Incidence of Functional Decline and Improvement in a Community-dwelling, Very Elderly Population

Réjean Hébert,1 Carol Brayne,2 and David Spiegelhalter3

With the aging of the population, functional decline is one of the major challenges to health care systems. The objective of this study was to estimate the incidence of functional decline and improvement in a community-dwelling population of people aged 75 years and above. A representative sample of elderly people living at home in the city of Sherbrooke (Québec, Canada) was assessed yearly on three occasions (1991-1993) by a nurse. Disabilities were measured by the Functional Autonomy Measurement System, a 29-item rating scale developed according to the World Health Organization classification of disabilities. From the 655 subjects who agreed to participate, a total of 572 subjects completed the study, including 68 who subsequently died. The probability of declining was 20.1% for the first year and 12.4% for the second year. The incidence of functional decline among previously stable subjects was 11.9% (95% confidence interval (Cl) 8.9-15.9). Age was strongly related to decline (relative risk (RR) = 1.15/year, 95% Cl 1.09-1.21), but there was no significant sex effect (RR male = 0.88, 95% Cl 0.55-1.39). The incidence of improvement among previously disabled subjects was estimated at 7.5% (95% Cl 5.1-10.9) for the first year and 17.9% (95% Cl 14.0-23.0) for the second year. Neither age (RR = 1.07, 95% Cl 0.99-1.15) nor sex (RR male = 1.70, 95% Cl 0.90-3.18) was significantly associated with the probability of improving. This study stresses the importance of precise measurement of disabilities and the complex and dynamic process of functional transitions. Am J Epidemiol 1997;145:935-44.

aged; disability evaluation; longitudinal studies

The proportion of people over 65 years is around 16 percent in European countries and 11 percent in North America (1). These proportions will rise over the next 30 years with the most rapid rise in the over 75-year age group. The age of 75 appears to be a watershed, after which disability, morbidity, and mortality rates begin to increase rapidly (2). A significant proportion of the life expectancy at 75 years of age is spent with disabilities. It is estimated that, for women, only 6.1 years of the 13.2 expected years of life will be disability free and that, for men, only 3.1 of 9.6 years will be disability free (3). These emerging data underline the importance of better understanding the process of functional decline in this population for planning appropriate services and preventive programs.

Relatively few longitudinal surveys have analyzed the incidence of functional decline in the elderly population, and many shortcomings may be identified from these studies. 1) The measurement of disability is far from being uniform and valid. Usually, the measurement is based on a specific instrument rather than on a theoretical framework, such as the World Health Organization classification of impairments, disabilities, and handicaps (4). In consequence, the measurement is based on a specific instrument rather than on a theoretical framework, such as the World Health Organization classification of impairments, disabilities, handicaps (4). In consequence, the measurement is usually incomplete, involving only activities of daily living (5) or activities of daily living with instrumental activities of daily living (6, 7), but rarely mobility (8-10) and never communication and mental disabilities. When many areas of functional abilities were assessed, the analysis was done separately on each dimension (10, 11) or on an index composed by putting together different scales (7, 8) without having performed a priori validation studies on this index. 2) In all the studies, information was obtained using questionnaires administered by trained lay interviewers. This approach is subject to responding bias and presents limitations, especially when the subject is...
cognitively impaired. The questionnaire is then answered by a proxy, introducing significant biases (12, 13). 3) The definition of functional decline is often very crude, being limited to two categories: able and disabled. Only Strawbridge et al. (8) attempted to refine the measurement by using a scoring system, but the definition of decline and improvement did not allow for the unreliability of the scale. A range of random variability around zero should be determined in order to define the critical difference that represents a real change in functional status. 4) Because of the significant death rate at this age and the dynamic process of functional decline and improvement, the incidence rates vary given the interval between the evaluations. In two studies (10, 14) that assessed subjects over 65 years old with a 1-year interval, about 5 percent of subjects regain independence, 82 percent remain stable, and 13 percent present functional decline, including 5–7 percent death. Manton (6), with a 2-year interval, reported that approximately the same proportion presents positive transition but that the negative transitional probability (functional decline and death) doubles. Within a 6-year interval, Strawbridge et al. (8) showed that nearly two thirds present a negative transition (with a quarter dying). With a 10-year interval, all the transitions were blurred by the very high death rate (56 percent in the Tempere Study (9)). The older the sample, the shorter should be the interval. For the elderly over 75 years old, the transitional probabilities observed by Branch (14) with an interval of 1.25 years are as follows: neutral, 72.3 percent; positive, 6.2 percent; and negative, 21.5 percent (including 9.7 percent death). 5) Three measurements are necessary in order to calculate the real incidence of functional decline. Since functional decline is a continuous process, the calculation of the incidence rates should include only people who were previously stable and not already engaged in the process. Functional autonomy should then be assessed twice in order to define the stable population, and it is the change between the second and a third assessment that produces incidence figures.

The objective of the study was to calculate the incidence of functional decline or improvement in a very elderly population living at home. To achieve this objective and in order to overcome the shortcomings of previous studies, we carried out the following: 1) use of a comprehensive and objective assessment of disabilities developed according to the World Health Organization classification; 2) assessment of subjects’ autonomy on three occasions separated by a short interval of 1 year; and 3) use of a definition of functional transition that allows for measurement error.

MATERIALS AND METHODS

Population and procedure

This is a longitudinal study on a representative sample of elderly individuals over 75 years old, followed up for 2 years with three yearly assessments: baseline (T1), after 1 year (T2), and after 2 years (T3). Subjects were elderly individuals over 75 years old, living in the community of Sherbrooke, Québec, Canada, a small city of 75,000 inhabitants (3,500 of these aged over 75 years). From the electoral poll, all subjects over 75 years old who were born between July 29th and November 24th were selected. Subjects who died, were admitted into an institution, moved outside the region, or did not speak French were excluded.

After having sent an introductory letter, one of three experienced in work with older people and specifically trained research nurses contacted all eligible subjects asking for an in-home interview. During the interview, the Functional Autonomy Measurement System (SMAF) was administered together with a questionnaire on health and other instruments measuring cognitive functioning and depression. One year and 2 years after the first interview, each subject was reassessed by the same nurse, and the SMAF was completed again, together with a questionnaire on health care service utilization. Mortality records and nursing home admission lists were also used to trace missing subjects.

Instrument

The SMAF (15) is a 29-item scale developed according to the World Health Organization classification of disabilities (4). It measures functional ability in five areas: activities of daily living (eating, washing, dressing, grooming, urinary and bowel functions, toileting); mobility (transfers, walking inside and outside, donning prosthesis or orthosis, propelling a wheelchair, negotiating stairs); communication (vision, hearing, speaking); mental functions (memory, orientation, comprehension, judgment, behavior); and instrumental activities of daily living (housekeeping, meal preparation, shopping, laundry, telephone, transportation, medication use, budgeting). Each item is scored on a four-point scale (0, independent; 1, needs supervision or stimulation; 2, needs help; 3, dependent) for a maximum score of 87. The SMAF must be administered by a trained health professional (nurse or social worker) who scores the individual after obtaining the information either by questioning the subject and proxies or by observing and even testing the subject. Reliability studies showed mean Cohen’s weighted kappas of 0.75 (16) for item scores and intraclass correlation coefficients of 0.95 for total.
SMAF scores (17). Validity was tested by comparing the SMAF score with the nursing time required for care \((r = 0.88)\) (16) and discriminating disability scores between residents living in settings of different levels of care (18). A difference of five points or more on the SMAF score can be considered as a real change, being outside the variability of stable subjects (19). Thus, functional decline was defined by an increase of five points or more in the SMAF score, improvement was a decrease of five points or more, and stability was a change in SMAF score between -4 and +4.

Analysis

First, subjects lost were compared with participants on age, sex, and baseline characteristics using the independent \(t\) test, Mann-Whitney \(U\) test (corrected for ties), and chi-square (20). The transitional probabilities of functional improvement, functional decline, and death were calculated for the overall 2-year period (T1 to T3) and for each of the 1-year periods: first (T1 to T2) and second (T2 to T3) years. The real annual incidence of functional decline was estimated by calculating transitional probabilities of functional decline during the second year among subjects who had been stable during the first year. The incidence of functional improvement was also calculated the same way. However, another adjustment was needed to take into account subjects who were totally independent at the beginning and were not at risk for improvement. Confidence intervals for incidence rates were calculated considering rates as Poisson variables with standard error of the log rates equal to the square root of \(1/d\), where \(d\) is the number of cases (21). The influence of age and sex on functional transitions was analyzed using logistic regression and unadjusted relative risk (with 95 percent confidence interval) with the stable population as reference. All analyses were carried out using SPSS software for Windows (release 6.0; SPSS, Inc., Chicago, Illinois).

RESULTS

Of the 1,175 subjects selected from the electoral poll, 842 were eligible to participate in the study. Of the 333 ineligible subjects, 197 were admitted into an institution, 61 had died, 17 had moved outside the area, 45 were not French speaking, and only 13 had not been found. From these 842 eligible subjects, 655 agreed to be interviewed at home (refusal rate of 22.2 percent). Between the first and second interviews, 48 subjects dropped out (7.8 percent) and 43 died (6.6 percent). Between the second and last interview, 35 subjects dropped out (6.2 percent) and 25 died (4.4 percent). Finally, 504 subjects participated in the last interview. In total, 572 subjects were included in the analyses: 504 subjects who participated in the three interviews and 68 subjects who died during the study. Table 1 shows the age and sex distribution of the sample. Figure 1 summarizes the flow of the subjects throughout the study.

The bias associated with initial refusal has been analyzed and fully reported elsewhere (22). In summary, the nonparticipants were very similar to the participants on the age-sex distribution, on answers to a postal questionnaire, and on the 1-year mortality rate. Comparisons between the dropout subjects and the participants using a multivariate logistic regression analysis showed that only sex (men: relative risk (RR) = 1.88, 95 percent confidence interval (CI) 1.11–3.17), satisfaction with relationships (very satisfied to very dissatisfied: RR = 0.54, 95 percent CI 0.32–0.91), and satisfaction with income (very satisfied to very dissatisfied: RR = 0.57, 95 percent CI 0.35–0.92) were independently associated with dropping out.

The mean SMAF score at baseline was 10.0 (standard deviation, 9.4) with a median of 7.0. Figure 2 compares the distribution of the SMAF total score and subscores at baseline according to sex. Women were significantly more disabled than were men for activities of daily living \((p = 0.006)\), mobility \((p < 0.001)\), and mental functions \((p < 0.001)\). However, they were more autonomous for instrumental activities of daily living \((p = 0.002)\) and the total SMAF score \((p < 0.001)\).

As opposed to the skewed distributions of SMAF scores at baseline, the differences between scores on the different annual interviews were nearly normally distributed. As shown in table 2, on average, subjects presented a significant decline in all areas of functioning between the baseline interview and the second interview, 1 year later. There was no influence of sex for the change in SMAF score and subscores. There was a significant correlation of age with the decline in total SMAF score \((r = 0.11)\) and the activities of daily living SMAF score \((r = 0.17)\). Between the second and third interviews, the mean differences of scores

---

**TABLE 1. Age-sex distribution of a representative sample of elderly people living at home in Sherbrooke (Canada), 1991–1993**

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>No. of females</th>
<th>No. of males</th>
<th>Total no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>75–79</td>
<td>197 (67.0)*</td>
<td>97 (33.0)</td>
<td>294</td>
</tr>
<tr>
<td>80–84</td>
<td>119 (61.0)</td>
<td>76 (39.0)</td>
<td>195</td>
</tr>
<tr>
<td>85 and over</td>
<td>55 (66.3)</td>
<td>28 (33.7)</td>
<td>83</td>
</tr>
<tr>
<td>Total</td>
<td>371 (64.9)</td>
<td>201 (35.1)</td>
<td>572</td>
</tr>
</tbody>
</table>

* Numbers in parentheses, percentage.
were not significantly different from zero, except for the instrumental activities of daily living that showed a slight decline (table 2). The overall differences in scores between the baseline and third interviews were dominated by the changes between the baseline and second interviews.

Table 3 shows the transitional probabilities for the overall 2-year period (T1 to T3) and for the first year (T1 to T2) and second year (T2 to T3) separately. For each of these, around two thirds of the subjects remained stable. For the overall 2-year period, 20.3 percent declined, 7.9 percent improved, and 11.9 percent died. These data exemplify how dying as an absorbing state may modify the transitional probabilities if a long interval is utilized between the assessments.

The transitional probabilities were different in the two separate years. The transitional probabilities were not influenced by sex, but in the overall 2-year period and in the second year, the probability of dying was significantly higher for men (18.4 percent and 9.4 percent) than for women (8.4 percent and 2.3 percent).

Over the 2-year period and in each year, the probabilities of dying, improving, and declining were higher in the older age group ($p < 0.001$). Conversely, the probability of remaining stable decreased with age.

The transitions during the overall 2-year period mask more complex transitional phenomena. Among the 343 subjects who remained stable during the overall 2-year period, six improved during the first year and then declined, and 38 declined during the first year and then improved. Among the 45 subjects who improved over the 2-year period, 10 (22.2 percent) were chronic improvers, 14 improved during the first year and then remained stable, 17 were stable during the first year and improved in the second year, and finally four declined during the first year and then improved. Among the 115 decliners, 28 (24.3 percent) declined chronically, 38 declined only in the first year, 44 declined only in the second year, and five improved in the first year and then declined.

Table 4 presents the transitional probabilities during the second year according to the transitions observed in the first year. Among those who were stable in the first year, 6.2 percent improved, 11.9 percent declined, and 3.4 percent died during the second year. The annual incidence of functional decline is thus 11.9 percent (46 of 386 subjects) with a 95 percent confidence interval of 8.9–15.9. If death (25) is included within functional decline, the annual incidence rises to 15.3 percent (95 percent CI 11.9–19.7). The occurrence of functional decline was higher among those who declined (15.7 percent) or improved (25.9 percent) during the first year.

For improvement, the denominator is more important, since the population at risk should be limited to those who are already disabled (SMAF score ≥ 5). Since only one of the subjects who improved during the second year was already improving during the first, this marginal effect on the numerator can be ignored. The incidence of improving can then be estimated at 7.5 percent (27 of 358 subjects) for the first year (95 percent CI 5.1–10.9) and 17.9 percent (62 of 346 subjects) for the second year (95 percent CI 14.0–23.0).

There was no significant influence of the sex on functional decline ($\text{RR}_{\text{male}} = 0.88$, 95 percent CI 0.55–1.39) or improvement ($\text{RR}_{\text{male}} = 1.70$, 95 percent CI 0.90–3.18). The relative risk for men of dying over the 2-year period was 2.53 times higher than for women (95 percent CI 1.09–1.21). Over the 2-year period, age was associated with functional decline ($\text{RR} = 1.15$/year of age, 95 percent CI 1.09–1.21) and dying ($\text{RR} = 1.12$, 95 percent CI 1.05–1.19) but not significantly with functional improvement ($\text{RR} = 1.07$, 95 percent CI 0.99–1.15).

incidence of functional changes in very elderly people

371 371 371 371 371 371
 conducts p=0.006

ADL p=0.002

FEMALE

201 201 201 201 201 201

MALE

ADL p=0.002

COMMUNICATION p<0.001

MENTAL p=0.001

EDTOTAL

p<0.001

• lADLp=0.002

Mobility p<0.001

Communication p=0.8

Mental p=0.001

FIGURE 2. Box plots of the mean total SMAF score and subscores at baseline (T1) according to sex, among a representative sample of elderly people living at home in Sherbrooke, Canada, 1991–1993. Scores of each section are divided by the number of items. p values compare scores according to sex (Mann-Whitney U test). SMAF, Functional Autonomy Measurement System; ADL, activities of daily living; IADL, instrumental activities of daily living.

TABLE 2. Mean difference between scores* on the SMAF† at three annual interviews of community-dwelling people aged over 75 years from Sherbrooke, Canada, 1991–1993

<table>
<thead>
<tr>
<th>SMAF score</th>
<th>Time 1 to time 2 (n = 528)</th>
<th>Time 2 to time 3 (n = 503)</th>
<th>Time 1 to time 3 (n = 504)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD†</td>
<td>p value†</td>
</tr>
<tr>
<td>Total</td>
<td>2.45</td>
<td>7.57</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ADL†</td>
<td>0.43</td>
<td>2.03</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mobility</td>
<td>0.51</td>
<td>2.00</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Communication</td>
<td>0.04</td>
<td>0.73</td>
<td>0.19</td>
</tr>
<tr>
<td>Mental</td>
<td>0.23</td>
<td>1.58</td>
<td>0.001</td>
</tr>
<tr>
<td>IADL†</td>
<td>1.23</td>
<td>3.97</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

* A difference expressed as a "plus value" indicates decline.
† SMAF, Functional Autonomy Measurement System; SD, standard deviation; ADL, activities of daily living; IADL, instrumental activities of daily living.
‡ Paired t-test.

DISCUSSION

The major bias that can challenge a longitudinal study is related to the dropout subjects. The dropout rates observed in the present study were 7.8 percent for the first year, 6.2 percent for the second year, and 12.7 percent for the overall 2-year period. These are comparable with the rates reported from the other longitudinal studies (8, 9, 14, 23, 24). Dropout subjects were mostly men and were more satisfied with their relationships and with their income. This contrasts with other studies that reported that elderly dropouts are older (25–27), less often married (28), less well-educated (25, 29–31), financially less well off (30, 32), in poorer health (27, 28, 30, 31), and more cognitively impaired (33, 34) than participants. However, most of these studies pooled together dropouts who died or who were not interested. More recent studies showed that it is important to distinguish between these two groups of dropouts because only death seems to be associated with specific sociodemographic and health characteristics (35–37), other dropouts being more similar to participants (35, 38). The present study confirmed these observations.

This elderly population living at home was relatively independent at baseline. Most of the disabilities were initially related only to instrumental activities of daily living. There was a significant decline in functional status during the first year, but the decline in the
TABLE 3. Transitional probabilities of functional status for the overall 2-year period and each year, according to age and sex, among community-dwelling people aged over 75 years from Sherbrooke, Canada, 1991-1993

<table>
<thead>
<tr>
<th></th>
<th>Stable Probability</th>
<th>Improve Probability</th>
<th>Decline Probability</th>
<th>Death Probability</th>
<th>Total Probability</th>
<th>Test statistic</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of subjects</td>
<td>No. of subjects</td>
<td>No. of subjects</td>
<td>No. of subjects</td>
<td>No. of subjects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall 2 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0.600</td>
<td>0.079</td>
<td>0.203</td>
<td>0.119</td>
<td>1.000</td>
<td>572</td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>0.547</td>
<td>0.100</td>
<td>0.169</td>
<td>0.184</td>
<td>1.000</td>
<td>201</td>
<td>0.001</td>
</tr>
<tr>
<td>Women</td>
<td>0.626</td>
<td>0.067</td>
<td>0.221</td>
<td>0.084</td>
<td>1.000</td>
<td>371</td>
<td></td>
</tr>
<tr>
<td>75-79 years old</td>
<td>0.735</td>
<td>0.068</td>
<td>0.122</td>
<td>0.075</td>
<td>1.000</td>
<td>294</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>≥80 years old</td>
<td>0.046</td>
<td>0.090</td>
<td>0.288</td>
<td>0.165</td>
<td>1.000</td>
<td>278</td>
<td></td>
</tr>
<tr>
<td>First year (time 1 to 2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0.675</td>
<td>0.047</td>
<td>0.201</td>
<td>0.075</td>
<td>1.000</td>
<td>571</td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>0.665</td>
<td>0.055</td>
<td>0.180</td>
<td>0.100</td>
<td>1.000</td>
<td>200</td>
<td>0.30</td>
</tr>
<tr>
<td>Women</td>
<td>0.682</td>
<td>0.043</td>
<td>0.213</td>
<td>0.062</td>
<td>1.000</td>
<td>371</td>
<td></td>
</tr>
<tr>
<td>75-79 years old</td>
<td>0.765</td>
<td>0.034</td>
<td>0.156</td>
<td>0.044</td>
<td>1.000</td>
<td>294</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>≥80 years old</td>
<td>0.581</td>
<td>0.061</td>
<td>0.249</td>
<td>0.108</td>
<td>1.000</td>
<td>277</td>
<td></td>
</tr>
<tr>
<td>Second year (time 2 to 3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>0.647</td>
<td>0.108</td>
<td>0.124</td>
<td>0.044</td>
<td>1.000</td>
<td>528</td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>0.667</td>
<td>0.111</td>
<td>0.128</td>
<td>0.094</td>
<td>1.000</td>
<td>180</td>
<td>0.003</td>
</tr>
<tr>
<td>Women</td>
<td>0.718</td>
<td>0.121</td>
<td>0.138</td>
<td>0.023</td>
<td>1.000</td>
<td>348</td>
<td></td>
</tr>
<tr>
<td>75-79 years old*</td>
<td>0.801</td>
<td>0.100</td>
<td>0.068</td>
<td>0.032</td>
<td>1.000</td>
<td>281</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>≥80 years old*</td>
<td>0.587</td>
<td>0.138</td>
<td>0.211</td>
<td>0.055</td>
<td>1.000</td>
<td>247</td>
<td></td>
</tr>
</tbody>
</table>

* Age at outset of the study.
second year was more modest and even not significant (table 2). Three explanations can account for this phenomenon: floor effect, survival effect, and regression toward the mean. Since at baseline the sample was relatively independent, there was less room for improvement (floor effect). At baseline, 213 of 571 subjects scored between 0 and 4 on the total SMAF (37.3 percent) as opposed to 182 of 528 (34.7 percent) subjects at the second interview. For a large proportion of the sample, only “bad things” could happen during the first year. This floor effect was less important for the second year, since a proportion of functionally intact subjects had declined during the first year and then became “at risk” of improving in the second year. The survival effect is related to the subjects who had died during the second year. Those decedents declined significantly during the first year (mean difference in the total SMAF score = 5.0 (standard deviation, 7.8)), and they were no longer contributing to the decline probability in the second year analyses. However, one could argue that this phenomenon also happened during the first year and, given that the death rate was higher in the first year, the survival effect would have had the opposite effect. Finally, the regression toward the mean could partly explain the less important decline observed in the second year. This phenomenon would tend to ascribe to random variation both individuals who improved and then declined and those who displayed the opposite pattern. Given the floor effect and the higher proportion of decliners, the latter group are of most interest. However, the choice of a five-point difference should mean that a classification of “decline” or “improvement” is not due to chance variation alone, so it is plausible that there is a true improvement of some decliners, possibly caused by effective medical and rehabilitation interventions.

One interesting finding from this study is the confirmation that a long interval between assessments masks many transitions happening during the interval. A proportion of 12.8 percent (38 + 6 of 343) of the subjects who were stable over the 2-year period experienced significant decline and improvement during each year. Only 22.2 percent (10 of 45) of the improvers were chronic improvers, and 24.3 percent (28 of 115) of decliners declined in both years. The high death rate in this population also masks previous transitions if the study period is too long because, as death is an absorbing state, the transitional probability of dying is the only one to increase steadily with time. The present study demonstrates that, for a very elderly population, this interval should not be longer than 1 year. However, it cannot be stated that a smaller interval would be more appropriate.

The difference in transitional probabilities between the 2 years is striking. The probabilities of remaining stable and dying are similar, but in the second year, the probability of improving more than doubles (from 4.7 percent to 10.8 percent), and the probability of declining decreases nearly by half (from 20.1 percent to 12.4 percent). Again, this can be explained by one of three phenomena: survival effect, floor effect, and regression toward the mean. Survival effect is caused by the removal from the cohort of the 43 subjects who died during the first year. Since these subjects are unhealthy, this could produce an underestimation of the probability of declining. Assuming that all these subjects would have declined and adding them to the 71 subjects who effectively declined during the second year, the probability of declining would have been 20.0 percent (71 + 43 of 572 subjects), which is similar to the first year. However, this correction is too simplistic, since only 44 percent of those who died during the second year were declining during the first year. Assuming that 44 percent of the 43 decedents during the first year would have declined during the second year, the probability of declining would have been 15.7 percent (71 + 19 of 572 subjects), which is similar to the first year. However, this correction is too simplistic, since only 44 percent of those who died during the second year were declining during the first year. Assuming that 44 percent of the 43 decedents during the first year would have declined during the second year, the probability of declining would have been 15.7 percent (71 + 19 of 572 subjects). Floor effect and regression toward the mean are probably related more to the probability of improving. These phenomena can be related to the criterion used to define a critical difference in total SMAF scores (five points). A sensitivity analysis carried out by moving the criterion upward or downward showed that the criterion of five points and more used in this study appears to be a good compromise between the floor effect and regression toward the mean. Finally, since age is only slightly related to the probability of improvement, aging of the cohort cannot be put for-
ward to explain the discrepancy. In summary, the discrepancy of the probabilities of declining and improving between the 2 years is probably real and may be explained by the association of survival with floor effect. The probability of declining decreases with time, because the unhealthy subjects are gradually eliminated. The probability of improving increases because more subjects become disabled and are then “at risk” of improving.

Comparisons of the transitional probabilities and incidence rates with the literature are not straightforward, since the definition of decline and improvement varies from one study to another, and because most studies reported data for subjects over 65 years of age without specific values for older age groups. The only study with which comparison is appropriate is the Massachusetts Health Care Panel Survey (MHCPS) (14). The probability of remaining stable was higher in that study (72.3 percent), since the criterion for decline was based on activities of daily living only. The probability of declining (decline in activities of daily living + institutionalization) was 11.8 percent in the MHCPS (14), a value higher than any of the probabilities observed in the present study (4.7 percent and 10.8 percent). The probability of improving in the disabled population (incidence rate) was 6.2 percent, a value lower than those observed in the present study (7.5 percent and 17.9 percent).

No study reported transitional probabilities of two successive periods with short intervals. More studies are available to compare death rate. The annual death rates observed in the present study (4.4–7.5 percent) were consistent with those reported in the literature for this age group: MHCPS, 9.7 percent (14); Longitudinal Study on Aging, 5.6 percent (7); Established Populations for Epidemiologic Studies of the Elderly (EPESE) Study, 9.4 percent (39); and Tempere Study, 7.5 percent (9).

In the present study, functional decline was associated with age but not with sex. Age is a very consistent factor in all the studies reported in the literature (6–8, 10, 11, 40–44). Even in the very elderly, age is still associated with decline with a relative risk of 1.15. It means that, for every 5-year increase in age, the odds of functional decline double. For sex, there are many controversies in the literature. Some large studies carried out with an interval of 2 years between assessments found that men were at higher risk of decline (6, 41). However, the difference between sexes reported by Manton (6) was not striking, and no statistical testing was reported. The relative risk associated with being a woman in the Longitudinal Study on Aging (41) was 0.82 but did not reach the significance level (95 percent CI 0.67–1.01). Two other papers from the same study reported an opposite association. Mor et al. (23) and Harris et al. (42) reported that women have a relative risk of 1.60 (95 percent CI 1.28–2.01) of losing the ability to climb stairs, carry 25 lb (11.35 kg), walk ¼ mile (0.4 km), and do heavy work over a 2-year period. With a longer interval, Lundgren-Lindquist and Jette (24) also showed that women declined more than men did with regard to similar physical abilities. From the data reported by Strawbridge et al. (8) from the Alameda County Study, a relative risk of 2.22 (95 percent CI 1.14–4.30) can be calculated (female vs. male). In the PAQUID Study (10), women were more likely to become disabled for instrumental activities of daily living and mobility but not for activities of daily living. Branch et al. (5) reported a higher risk of functional decline in activities of daily living for females. Beckett et al. (11) from the large EPESE Study showed a small increase in the probability of functional decline for women over 65 years old, but this association was not statistically significant for all four centers of the study and for all types of disabilities. In conclusion, the sex differences reported in the literature seem small, if any, and are related to the disabilities measured. The discrepancies are probably related to the fact that sex is not a strong factor for functional decline. As confirmed in the present study, sex is more strongly associated with the probability of dying. The higher survival of women probably explains the higher prevalence of disability in women, despite the fact that the incidence is not very different from that of men. Manton (6) argued that this phenomenon is related to the causes of disability, which are less lethal in women (arthritis and locomotor problems) than in men (cardiovascular problems).

This study demonstrated that functional decline is not an ineluctable process. The annual incidence of improvement among disabled individuals lies between 7.5 percent and 17.9 percent. Age was a marginally significant factor for improvement in the present study. It means that the older the subject, the more likely to improve he was. A reverse association had been reported by Rogers et al. (41) from the Longitudinal Study on Aging, Beckett et al. (11) from the EPESE Study, and Sauvel et al. (10) from the PAQUID Study. In these three studies, a lower age was associated with improvement, but these surveys were carried out on subjects aged over 65. It is then probable that most of the protective effects of age are confined to the 65- to 74-year age group as compared with older subjects. In two studies (10, 41), sex was not a significant factor of improvement, whereas the EPESE Study (11) showed that males were more likely to recover from disability.
also showed a male advantage (RR = 1.70), but this was not powerful enough to detect a significant sex difference on improvement.

In conclusion, functional decline represents a major health problem for very elderly individuals. The annual incidence of functional decline is 11.9 percent among previously stable subjects aged 75 years and over. The risk of functional decline increases tremendously with age, doubling every 5 years. With the expected aging of the population, this health problem will become the major challenge for health systems. Health objectives should now be shifted toward morbidity and disability reduction. Disability should then be one of the outcome measures in studies of the elderly population and should be measured with sensitive and comprehensive instruments, since functional decline is a complex and continuous process. Measurement must also take into account the relatively rapid and dynamic process of functional transitions. The next step in this study will be to analyze in depth the factors associated with functional decline and improvement in order to identify risk and protective factors that would be useful in preventive programs.

REFERENCES