonstration of its validity and reliability have clarified its limits in clinical use and made its use possible in clinical, epidemiological and evaluative studies. A new section of the SMAF assessing capacities in social roles is currently being developed.

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