

Research Article

Defining Health Trajectories in Older Adults With Five Clinical Indicators

Giola Santoni,¹ Alessandra Marengoni,^{1,2} Amaia Calderón-Larrañaga,^{1,3} Sara Angleman,¹ Debora Rizzuto,¹ Anna-Karin Welmer,^{1,4} Francesca Mangialasche,¹ Nicola Orsini,⁵ and Laura Fratiglioni^{1,4}

¹Aging Research Center, Department of Neurobiology, Care Sciences and Society, Karolinska Institutet, and Stockholm University, Sweden. ²Department of Clinical and Experimental Sciences, University of Brescia, Italy. ³EpiChron Research Group on Chronic Diseases, Aragon Health Sciences Institute, Sweden. ⁴Stockholm Gerontology Research Center, Sweden. ⁵Department of Public Health Sciences, Karolinska Institutet, Solna, Sweden.

Address correspondence to Giola Santoni, PhD, Aging Research Center, NVS, Karolinska Institutet, Gävlegatan 16, SE-13330 Stockholm, Sweden. E-mail: giola.santoni@ki.se

Received June 27, 2016; Accepted September 23, 2016

Decision Editor: Stephen Kritchevsky, PhD

Abstract

Background: People age differently, challenging the identification of those more at risk of rapid health deterioration. This study aimed to explore the heterogeneity in the health of older adults by using five clinical indicators to detect age-related variation and individual health trajectories over time.

Methods: Health of 3,363 people aged 60+ from the Swedish National study on Aging and Care-Kungsholmen (SNAC-K) assessed at baseline and at 3- and 6-year follow-ups. Number of chronic diseases, physical and cognitive performance, personal and instrumental activities of daily living were integrated in a health assessment tool (HAT). Interindividual health differences at baseline and follow-ups were assessed with logistic quantile regression. Intraindividual health trajectories were traced with quantile mixed-effect models.

Results: The HAT score ranges from 0 (poor health) to 10 (good health); each score corresponds to a specific clinical profile. HAT was reliable over time and accurately predicted adverse health outcomes (receiver-operating characteristic areas: hospitalization = 0.78; 95% confidence interval = 0.74–0.81; mortality = 0.85; 95% confidence interval = 0.83–0.87; similar areas obtained for gait speed). Before age 85, at least 90% of participants were free of severe disability, and at least 50% were functionally independent despite chronic disorders. Age- and sex-related variation and high heterogeneity in health were detected at baseline and confirmed by intraindividual health trajectories.

Conclusions: This study provides a positive picture of the health status of people 60+. Despite the complexity and heterogeneity of health in this age group, we could identify age- and sex-specific health trajectories using an integrated HAT. HAT is potentially useful in clinical practice and public health interventions.

Keywords: Cognition—Gait—Multimorbidity—Physical function

In our aging society, helping people remain healthy as long as possible is an important way to sustain care systems and promote individual quality of life. Clinical and epidemiological studies have identified actions that may lead to healthier aging (1,2). However, we still have limited knowledge of who would mostly benefit from these actions and when the actions would be most beneficial. The multifaceted and heterogeneous nature of health status in older people makes it challenging to trace health trajectories in aging (3) and,

hence, to identify those people whose health decline is faster than expected and who need timely interventions and specific care.

Researchers have developed several comprehensive instruments that can be used to summarize the complexity and variability of health in older people in clinical settings (4,5). However, few indices have been proposed for use at the community level, and the few that exist are largely based on self-reported information (6). Although subjective measures can sometimes identify health

problems undetected by objective examination, objective measures are more specific and more reliable for assessing interindividual differences and tracing intraindividual changes over time (7). The few indices based on objective measures (such as the Multidimensional Prognostic Index (5)) have not been widely tested in population-based settings (8), have been designed mostly for geriatric patients in hospital settings or affected by specific diseases, and have not been designed for use in relatively highly functioning older adults.

Although developing a disease may greatly affect the health of older people (9), measures of morbidity alone are insufficient to capture the complexity of health and its changes; functioning must also be taken into account (10–13). Previous reports have shown that morbidity, physical and cognitive impairment, and disability are fundamental indicators of health in the older population (14,15). Although distinct from each other, morbidity, measures of functioning (physical and cognitive impairment), and disability are highly interrelated (9–14). As people age, functional and clinical changes accelerate and increasingly affect independence. Monitoring health changes at the individual level, although challenging, can help identify those people who deviate negatively from expected trajectories and could benefit from specific treatments or other interventions (16). Finally, recent research calls into question common views of aging as a phase of life characterized by severe health problems. In a previous study, we found that 73% of the elderly population was completely independent up to age 90 suggesting that good functional health is preserved also in advanced ages (14).

To further explore age-related variation in the health of older adults, we assessed both the medical and functional health of a population aged 60 to more than 100 years and traced intraindividual changes longitudinally. To that end, we developed a health assessment tool (HAT) that can be easily and quickly administered both in clinical settings and at the community level. In this study, we specifically aimed to (a) explore the reliability of HAT over time and its ability to accurately predict hospitalization and mortality, (b) analyze cross-sectional interindividual health variability, and (c) assess 6-year intraindividual longitudinal changes in health status.

Methods

Study Population

Data were gathered from the community-based, longitudinal Swedish National study of Aging and Care in Kungsholmen (SNAC-K) (17). Participants were randomly selected people aged 60+ who were living at home or in institutions in Kungsholmen, Stockholm, between 2001 and 2004. The sample was stratified into 11 cohorts by age. There is a 6-year interval between the younger cohorts (60, 66, and 72, $n = 1,782$) and a 3-year interval between the older cohorts (78, 81, 84, 87, 90, 93, 96, 99+, $n = 1,581$). A total of 3,363 people were examined at baseline (participation rate of 73.3%). Participants aged 60–72 are re-examined every 6 years, and participants aged 78+, every 3 years. At the 3-year follow-up (2004–2007, older cohorts only), 992 participated; 437 (28%, 437/1,581) had died; and 152 (9%, 152/1,581) declined to participate. At the 6-year follow-up (2007–2010, all cohorts), 2,058 participated; 406 (15%, 406/2,774) had died; and 310 (11%, 310/2,774) declined to participate (Supplementary Figure 1). A total of 803 (81%, 803/992) had complete health assessment data from the 3-year follow-up and 1,902 (92%, 1,902/2,058) from the 6-year follow-up.

Data Collection

At baseline and follow-up, nurses collected information about personal and family histories and assessed physical functioning,

physicians collected medical histories and performed geriatric and neuropsychiatric examinations, and psychologists administered cognitive test batteries. Data on vital status during the 5 years after baseline were obtained from the Swedish Cause of Death Register. Data on number of hospital admissions during the year after baseline were retrieved from the National Patient Register.

Health Indicators

On the basis of previous reports (9–15), five indicators were chosen to summarize health status and changes in health status in the study population:

1. Physical function was measured as gait speed. Participants were asked to walk 6 or 2.44 m if the participant reported walking quite slowly. If the participant was unable to walk or attempted unsuccessfully to walk, a value of 0 was recorded.
2. Cognitive functional status was assessed with the Mini-Mental State Examination (MMSE). MMSE scores range from 30 (best possible score) to 0.
3. Chronic morbidity was measured as number of chronic conditions. Chronic conditions were defined based on previously validated criteria (14). Clinical diagnoses (ICD-10 diagnostic criteria) were made by the examining physicians based on their clinical assessment, laboratory tests, and hospital records. We considered only the count of diseases, as their severity was taken into consideration by including other health indices in HAT. Dementia was not included in the count because the MMSE test was already included among the HAT indicators.
4. Mild disability was measured as the number of instrumental activities of daily living (IADL), a person was unable to perform independently. Four tasks were included in our analyses: grocery shopping, managing money, using the telephone, and using public transportation. Housework activities were removed to avoid gender disparities. People living in institutions were assumed to depend on others for grocery shopping.
5. Severe disability was measured as the number of personal ADL (PADL) a person was unable to perform independently. PADL included five basic self-care tasks: bathing, dressing, toileting, transferring, and eating.

Statistical Analysis

The five health indicators measured at baseline were integrated in HAT using a nominal response model (NRM) in which the health indicators were regressed against the latent variable “health status.” A more detailed description of the statistical methods is provided in Supplementary Appendix. In brief, to test the precision of the model, for each health indicator, two parameters were extracted from the NRM; namely, difficulty (the value of the latent trait when the probability of choosing one category is the same as the probability of choosing the next category) and discrimination (how fast the probability of a certain answer changes across the latent variable). Good models have difficulty values that cover the largest range of latent values and discrimination values above one. Multiple NRM models were run with health indicator categories defined in different ways in each model (Supplementary Appendix Table 1). In general, most of the cutoffs chosen for the categories were present in the literature. The internal consistency of each model was verified by running each model on 10 samples ($N = 3,363$) drawn randomly with replacement from the study population. Three hundred models were tested, and the final model was chosen based on a priori criteria reported in Supplementary Appendix Table 2.

To derive HAT scores for each person, the weights for each category were derived by regressing the NRM test characteristic curve (expected score) against the health indicators. Because of the high discrimination power of the ADL variables (Supplementary Appendix Table 3), the regression was stratified by limitation status (no limitation, only IADL limitations, and any ADL limitation). We tested for interactions between the variables, and those interactions with the largest effects were included in the model. The coefficients from the regression analyses are reported in Supplementary Appendix Table 4. The R^2 values for the regressions were all above .99.

The most frequent components for units of HAT score were checked by deriving for each health indicator in HAT the category with the proportion of people above 50% for the specific HAT score range. If no category was above 50%, the two with the highest percentage were considered.

The reliability of HAT was tested by comparing the sex-adjusted medians and first and ninth deciles of the HAT score distribution at baseline with the corresponding values at the 3-year and 6-year follow-ups. The median and the two deciles were derived from the logistic quantile regression in which age was introduced as a cubic spline with four knots (18,19).

We tested the ability of HAT to accurately predict death in the 5 years after baseline and two or more hospital admissions (among community-dwelling people) in the year after baseline. Two areas under the receiver-operating characteristics curve were computed.

Cross-sectional differences in HAT score across age groups and between women and men at baseline were detected with logistic quantile regression. The median and the two deciles were calculated with age as a cubic spline with four knots.

Six-year longitudinal changes in HAT scores were computed with a linear quantile mixed-effect model (20) with age as the time line. The model was adjusted for birth cohort and sex.

SNAC-K received ethical permission for baseline and follow-ups from the Ethics Committee at Karolinska Institutet and the Regional Ethics Review Board in Stockholm (Dnrs: 01-114, 04-929/3, 2007/279-31). Written informed consent was obtained from all participants. Statistical analyses were performed with Stata/SE 14.0 software (College Station, TX).

Results

The baseline characteristics of the study population are reported in Table 1. As expected, all indicators varied significantly by age.

The results of the NRM analysis are reported in the Supplementary Appendix. The final model included two categories of IADL and two of PADL impairments (0 impairments or 1+ impairments), four categories of MMSE score (30, 29, 28–20, or 19–0), four categories of gait speed (≥ 1.5 , $<1.5-1$, $<1-0.4$, or <0.4 m/s), and three categories of chronic diseases (0, 1–2, and 3+ diseases).

HAT is a semicontinuous scale ranging from 0 (poor health) to 10 (good health). Table 2 summarizes the clinical significance of each HAT score represented by the most frequent components for units of HAT score. In general, scores 5 and above indicate complete functional independence, and scores below 5, some functional dependence. Disability severity and physical functioning problems decrease with increasing HAT score indicating a clear hierarchical order between the three indicators. Number of chronic diseases and cognitive problems increased within each level of physical and disability level, but they did not decrease continuously with decreasing level of HAT. Although the distribution of HAT scores was skewed to the left in adults aged 60–78 (skewness = -2.3), almost no skewness was present among adults aged 81+ (skewness = -0.6).

Equivalent distributions were detected at baseline, at first follow-up, and at second follow-up, which confirmed the reliability of HAT over time (Figure 1). The curves showed that heterogeneity in health increased with age, as the distance between the two deciles was larger for older cohorts.

HAT's predictive accuracy was good. The receiver-operating characteristic area was equal to 0.85 (95% confidence interval = 0.83–0.87) in analyses of time to death in the 5 years after baseline and 0.78 (95% confidence interval = 0.75–0.81) in analyses of two or more hospital visits in the year after baseline. All components of HAT and other tests, such as the Multidimensional Prognostic Index and subjective rated health, had lower receiver-operating characteristic areas when tested on the same population and same outcomes (Supplementary Table 1 and 2). However, the predictive ability of the single task gait speed was similar to that of HAT.

Table 1. Baseline Characteristics of the Study Population

Characteristics	Total <i>n</i> = 3,363	Age Groups		
		60–72 y <i>n</i> = 1,782	78–84 y <i>n</i> = 914	87+ y <i>n</i> = 667
Age, mean (<i>SD</i>)	74.7 (11.2)	65.5 (4.8)	80.5 (2.5)	91.3 (3.5)
Women, number (%) [*]	2,182 (65%)	1,024 (57%)	621 (68%)	537 (81%)
Level of education, number (%) [*]				
Low (0–8 y)	936 (28%)	282 (16%)	315 (35%)	339 (52%)
Medium (9–12 y)	1,305 (39%)	687 (39%)	389 (43%)	229 (35%)
High (13+ y)	1,090 (33%)	810 (46%)	201 (22%)	79 (12%)
Living in institution, number (%) [*]	191 (6%)	11 (1%)	36 (4%)	144 (22%)
Number of PADL impairments, mean (<i>SD</i>) [*]	0.2 (0.9)	0.0 (0.3)	0.1 (0.7)	0.9 (1.7)
Number of IADL impairments, mean (<i>SD</i>) [*]	0.4 (1.0)	0.1 (0.4)	0.4 (0.9)	1.6 (1.5)
MMSE, mean (<i>SD</i>)	27 (5.7)	29.0 (2.4)	27.4 (4.6)	21.9 (9.1)
Gait speed (m/s), mean (<i>SD</i>) [*]	1.0 (0.5)	1.2 (0.3)	0.9 (0.4)	0.4 (0.4)
Number of chronic diseases, mean (<i>SD</i>) [*]	1.8 (1.5)	1.3 (1.3)	2.2 (1.6)	2.5 (1.6)

Note: IADL = instrumental activities of daily living; MMSE = Mini-Mental State Examination; PADL = personal activities of daily living; *SD* = standard deviation.

^{*}*p* < .001 for difference among age groups (jointly tested).

Table 2. Most Frequent Components by HAT Score Reported for Each Health Indicator, as the Category With Prevalence Above 50%

HAT Score	PADL Limitations	IADL Limitations	Gait Speed (m/s)	Number of Chronic Diseases	MMSE Score
9.5–10	0	0	≥1.5	0	30
9.0–9.4	0	0	1.5–1.0	1 or 2	30
8.0–8.9	0	0	1.5–1.0	1 or 2	20–29 ^a
7.0–7.9	0	0	1.0–0.4	1 or 2	30
6.0–6.9	0	0	1.0–0.4	3+	20–28
5.0–5.9	0	0	<0.4	1 or 2	20–29 ^a
4.0–4.9	0	1+	1.0–0.4	3+	20–28
3.0–3.9	0	1+	<0.4	1 or 2	20–28
2.0–2.9	1+	1+	<1.0 ^a	1 or 2	0–28 ^a
1.0–1.9	1+	1+	<0.4	1 or 2	20–28
0.0–0.9	1+	1+	<0.4	3+	0–19

Note: HAT = health assessment tool; IADL = instrumental activities of daily living; MMSE = Mini-Mental State Examination; PADL = personal activities of daily living. Darker areas of the table represent worse health status.

^aAs no category was above 50%, the two with highest prevalence are reported.

The age distribution (the median and the first and ninth deciles) of the HAT score at baseline for men and women is reported in Figure 2. The median HAT score of women under the age of 89 was above 5 (indicating functional independence), whereas the median HAT score of men under age 95 was above 5. The ninth decile of HAT scores was high (>9) in people younger than 85, whereas scores decreased steeply after that age. The distribution of HAT scores differed by sex such that, in general, women’s scores indicated worse health. This was especially true among the oldest participants and those with the worst health status. The patterns of change by sex were similar across cohorts in the median and ninth deciles of HAT scores. In the first decile of HAT scores, however, the pattern of change by sex diverged such that scores remained constant between age 65 and 75 in men but not in women.

The intraindividual changes in HAT score during 6 years of follow-up are graphed in Figure 3 (a spaghetti plot of a random sample of 500 people is reported in Supplementary Figure 2). The cohort effect is shown by the different segments of each percentile line. The segments are close together indicating that the cohort effect was irrelevant, at least in 6 years of follow-up. In both men and women, the age-related changes in scores are similar to those graphed in Figure 2 for the cross-sectional data. In comparison to

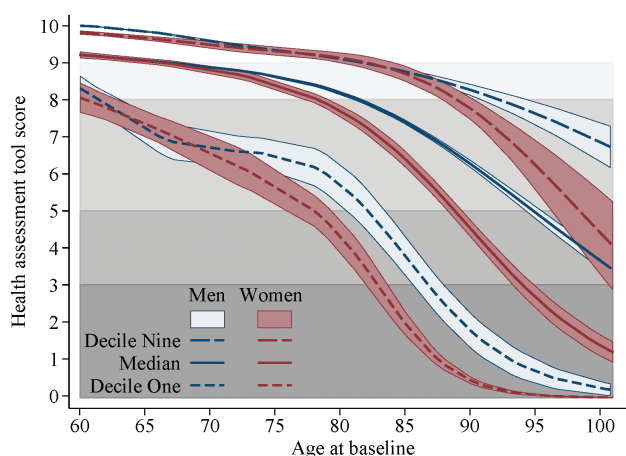


Figure 2. Distribution of health assessment tool scores at baseline across age by sex. Areas around the curves indicate 95% confidence intervals. The gray horizontal areas indicate health status as reported in Table 2. Solid line: median; dashed line: decile one; long dashed line: decile nine.

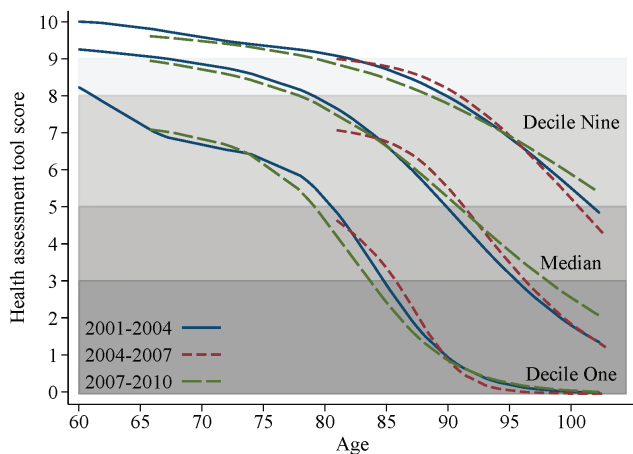


Figure 1. Distribution of health assessment tool scores at baseline baseline (2001–2004, solid lines), after 3 years (2004–2007, dashed lines), and after 6 years (2007–2010, long dashed lines) across age, adjusted by sex. The gray horizontal areas indicate health status as reported in Table 2.

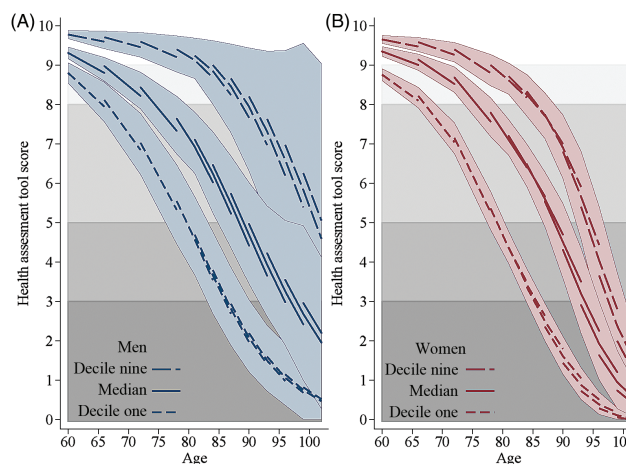


Figure 3. Areas around the curves indicate 95% confidence intervals. The gray horizontal areas indicate health status as reported in Table 2. (A) Men; (B) women. Solid lines: median; dashed lines: decile one; long dashed lines: decile nine.

the cross-sectional age distribution of scores, the longitudinal curves reveal less heterogeneity in health status. The difference in distribution between men and women was evident for the ninth decile of the distribution (people with health better than the 90% of the sample).

Discussion

This study has two major results. First, we propose a method to assess and follow health changes in older adults that is easy to use and has the potential to detect unexpected health decline and new care needs in a timely manner. This method takes advantage of a HAT that is reliable over time and predicts accurately both hospitalization and mortality. Second, our findings confirm our initial hypothesis that the health of older adults in a 21st century western urban society is fairly good. Despite the large heterogeneity detected in both cross-sectional and longitudinal analyses, the longitudinal analysis confirms that more than half of the population have no severe disability up to age 95.

Health Status in People 60+

A general negative attitude toward aging is still present in society. Chronological age is directly related to negative stereotypes (21), and older adults are regarded as a major challenge to current and future welfare systems. Like other reports (14,22,23), this study provides evidence of older people's relatively good health status. First, at least 10% of the 60- to 87-year-old adults had high levels of physical and mental functioning and few chronic disorders. Second, before age 85, at least half of the older adults in each age group had no disability, although they had chronic disorders and some functional impairment. Third, before age 85, at least 90% were free of severe disability (PADL disability). These positive results were found in both men and women, but age-related health decline was more evident in women, and sex differences increased with age.

Despite the finding of relatively healthy and active lives even after 85, other authors emphasized the health heterogeneity in any measure considered that makes chronological age an unreliable marker of aging (3). The topic of heterogeneity in aging has been studied sparsely and almost abandoned in recent years (24,25). The great bulk of research still focuses on average differences between age groups and does not take interindividual differences into consideration. Our findings provide strong evidence of high interindividual heterogeneity in health. Such heterogeneity increased after age 70 and it was not due to birth cohort effects, as it was also present in the longitudinal analysis of intraindividual health changes. Like Lowsky and colleagues (3), we are convinced that understanding heterogeneity in the health of aging people could create opportunities to develop targeted interventions.

Finally, health differences between older men and women are well documented and remain after taking structural, behavioral, and psychological factors into account (26–28). In our study, sex disparities were consistently present in those aged 85+, disparities that could be explained by the shorter life expectancy generally found in men than in women, but among younger-old adults, they were only evident in people with worse health. Investigating the reasons for this pattern was beyond the scope of the current study, but the potential clinical implications of this finding make it worthy of further investigation.

Defining Health Trajectories in Older Adults

As in children, physical changes in older people occur more rapidly than in younger and middle-aged adults, and deviations from expected health trajectories must be handled in a timely manner.

However, whereas in children, height and weight seem to be sufficient to indicate deviations from expected health trajectories (29), tools that identify such deviations in older people are more difficult to construct. Older adults often have multiple diseases, changes in cognitive functioning, changes in physical functioning, and disabilities (30), factors that make it difficult to summarize their health condition. An index composed of relatively few items that capture both health and functioning could be a good tool for identifying such deviations in a timely manner at the individual level and for determining medical, rehabilitation, or social health service needs at the population level. At the individual level, practitioners should expect that HAT scores decline over time at a faster rate for people that are older than younger-old adults. However, they should pay particular attention to patient with an age- and sex-specific score location in the HAT distribution that shifts rapidly toward lower values of HAT and consider a more thorough check-ups. At the population level, physical activity, mental and social stimulation, and good control of circulatory disorders should be encouraged and facilitated to prevent rapid change in HAT with age and hopefully to improve the HAT distribution of future generations (31,32).

In this study, we developed a HAT by integrating five clinical indicators chosen on the basis of the findings of previous studies (9–14) and conventional tests that are part of the Comprehensive Geriatric Assessment (33). HAT's semicontinuous scale from 0 to 10, which theoretically includes 81 distinct scores, facilitates the observation of gradual changes in health status. Measures that can be applied to people of a broad age range (60+ years) who live either at home or in institutions are seldom free from ceiling or floor effects. However, the distribution of HAT scores had low skewness among older people and where the skewness was higher (younger-old people) the distribution of HAT between the first and the ninth decile varied among several (>12) distinct scores. Moreover, we hypothesize that deviations of HAT score from the expected age and gender-specific values are more insightful than the absolute score temporal changes. For instance, if a change in HAT makes the person's percentile shift from the ninth decile to the median, this should prompt further investigation, even though the absolute change is small. However, this statement requires further validation. Another advantage of HAT is the hierarchical structure that links any score to a specific combination of the five health indicators. In other words, each score indicates a level of health status that is based on a combination of medical and functional information and thus reflects both health and social care needs. Moreover, HAT was reliable when tested on the same population at different points in time and predicted adverse health outcomes (such as hospitalization and death) as effectively as other indices used in hospital settings (5). Finally, we estimated that HAT takes a maximum of 20 minutes to complete the first time.

Strength and Limitations of Study

The major findings of this article are hampered by their limited generalizability, as HAT was derived from the SNAC-K study, which is representative only of urban and well-educated Western populations. In addition, our sample represented people who had survived beyond baseline age. Further, as already reported in a previous article (14), SNAC-K participants (with the exception of nonagenarians) showed a lower mortality in 2 years than those who declined to participate suggesting that the study might underestimate the health heterogeneity of the old adults and detect a more positive picture of the health of the population. However, mortality after 2 years was the same among sexagenarians and nonagenarians between participants

and nonparticipants, and the difference was attenuated for the septuagenarians and the octogenarians; the results derived through the longitudinal analysis might have been affected only marginally. Another important limitation of the study is that HAT has not been validated in any other population. Further validation in other countries, in larger samples, and over longer follow-up periods is required. However, HAT is reliable over time and accurately predicts adverse health outcomes. Gait speed was the single item with values comparable to HAT, but HAT gives not only prediction but also a quite complete picture of the health status of a person as it takes also into consideration health components that can be suitable of improved treatment such as morbidity, cognitive functioning, and disability. However, we acknowledge that in some research and clinical settings gait speed may be a preferred measure for predicting health outcomes. HAT has proven to have higher predictive ability of adverse outcomes with respect to at least two other assessment tools, although further validation is needed in other populations. We would like to stress that the aim in deriving HAT was to create an index of health status that describes health comprehensively and that could be used at the community level to follow gradual or rapid changes in people's health over time. Other indices, like the Multidimensional Prognostic Index (MPI), have been developed for hospitalized geriatric population or for people with specific geriatric conditions to predict the risk of mortality; hence, it is mostly useful for that part of the population with severe or moderate health problems. Finally, other measures of health could have been included in HAT, such as polypharmacy (taking five or more medications), but the individual indicators do take the consequences of polypharmacy into account.

Conclusions and Policy Implications

In conclusion, this study provides a relatively positive picture of the health status of people 60+ years and illuminates the complexity and heterogeneity of health in older adults. We propose that after further validation in larger populations and over longer follow-up periods, the HAT assessment tool can be used to monitor changes in health status both at the individual and population levels.

Physical changes occur more rapidly in older people than in younger and middle-aged adults, and deviations from expected health trajectories must be handled in a timely manner. An assessment composed of relatively few items that capture both health and functioning could be a good tool for identifying such deviations at the individual level and for determining medical, rehabilitation, or social care needs at the population level.

Supplementary Material

Supplementary data are available at *The Journals of Gerontology, Series A: Biological Sciences and Medical Sciences* online.

Funding

This work was supported by the funders of the Swedish National study on Aging and Care, SNAC: the Ministry of Health and Social Affairs, Sweden, the participating County Councils and Municipalities, and the Swedish Research Council. Specific grants were obtained from the Swedish Research Council for Health, Working Life and Welfare (Forte, 2006-1612), the Swedish Research Council (Vetenskapsrådet, 825-2011-6243), and the Lundströms Minne Foundation (LA2015-0438).

Conflict of Interest

All authors declare no conflict of interest.

References

- Daniels R, van Rossum E, de Witte L, Kempen GI, van den Heuvel W. Interventions to prevent disability in frail community-dwelling elderly: a systematic review. *BMC Health Serv Res*. 2008;8:278. doi:10.1186/1472-6963-8-278
- Theou O, Stathokostas L, Roland KP, et al. The effectiveness of exercise interventions for the management of frailty: a systematic review. *J Aging Res*. 2011;2011:569194. doi:10.4061/2011/569194
- Lowsky DJ, Olshansky SJ, Bhattacharya J, Goldman DP. Heterogeneity in healthy aging. *J Gerontol A Biol Sci Med Sci*. 2014;69:640–649. doi:10.1093/gerona/glt162
- McDowell I. *Measuring Health: A Guide to Rating Scales and Questionnaires*. Oxford: Oxford University Press; 2006. doi:10.1093/acprof:oso/9780195165678.001.0001
- Sancarlo D, D'Onofrio G, Franceschi M, et al. Validation of a Modified-Multidimensional Prognostic Index (m-MPI) including the Mini Nutritional Assessment Short-Form (MNA-SF) for the prediction of one-year mortality in hospitalized elderly patients. *J Nutr Health Aging*. 2011;15:169–173. doi:10.1007/s12603-010-0293-5
- Ware JE Jr, Sherbourne CD. The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection. *Med Care*. 1992;30:473–483. doi:10.1097/00005650-199206000-00002
- Guralnik JM, Branch LG, Cummings SR, Curb JD. Physical performance measures in aging research. *J Gerontol*. 1989;44:M141–M146. doi:10.1093/geronj/44.5.m141
- Angleman SB, Santoni G, Pilotto A, et al. Multidimensional Prognostic Index in association with future mortality and number of hospital days in a population-based sample of older adults: results of the EU funded MPI AGE project. *PLoS One*. 2015;10:e0133789.
- Aarts S, den Akker MV, Bosma H, et al. The effect of multimorbidity on health related functioning: temporary or persistent? Results from a longitudinal cohort study. *J Psychosom Res*. 2012;73:211–217. doi:10.1016/j.jpsychores.2012.05.014
- Studenski S, Perera S, Wallace D, et al. Physical performance measures in the clinical setting. *J Am Geriatr Soc*. 2003;51:314–322. doi:10.1046/j.1532-5415.2003.511104.x
- Atkinson HH, Rosano C, Simonsick EM, et al.; Health ABC Study. Cognitive function, gait speed decline, and comorbidities: the health, aging and body composition study. *J Gerontol A Biol Sci Med Sci*. 2007;62:844–850. doi:10.1093/gerona/62.8.844
- Diehr PH, Thielke SM, Newman AB, Hirsch C, Tracy R. Decline in health for older adults: five-year change in 13 key measures of standardized health. *J Gerontol A Biol Sci Med Sci*. 2013;68:1059–1067. doi:10.1093/gerona/glt038
- Marengoni A, Winblad B, Karp A, Fratiglioni L. Prevalence of chronic diseases and multimorbidity among the elderly population in Sweden. *Am J Public Health*. 2008;98:1198–1200. doi:10.2105/AJPH.2007.121137
- Santoni G, Angleman S, Welmer AK, Mangialasche F, Marengoni A, Fratiglioni L. Age-related variation in health status after age 60. *PLoS One*. 2015;10:e0120077. doi:10.1371/journal.pone.0120077
- Fried LP, Ferrucci L, Darer J, Williamson JD, Anderson G. Untangling the concepts of disability, frailty, and comorbidity: implications for improved targeting and care. *J Gerontol A Biol Sci Med Sci*. 2004;59:255–263. doi:10.1093/gerona/59.3.m255
- Steves CJ, Spector TD, Jackson SH. Ageing, genes, environment and epigenetics: what twin studies tell us now, and in the future. *Age Ageing*. 2012;41:581–586. doi:10.1093/ageing/afs097
- Lagergren M, Fratiglioni L, Hallberg IR, et al. A longitudinal study integrating population, care and social services data. The Swedish National study on Aging and Care (SNAC). *Aging Clin Exp Res*. 2004;16:158–168. doi:10.1007/bf03324546
- Bottai M, Cai B, McKeown RE. Logistic quantile regression for bounded outcomes. *Stat Med*. 2010;29:309–317. doi:10.1002/sim.3781.
- Orsini N, Bottai M. Logistic quantile regression in Stata. *Stata J*. 2011;11:327–344.
- Geraci M, Bottai M. Quantile regression for longitudinal data using the asymmetric Laplace distribution. *Biostatistics*. 2007;8:140–154. doi:10.1093/biostatistics/kxj039

21. Sanderson WC, Scherbov S. Remeasuring aging. *Science*. 2010;329:1287–1288. doi:10.1126/science.1193647
22. Jacobs JM, Maaravi Y, Cohen A, Bursztyn M, Ein-Mor E, Stessman J. Changing profile of health and function from age 70 to 85 years. *Gerontology*. 2012;58:313–321. doi:10.1159/000335238
23. Collerton J, Davies K, Jagger C, et al. Health and disease in 85 year olds: baseline findings from the Newcastle 85+ cohort study. *Br Med J*. 2009;339:b4904. doi:10.1136/bmj.c2972
24. Stone ME, Lin J, Dannefer D, Kelley-Moore JA. The continued eclipse of heterogeneity in gerontological research. *J Gerontol B Psychol Sci Soc Sci*. 2016. Advance Access publication on February 1, 2016. doi:10.1093/geronb/gbv068
25. Nelson EA, Dannefer D. Aged heterogeneity: fact or fiction? The fate of diversity in gerontological research. *Gerontologist*. 1992;32:17–23. doi:10.1093/geront/32.1.17
26. von Strauss E, Agüero-Torres H, Kåreholt I, Winblad B, Fratiglioni L. Women are more disabled in basic activities of daily living than men only in very advanced ages: a study on disability, morbidity, and mortality from the Kungsholmen Project. *J Clin Epidemiol*. 2003;56:669–677. doi:10.1016/s0895-4356(03)00089-1
27. Arber S, Cooper H. Gender differences in health in later life: the new paradox? *Soc Sci Med*. 1999;48:61–76. doi:10.1016/s0277-9536(98)00289-5
28. Denton M, Prus S, Walters V. Gender differences in health: a Canadian study of the psychosocial, structural and behavioural determinants of health. *Soc Sci Med*. 2004;58:2585–2600. doi:10.1016/j.socscimed.2003.09.008
29. de Onis M, Wijnhoven TM, Onyango AW. Worldwide practices in child growth monitoring. *J Pediatr*. 2004;144:461–465. doi:10.1016/j.jpeds.2003.12.034
30. Christensen K, Doblhammer G, Rau R, Vaupel JW. Ageing populations: the challenges ahead. *Lancet*. 2009;374:1196–1208. doi:10.1016/S0140-6736(09)61460-4
31. Gustafsson S, Wilhelmson K, Eklund K, et al. Health-promoting interventions for persons aged 80 and older are successful in the short term—results from the randomized and three-armed Elderly Persons in the Risk Zone Study. *J Am Geriatrics Soc*. 2012;60:447–454. doi:10.1111/j.1532-5415.2011.03861.x
32. Rizzuto D, Orsini N, Qiu C, Wang HX, Fratiglioni L. Lifestyle, social factors, and survival after age 75: population based study. *Br Med J*. 2012;345:e5568. doi:10.1136/bmj.e5568
33. Devons CA. Comprehensive geriatric assessment: making the most of the aging years. *Curr Opin Clin Nutr Metab Care*. 2002;5:19–24. doi:10.1097/00075197-200201000-00004