Falls in the Elderly: A Prospective Study of Risk Factors and Risk Profiles

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In this prospective study, the authors determined intrinsic risk factors for falls and recurrent falls and constructed a risk profile that indicated the relative contribution of each risk factor and also estimated the probabilities of falls and recurrent falls. In 1992, over a 28-week period, falls were recorded among 354 elderly subjects aged 70 years or over who were living in homes or apartments for the elderly in Amsterdam and the vicinity. During the study period, 251 falls were reported by 126 subjects (36%), and recurrent falls (≥2 falls) were reported by 57 subjects (16%). Associations of falls and recurrent falls with potential risk factors were identified in logistic regression models. Mobility impairment regarding one or more of the tested items (i.e., impairment of balance, leg-extension strength, and gait) was associated with falls (adjusted odds ratio (OR) = 2.6) and was strongly associated with recurrent falls (OR = 5.0). Dizziness upon standing was associated with falls (OR = 2.1) and recurrent falls (OR = 2.1). However, several risk factors were associated with recurrent falls only: history of stroke (OR = 3.4), poor mental state (OR = 2.4), and postural hypotension (OR = 2.0). The authors constructed a risk profile for recurrent falls that included the five risk factors mentioned above. Inclusion of all risk factors in the profile implied an 84% probability of recurrent falls over a period of 28 weeks, compared with 3% when no risk factor was present. The probability of recurrent falls ranged only from 11% to 29% when predicted by number of falls occurring in the previous year. Physical activity, use of high-risk medication, and the use of vitamin D₃, which was randomly allocated to the participants, were not strongly related to either falls or recurrent falls. In conclusion, a large range of probabilities of falls, especially of recurrent falls, was estimated by the risk profiles, in which mobility impairment was the major risk factor. Recurrent fallers may therefore be especially amenable to prevention based on mobility improvement. Am J Epidemiol 1996;143:1129–36.

accidental falls; aged; risk factors

Falls are a major problem in the elderly, causing injuries, psychological difficulties, and social isolation. Approximately 1 percent of falls result in a hip fracture, and over 90 percent of hip fractures are caused by a fall (1–3). Other consequences of falls are head traumas and various other types of fractures (4). The incidence of falls rises exponentially with age in the elderly and is higher in women than in men (5–7). Among elderly people, the cumulative incidence of falling over a 1-year period varies between 30 percent and 50 percent (3, 5, 8)—a variation which may be a consequence of study population characteristics, housing accommodation, or study design. Falling is a multifactorial problem due to both extrinsic (e.g., environmental and housing conditions) and intrinsic risk factors, but usually a combination of factors is responsible. Falls may be prevented by compensatory mechanisms in which failure of one system (e.g., instability) may be compensated for by another (e.g., visual feedback), but multiple pathology may hamper these mechanisms. In general, mobility impairment, cognitive impairment, and use of medications, especially sedatives, have been identified as important risk factors for falls in previous studies (3, 6, 7, 9–11).

Many previous studies have been retrospective, which makes the reported information on falling frequency unreliable. Falls are easily forgotten; therefore, reported frequencies of falling vary according to the ascertainment method used (8, 12). Recently, however, some prospective studies have been published in which the selective underestimation of falls has been duly taken into account (3, 2, 9, 11, 13, 14). Little research has been done to investigate the relation of physical activity to falls and to determine the relative contribution of putative risk factors, which is neces-

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Abbreviations: CI, confidence interval; MMSE, Mini–Mental State Examination; OR, odds ratio; SBP, systolic blood pressure.

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sary in order to develop preventive strategies. In this prospective study, we carefully registered falls and examined the role of potential risk factors in falls and recurrent falls. We subsequently combined these risk factors to form risk profiles.

MATERIALS AND METHODS

Subjects

Potential participants were 458 men and women living in 13 homes or apartment houses for the elderly in Amsterdam and the vicinity. Homes and apartment houses for the elderly were chosen for their large numbers of residents and well-organized communication with our research workers. In the Netherlands, care is provided in homes for the elderly, but it is less than that provided in nursing homes. Subjects were members of a cohort (n = 2,578) participating in a clinical trial (1989–1994) designed to evaluate the effect of vitamin D₃ supplementation on the incidence of hip fractures. Participants were randomly assigned to receive a daily dose of either vitamin D₃ (400 IU) or placebo (15), and were eligible for participation if they were aged 70 years or older. Exclusion criteria for this trial were: a past hip fracture, total hip prosthesis, hypercalcemia or sarcoidosis, or a recent history of urolithiasis. The potential participants received a letter informing them about the study, and were asked for informed consent during a subsequent visit from the research workers in February and March 1992. The protocol was approved by the Ethical Review Board of the Free University (Vrije Universiteit) Hospital, Amsterdam.

Outcome and follow-up

The participants were asked to record in a diary any falls they had during a 28-week period. Every week, participants registered whether or not they had fallen, as well as the location, time, and circumstances of each fall. Approximately every 2 months, the fall registrations were collected and any falls were discussed. If there was any doubt about the reliability of the registration, the participant was assisted with the registration by a nurse of the residence. A fall was defined as unintentionally coming to rest at a lower level or on the ground. Two outcome measures were delineated: any falls (≥1 fall) and recurrent falls (≥2 falls).

Measurements

During four visits from the research workers, approximately once every 2 months, questionnaires were filled in and tests were carried out. Information on each participant’s medical history and use of medications was obtained at baseline; information on mobility impairment and activity score was obtained at the second visit; cognitive parameters were measured at the third visit; and postural hypotension was assessed at the last visit.

Questionnaires. The participant’s medical history with respect to falling was obtained by means of a questionnaire focusing on poor distance vision (wearing glasses as usual if applicable), history of stroke, dizziness upon standing, falls occurring during the previous year, and any disability of the lower extremities (e.g., foot or joint complaints). Medicines were coded and grouped using the anatomical-therapeutic-chemical (ATC) classification (16). Categories of medicines considered to increase the risk of falling were diuretics, benzodiazepines, hypnotics/sedatives, antihypertensives, analgesics, nitrates, nonsteroidal antiinflammatory drugs, peripheral vasodilators, and antidepressants. The hypnotics/sedatives group included some medicines that were also classified in the benzodiazepines category. An index for activities of daily living was used to determine the level of independent functioning (17). Physical activity was measured by means of a questionnaire for the elderly which covered household activities, sports, and leisure activities. Summation of the different types of physical activity was based on energy expenditure (18).

Tests. Mobility-impairment tests were adapted from tests used in the US Third National Health and Nutrition Examination Survey (T. Harris, National Institute of Aging (Bethesda, Maryland), personal communication, 1992). Participants could score one point on each of four conceptually independent items indicating mobility impairment. Balance was tested by asking the subject to perform a tandem-stand for at least 3 seconds, during which one foot is placed behind the other on a straight line. Leg-extension strength was tested by the subject’s repeating five chair-stands within 30 seconds, with the arms crossed over the chest. Participants were asked to walk approximately 3 meters, turn 180°, and walk 3 meters back in a straight line without staggering or stumbling (walking aids were allowed if normally used). The use of a wheelchair or walking aid automatically scored one point on the mobility-impairment scale. When functional disabilities clearly indicated an inability to perform any of the mobility-impairment tests (e.g., in participants using a wheelchair), the participant scored four points. The final mobility-impairment score constituted the summation of scores for the separate items (score range, 0–4). The score increased according to the severity of the mobility impairment.
Cognitive functioning was tested by means of the Mini-Mental State Examination (MMSE) (19) (score range, 0–30). Since depression and educational level could have confounded the relation between the MMSE test result and falls, these factors were assessed by means of the Geriatric Depression Scale (20) and a reading test consisting of 50 words in Dutch (21). The score for this reading test was the total number of words pronounced correctly. Participants were classified as being in a poor mental state if their MMSE test score was 24 or less (19), and were classified as depressed if 10 or more of the 30 answers on the Geriatric Depression Scale indicated a depressed state (22).

Postural blood pressure change was measured after the participant had lain in a supine position for 5 minutes and then stood for 1 minute (23). Orthostatic hypotension was defined as a drop of ≥20 mmHg in systolic blood pressure and/or a drop of ≥10 mmHg in diastolic blood pressure (23).

Data analysis

The relations between falls and the risk factors were examined by means of logistic regression analysis, which was performed for each risk factor and adjusted for age and sex. If any other potential confounding factor was obvious, adjustments were made. Two outcome variables were defined: “fallers” (≥1 fall) were contrasted with “nonfallers,” and “recurrent fallers” (≥2 falls) were contrasted with participants who had no falls or only one fall (≤1 fall). The participant’s mobility-impairment score and drop in systolic blood pressure after standing were analyzed as both continuous and categorical variables. This approach made it possible to evaluate nonlinear effects. Cutpoints (median values) were used for data presentation, transforming the continuous variables of age and activity score into dichotomous variables, and when used as potential confounders, age and activity score were analyzed as continuous variables. With regard to postural hypotension, the MMSE score, and the depression score, cutpoints were used as recommended in the literature (19, 22, 23).

A risk profile was obtained by stepwise logistic regression (backward elimination, p = 0.05), retaining only the most strongly related variables. Initially, all variables that were significantly related to falls or recurrent falls were entered. Although past falls might be a useful indicator for future falls, determinant and outcome measure become ambiguous. The risk-profile analysis was therefore performed by both excluding and including this variable. In the risk profile, odds ratios produced by logistic regression were transformed into estimated probabilities to permit a more straightforward interpretation of the risk. This was done by using the formula of the logistic model:

\[
\text{Risk of falls (} p \text{)} = \frac{e^{\text{logit}(p)}}{1 + e^{\text{logit}(p)}}.
\]

Logit(\( p \)) is the result of the summation of the relevant \( \beta_i \) and \( \alpha_0 \) (intercept) in the model for a specified risk profile. In the multiple logistic models, missing values for one or more variables did not result in exclusion of these cases. The presence of information was represented by an indicator variable that equaled “1” if information on a variable was available and “0” if information was not available. The risk factor of interest was entered as an interaction with the availability variable (24). This provided information on the risk factor, if available, and also on the impact of unavailability of the information.

RESULTS

Over a period of 2 months, 368 of the 458 eligible elderly subjects were enrolled in this study. Reasons for not participating were illness, inability to give informed consent (e.g., severe cognitive problems), and lack of interest in the study. Participants did not differ from eligible subjects who did not participate with regard to age and sex. During the 28-week study period, 10 participants died, two moved away from the area, and two dropped out. All 14 of these participants were excluded from further analysis, leaving 354 participants in the final analysis: 52 men (15 percent) and 302 women (85 percent) with a mean age of 83 years (standard deviation, 6 years), 172 (49 percent) living in homes for the elderly and 182 (51 percent) living in apartments for the elderly.

Falls

During the 28-week period, 251 falls were reported by 126 participants (36 percent). At least two falls were reported by 57 individuals (16 percent), and 26 people (7 percent) reported having at least three falls, increasing to nine falls for two participants. The majority (79 percent) of the falls occurred indoors. The time of the fall was reported in 65 percent of cases; peak incidence times were 8:00–10:00 a.m. and 1:00–3:00 p.m. There was no obvious seasonal trend. As a consequence of falls, six hip fractures, one wrist fracture, one humerus fracture, one nose fracture, and numerous soft tissue injuries were reported.

Measurements

Table 1 shows the variables measured in relation to falls and recurrent falls. Age as a continuous variable, adjusted for sex, was significantly (\( p < 0.05 \)) associ-
**TABLE 1.** Prevalence of and odds ratios for risk factors for falls and recurrent falls, as well as incidence (I) of falls (≥1 fall) and recurrent falls (≥2 falls) in the presence (I) and absence (I) of each risk factor: Amsterdam, The Netherlands, 1992*

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Prevalence (%)</th>
<th>Falls (≥1 fall)†</th>
<th>Recurrent falls (≥2 falls)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I (%)</td>
<td>B (%)</td>
<td>OR§</td>
</tr>
<tr>
<td>Sociodemographic factors (n = 354)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age ≥83 years†</td>
<td>51</td>
<td>40</td>
<td>32</td>
</tr>
<tr>
<td>Female sex†</td>
<td>84</td>
<td>39</td>
<td>22</td>
</tr>
<tr>
<td>Residing in home for the elderly</td>
<td>49</td>
<td>42</td>
<td>30</td>
</tr>
<tr>
<td>Physical symptoms or impairments (n = 348)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dizziness upon standing</td>
<td>16</td>
<td>39</td>
<td>35</td>
</tr>
<tr>
<td>Fall(s) in the previous year#</td>
<td>11</td>
<td>49</td>
<td>34</td>
</tr>
<tr>
<td>Urinary incontinence (n = 324)</td>
<td>22</td>
<td>52</td>
<td>31</td>
</tr>
<tr>
<td>Handicapped on ≥1 ADLS item (n = 324)</td>
<td>33</td>
<td>53</td>
<td>28</td>
</tr>
<tr>
<td>Disability of lower extremities</td>
<td>30</td>
<td>55</td>
<td>30</td>
</tr>
<tr>
<td>Orthostatic hypotension (n = 298)</td>
<td>21</td>
<td>41</td>
<td>33</td>
</tr>
<tr>
<td>Activity and mobility impairment (n = 328)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity score &lt;3.6**</td>
<td>50</td>
<td>41</td>
<td>32</td>
</tr>
<tr>
<td>Incapable of chair-stands</td>
<td>37</td>
<td>53</td>
<td>29</td>
</tr>
<tr>
<td>Incapable of tandem-stand</td>
<td>48</td>
<td>49</td>
<td>28</td>
</tr>
<tr>
<td>Abnormalities in gait</td>
<td>33</td>
<td>55</td>
<td>30</td>
</tr>
<tr>
<td>Use of walking aid</td>
<td>21</td>
<td>59</td>
<td>33</td>
</tr>
<tr>
<td>Cognitive functioning (n = 277)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMSE score &lt;24††</td>
<td>30</td>
<td>46</td>
<td>34</td>
</tr>
<tr>
<td>Depression (GDS§) score &gt;10</td>
<td>23</td>
<td>48</td>
<td>34</td>
</tr>
<tr>
<td>Vitamin D₃†† (n = 354)</td>
<td>50</td>
<td>35</td>
<td>37</td>
</tr>
</tbody>
</table>

* Odds ratios were adjusted for age and sex, unless otherwise noted.
† "Fallers" (≥1 fall) versus "nonfallers."
‡ "Recurrent fallers" (≥2 falls) versus "nonfallers" and participants reporting only one fall (≤1 fall).
§ OR, odds ratio; CI, confidence interval; ADLS, activities of daily living; MMSE, Mini-Mental State Examination; GDS, Geriatric Depression Scale.
∥ Adjusted for sex.
¶ Adjusted for age.
# Unadjusted.
** Adjusted for mobility impairment.
†† Adjusted for age, sex, depression score, and reading ability.
†‡ Participants were randomly allocated to receive either daily vitamin D₃ supplements (400 IU) or placebo tablets.

...ated with recurrent falls only. The odds ratio for every 10-year increase in age was 1.7 for recurrent falls. Use of medication, adjusted for age and sex, was for most medicine groups not related to falls or recurrent falls. However, the use of nitrates (18 percent of participants) was significantly associated with falls (odds ratio (OR) = 2.2, 95 percent confidence interval (CI) 1.3–3.9), and the use of peripheral vasodilators (5 percent of participants) was significantly associated with recurrent falls (OR = 3.8, 95 percent CI 1.4–10.2). Benzodiazepines, hypnotics/sedatives, and diuretics were frequently used by 32 percent, 23 percent, and 41 percent of participants, respectively. Anti-depressants were used by only 3 percent of participants.

Postural blood pressure change was measured for 298 participants. The main reason for missing data on this factor was a participant’s inability to change from a lying position to a standing position. The systolic criterion for orthostatic hypotension (a decrease of ≥20 mmHg) was met by 19 percent of the participants, while 3 percent of participants met the diastolic criterion (a decrease of ≥10 mmHg). Figure 1 shows the odds ratios for recurrent falls as a function of change in systolic blood pressure (ΔSBP). A systolic blood pressure decrease of approximately 6 mmHg
(the mean value) was chosen as the reference category (OR = 1). Forty-five percent of the participants with orthostatic hypotension reported dizziness upon standing, but in the group with no orthostatic hypotension, only 23 percent reported dizziness upon standing. Orthostatic hypotension was not related to any of the categories of medicines.

Activity and mobility-impairment scores were obtained for 328 participants, but because of illness or missed appointments, no information was obtained from the remaining participants. The mean and median activity scores were 4.0 and 3.6, respectively (score range, 0–17). The odds ratios for falls and recurrent falls for participants with an activity level below the median were 1.3 (95 percent CI 0.8–2.1) and 2.4 (95 percent CI 1.3–4.7), respectively. However, after adjustment for mobility impairment, the odds ratios changed (table 1). A one-point higher score on the mobility-impairment scale, when mobility impairment was analyzed as a continuous variable, corresponded to an odds ratio for falling of 1.5 (95 percent CI 1.3–1.9) and an odds ratio for recurrent falls of 1.7 (95 percent CI 1.3–2.2), adjusted for age and sex (figure 2).

The cognitive parameters were measured in 277 participants. Poor vision and loss of hearing were the main factors that inhibited testing. Mean and median scores on the MMSE were 24 and 25, respectively (score range, 4–30), and on the Geriatric Depression Scale they were 7 and 5, respectively (score range, 0–23). The mean number of wrongly pronounced
words on the Dutch reading test was 19 (score range, 2–48).

The profile for the risk of falls or recurrent falls over a 28-week period is shown in table 2. Participants were classified as immobile if they scored one or more points on the mobility-impairment scale. Figure 3 shows the probability of recurrent falls, as estimated by the model. In this example, the sequence of entering the risk factors in the calculations has been chosen to correspond to their prevalence, immobility being the most frequent and stroke the least frequent. Participants with no risk factors had a 3 percent probability of falling. The risk of recurrent falls was 84 percent for participants who suffered from all five disorders in the risk-profile model. Inclusion of falls that occurred during the previous year, along with the other variables, changed the risk profile slightly. Significant odds ratios were found for recurrent falls with regard to the following variables: immobility (OR = 4.0), poor mental state (OR = 2.3), dizziness upon standing (OR = 1.9), history of stroke (OR = 3.1), and falls in the previous year (OR = 2.4). This risk profile, including falls in the previous year, estimated a risk of recurrent falls of up to 81 percent over a 28-week period. Including the variable “falls in the

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR†</th>
<th>95% CI†</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Falls‡</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immobility</td>
<td>2.6</td>
<td>1.6–4.3</td>
</tr>
<tr>
<td>Dizziness upon standing</td>
<td>2.1</td>
<td>1.2–3.7</td>
</tr>
<tr>
<td><strong>Recurrent falls§</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immobility</td>
<td>5.0</td>
<td>2.2–11.4</td>
</tr>
<tr>
<td>History of stroke</td>
<td>3.4</td>
<td>1.5–7.9</td>
</tr>
<tr>
<td>Poor mental state</td>
<td>2.4</td>
<td>1.2–4.8</td>
</tr>
<tr>
<td>Dizziness upon standing</td>
<td>2.1</td>
<td>1.1–4.2</td>
</tr>
<tr>
<td>Orthostatic hypotension</td>
<td>2.0</td>
<td>1.0–4.2</td>
</tr>
</tbody>
</table>

* Each odds ratio was adjusted for all of the other variables in the model.
† OR, odds ratio; CI, confidence interval.
‡ “Fallers” (≥1 fall) versus “nonfallers.”
§ “Recurrent fallers” (≥2 falls) versus “nonfallers” and participants reporting only one fall (≤1 fall).

previous year” slightly changed the risk profile for any falls (≥1 fall). Significant odds ratios were found for immobility (OR = 2.2), dizziness upon standing (OR = 1.9), and falls in the previous year (OR = 2.4).

![Figure 3](image-url)  
**Figure 3.** Estimated probability of recurrent falls (≥2 falls) during a 28-week period and its relation to the presence of the risk factors in the risk profile, Amsterdam, The Netherlands, 1992. Factors are shown in order of descending prevalence: immobility, poor mental state, orthostatic hypotension, dizziness, and stroke.
DISCUSSION

This study analyzed two different outcome measures of falls in an elderly institutionalized population: at least one fall (≥1 fall) versus no falls, and recurrent falls (≥2 falls) versus one fall or less (≤1 fall). Since only 27 participants fell three times or more, fall incidence as a continuous variable was not considered relevant. From a clinical point of view, it is interesting to distinguish between “one-time fallers” and “recurrent fallers.” It can be argued that the subjects most eligible for a preventive strategy based on intrinsic risk factors are the recurrent fallers. The different relations of these two outcome variables with risk factors were apparent in this study, as well as in previous studies (3, 11, 25). A history of stroke, postural hypotension, disabilities of the lower extremities, and impaired cognitive functioning increased only the risk of recurrent falls, and the immobility items were also more strongly related to recurrent falls.

The mean age of participants was higher in this study than in the majority of previous studies of falls (3, 2, 10, 14), which resulted in a high incidence of falls. Advanced age puts limitations on compliance and on testing of older participants. Loss of hearing, poor eyesight, illness, or simply forgetting an appointment resulted in incomplete data sets, especially with regard to test items such as the MMSE, the Geriatric Depression Scale, and the reading test. We compensated for this in the multiple logistic regression models by introducing a dichotomous variable that indicated the selectiveness of the missing data. No selection bias was found, since none of the indicative variables for incomplete data sets were related to falls or recurrent falls. The age range (72–98 years) was restricted in comparison with several other studies (6, 7), which may explain the merely moderate association with falls and recurrent falls.

Although the study period was only 28 weeks long, changes in risk factor status may have occurred during this period. For practical reasons, the risk factors were assessed during the course of the study. The risk factors most prone to change were measured at baseline and the more stable risk factors after a few months. The possible variability of some risk factors during the course of the study may have diluted the relations with falls and recurrent falls.

The relation between the measures of activity and mobility refers to the relation between physical activity and physical ability. When the level of physical activity exceeds physical ability (i.e., when the activity level is higher than the person can cope with), falls may occur. Level of physical activity was especially related to recurrent falls in this study. However, after adjustment for mobility impairment, the odds ratio for the relation between recurrent falls and activity level (table 1) indicated that the physical activity level was in close agreement with physical potential. Overactivity with respect to physical potential was not a risk factor for falls in this population.

Orthostatic hypotension was a significant risk factor for recurrent falls, and was mainly due to a decrease in systolic blood pressure after standing. Categorical analysis showed a slightly different pattern than the continuous fit. The number of participants decreased as the category deviated further from the reference category. Especially in the upper category (ΔSBP > 30 mmHg), only 17 participants were included, a situation that results in an inaccurate estimation of the true odds ratio.

The use of medication did not reveal a strong relation with falls or recurrent falls, in contrast to a number of other studies (1, 3, 6, 26). We measured this time-dependent covariate at baseline, while many other studies used a case-control design that ascertained medication use at the time of the fall. This may have led to misclassification and loss of precision in the analysis. Furthermore, study population characteristics may be responsible for the lack of association. In this very elderly institutionalized population, the relative contribution of medication use to the risk of falls was insignificant. All participants had been taking vitamin D3 or a placebo for a median period of approximately 2 years. There is some evidence that neuromuscular functioning deteriorates with vitamin D deficiency (27), which may increase the risk of falling. Vitamin D supplementation has been beneficial for muscle strength in patients with severe vitamin D deficiency (28), but not in an elderly population (29). In our study, vitamin D3 use did not help to prevent falls.

The risk profile indicated which risk factors were the strongest predictors of falls. To obtain more insight into the estimated probability of recurrent falls, we included specific combinations of risk factors in the calculation, i.e., in the sequence of their prevalence in the study population. The probability of recurrent falls ranged from 3 percent to 84 percent, which indicates a sensitive predictive model. Prediction of recurrent falls by falls occurring in the previous year was less sensitive (range, 11 percent–29 percent). A risk profile is only valid for specific populations, and this risk profile cannot automatically be applied to other populations. The risk profile for a younger, non-institutionalized population would probably be different from the profile constructed in this study. Moreover, the last category (figure 3) including all risk factors contained few participants, and should be regarded as an extrapolation of the results. This can be shown by
categorizing the estimated risk and selecting participants with an estimated risk of recurrent falls above the 90th percentile. Mean estimated risk for recurrent falls in the upper decile is 53 percent; the observed probability was 54 percent.

The results of our study show that elderly persons who have recurrent falls may be especially amenable to preventive strategies with regard to intrinsic risk factors. The relative efficacy of preventive strategies may depend on population characteristics, which can be illustrated by risk profiles. Mobility impairment was the strongest risk factor in this study and may be the easiest to change in a prevention program that includes exercise. Exercise may improve balance and muscle strength (30), and also may increase bone mineral density (31). Although recent studies have demonstrated the effectiveness of preventive strategies in averting falls (32, 33), the effectiveness of such strategies in the prevention of fractures remains to be established.

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REFERENCES