

## **Circumstances leading to injurious falls in older men and women in the Netherlands**

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## **Author contributions**

NvdV, EvL, KH, TvdC, PP, and EvB designed the study, obtained funding and recruited participating centres. NB, FMR, NvdV, KH, OdV, TvdC, AK, and MB supervised conduct of trial, screening of records, and collected data. NB, FMR, EvL, and EvB analyzed and interpreted data. NB drafted the manuscript, and all authors contributed substantially to its revision. All authors approved the final version of the manuscript.

## **ABSTRACT**

**Background:** Fall-induced injuries in persons aged 65 years and older are a major public health problem. Data regarding circumstances leading to specific injuries, such as traumatic brain injury (TBI) and hip fractures in older adults are scarce.

**Objective:** To investigate the activity distributions leading to indoor and outdoor falls requiring an Emergency Department (ED) visit, and those resulting in TBIs and hip fractures.

**Participants:** 5880 older adults who visited the ED due to a fall.

**Methods:** Data is descriptive and stratified by age and gender.

**Results:** Two-thirds of all falls occurred indoors. However, there were higher proportions of outdoor falls at ages 65-79 years (48%). Walking up or down stairs (51%) and housekeeping (17%) were the most common indoor activities leading to a TBIs. Walking (42%) and sitting or standing (16%) were the most common indoor activities leading to a hip fracture. The most common outdoor activities were walking (61% for TBIs and 57% for hip fractures) and cycling (10% for TBIs and 24% for hip fractures).

**Conclusion:** In the present study we found that the indoor activities distribution leading to TBIs and hip fractures differed. Notably, about half of the traumatic brain injuries and hip fractures in men and women aged 65-79 years occurred outdoors. This study provides new insights into patterns leading to injurious falls by age, gender and injury type, and may guide the targeting of falls prevention at specific activities and risk groups, including highly functional older men and women.

## INTRODUCTION

Falls affect approximately a third of the population aged 65 years and older, and are associated with major adverse consequences such as disability, loss of quality of life, institutionalization, and high morbidity and mortality rates<sup>1-8</sup>. Furthermore, falls place a substantial burden on healthcare systems due to the large amount of visits to emergency departments, hospital admissions, admissions to long-term care and rehabilitation facilities, and related healthcare costs<sup>3,4,7,9-11</sup> making falls prevention a public health priority<sup>12,13</sup>.

The most common injuries due to falls in the population aged 65 years and older in the Netherlands are superficial injuries, hip fractures, upper extremity fractures, and traumatic brain injury (TBI)<sup>10</sup>. Approximately 30% of people with a hip fracture will die within a year, and many more will experience significant functional loss<sup>2</sup>. Similarly, TBI is associated with serious consequences. Falls cause 61% of TBIs among persons aged 65 years and older in the United States<sup>14</sup>. Furthermore, recent studies in the United States<sup>14</sup>, the Netherlands<sup>15</sup>, and Finland<sup>16</sup> showed an increase in fall-related TBIs.

An important yet overlooked aspect regarding falls in the elderly is the paucity of evidence regarding patterns in the circumstances leading to injurious falls. Falls are the most important cause of TBIs and hip fractures in older adults, thus these patterns are valuable because they could highlight subgroups that may benefit from targeted falls prevention strategies<sup>2,15,17</sup>. However, data on circumstances leading to major consequences of falls in older adults, such as hip fractures and TBIs are scarce; and the number of events in the available studies is relatively low<sup>18-21</sup>.

In this study, we investigated the indoor and outdoor activities leading to injurious falls in a large number of older men and women who visited the Emergency Department (ED) after experiencing a fall.

## **METHODS**

### **Study population**

For the present study, screening data were extracted from the IMPROveFALL study<sup>22</sup>. The IMPROveFALL study is a randomized multicenter trial investigating the effect of withdrawal of fall-risk increasing drugs versus ‘care as usual’ on reducing falls in community-dwelling older men and women. Patients meeting the following criteria were screened for potential enrolment in the IMPROveFALL study: aged 65 years or older, visited the ED due to a fall. A fall was defined as coming to rest unintentionally on the ground or a lower level with or without losing consciousness, but not induced by acute medical conditions, *e.g.* stroke, or exogenous factors such as a traffic accident<sup>23</sup>. All patients meeting the screening criteria were included in the current study. Screening was performed at two academic and five regional hospitals in the Netherlands, all located in highly urbanized areas. Screening started in October 2008 and was completed in October 2011. The local Medical Research Ethics Committees at all participating sites approved the study.

### **Data collection**

Data regarding age, gender, dwelling, date of ED visit, location of fall, activity during fall, and injuries sustained were collected from ED records. Records were made by ED personnel, were free-form, and paper or electronic depending on the hospital. Records were collected and managed by the research nurse and research physician. ED personnel were not aware of specific data being collected from records, therefore, there was a fair amount of missing data. Regarding the location of the fall, 27% of the data were missing; and regarding activity prior to the fall, 34% of the data was missing. Data regarding hospital stay and hospital mortality were not collected.

Age was categorised as 65 to 79 years old or 80 years and older. Dwelling was categorised as community-dwelling or living in a care facility (assisted living facility or nursing home). Location at time of fall was categorised as indoors or outdoors. Activity at time of fall was categorised as walking, sitting or standing, walking up or down stairs, lavatory visit, sports and recreation, out of bed, housekeeping, cycling, or other. Season during which fall occurred was categorised as winter (December, January and February), spring (March, April and May), summer (June, July and August) , and autumn (September, October and November). Injuries were defined by the International Classification of Diseases 10<sup>th</sup> revision (ICD-10) <sup>24</sup> and categorised as superficial injury, open wound, head injuries (*i.e.*, superficial injury, open wound, skull/facial fracture, and TBI), and fractures (*i.e.*, spine, rib, shoulder and upper arm, elbow and forearm, wrist and hand, pelvis, hip, knee and lower leg, or ankle and foot). Activity distributions leading to indoor and outdoor falls were described separately for all falls, and for the two major fall-related injuries, *i.e.* TBIs and hip fractures.

## RESULTS

In total data of 5880 fall-related ED visits of persons aged 65 years and older were included in this study. The mean age was 80 years with a standard deviation of 8, and the study population consisted of 1824 (31%) men and 4056 (69%) women.

The overall gender and age specific circumstances surrounding a fall are shown in table 1. Data concerning dwelling was obtained from 5489 patients. Most patients were community-dwelling (n=4734, 86%), with 95% of both men and women aged 65-79 years, and 83% of the men and 75% of women aged  $\geq 80$  years being community-dwelling, the remaining were residing in a care facility. Data concerning location of the fall were obtained from 4279 patients. Most falls occurred indoors (n=2773, 65%). However, this differed between the age and gender categories; there were higher proportions of outdoor falls at ages 65-79 years (48%), and overall 41% of the men fell outdoors. Data concerning activity were obtained from 3871 participants. Overall, the most common activity at time of the fall was walking (n=1898, 49%). Other common activities were walking up or down stairs (n=409, 11%) and sitting / standing (n=371, 10%). Data concerning the season during which the fall occurred was obtained from all 5880 patients. Overall most falls occurred during summer (n=1802, 31%), 28% of men and 32% of women fell during summer. The least amount of falls occurred during autumn (22%) for men, and winter (21%) for women.

Of the ED records with missing data regarding either the location or activity at time of the fall, the mean age was 81 years with a standard deviation of 8, and the population consisted of 687 (27%) men, and 1822 (73%) women. Furthermore, 1819 (81%) were community-dwelling, and 421 (19%) resided in a care-facility.

The age and gender specific injuries following a fall are shown in table 2. Data concerning injury were collected from all 5880 patients. Falls caused superficial injury in



1951 patients (33%), open wounds in 461 (8%), TBIs in 254 (4%) and fractures in 2700 (46%) of the population. The most common fracture was a hip fracture (n=883, 15%).

### **All injurious falls**

The location and activity surrounding a fall requiring an ED visit was obtained from 3371 records and are shown in figure 1. The overall most common indoor activities were walking (n=658, 34%) and walking up or down stairs (n=322, 17%) [Figure 1 A, B]. The overall most common outdoor activities were walking (n=946, 66%) and cycling (n=200, 14%) [Figure 1 C, D].

### **Traumatic brain injury**

Overall, 254 falls resulted in a TBI. The location and activity surrounding a fall leading to a TBI was obtained from 176 records and are shown in figure 2. Falls resulting in TBIs had a similar indoor (n=92, 52%) and outdoor (n=84, 48%) prevalence. The most common indoor activities were walking up or down stairs (n=47, 51%) and housekeeping (n=16, 17%) [Figure 2 A, B]. The most common outdoor activities were walking (n=51, 61%) and cycling (n=8, 10%) [Figure 2 C, D].

### **Hip fractures**

Overall, 883 falls resulted in a hip fracture. The location and activity surrounding a fall leading to a hip fracture was obtained from 468 records and are shown in figure 3. A fall resulting in a hip fracture most commonly occurred indoors (n=341, 73%) except for the men aged 65-79 years, in whom hip fractures most commonly occurred outdoors (n=33, 54%). The most common indoor activities were walking (n=144, 42%) and sitting or standing (n=55,

16%) [Figure 3 A, B]. The most common outdoor activities were walking (n=72, 57%) and cycling (n=30, 24%) [Figure 3 C, D].

### **Falls by season**

The season, location and activity surrounding a fall requiring an ED visit was obtained from 3371 records and are shown in supplementary figure X. The most common indoor activities surrounding a fall during winter were walking (n=123, 33%) and walking up or down stairs (n=65, 18%). The most common outdoor activities surrounding a fall during winter were walking (n=300, 77%) and cycling (n=37, 10%). The most common indoor activities during spring were walking (n=160, 33%) and walking up or down stairs (n=79, 16%) and housekeeping (n=79, 16%). The most common outdoor activities during spring were walking (n=224, 64%) and cycling (n=44, 13%). The most common indoor activities during summer were walking (n=192, 33%) and walking up or down stairs (n=100, 17%). The most common outdoor activities during summer were walking (n=227, 59%) and cycling (n=84, 22%). The most common indoor activities during autumn were walking (n=183, 36%) and housekeeping (n=87, 17%). The most common outdoor activities during autumn were walking (n=195, 65%) and cycling (n=35, 12%).

## DISCUSSION

In this study two-thirds of all falls occurred indoors. However, this differed between the age and gender categories, with higher proportions of outdoor falls at ages 65-79 years and among men. The overall most common indoor activities leading to injurious falls were walking and walking up or down stairs. The overall most common outdoor activities were walking and cycling. We found that the indoor activities leading to major injuries, *i.e.* TBIs and hip fractures differed. Walking up or down stairs and housekeeping were the most common activities leading to a TBIs whereas walking and sitting / standing were the most common activities leading to a hip fracture. Notably, about half of the traumatic brain injuries and hip fractures in men and women aged 65-79 years occurred outdoors. The most common outdoor activities leading to both injuries were walking and cycling. To our knowledge this is the largest study investigating patterns leading to fall-related TBIs and hip fractures in community dwelling older adults.

Falls are the leading cause of TBIs and hip fractures in the elderly population <sup>4,15,17</sup>. Falls cause 61% of traumatic brain injuries in persons aged 65 years and older in the US <sup>17</sup>, and recent studies in the US, the Netherlands, and Finland showed an increase in fall-related TBIs <sup>15-17</sup>. About 30% of people with a hip fracture will die in the following year, and many more will experience significant functional loss <sup>2</sup>. Furthermore, TBIs and hip fractures contribute considerably to healthcare costs <sup>4</sup>. Therefore, interventions targeted toward this group have the potential to be very (cost-) effective. The two most common indoor activities leading to a TBI were walking up or down stairs and housekeeping. Furthermore, about half of the hip fractures in men and women aged 65-79 years occurred outdoors, and approximately a third of those while cycling. These all suggest high activity levels. Up to now, little to no special attention has been paid to outdoor activities such as cycling and

'higher level' activities such as housekeeping. Few have incorporated strategies for falls prevention derived from these specific circumstances. Partly, this can be accomplished by education of the risk groups. Healthy and highly functional older adults may be unaware that their higher activity levels may increase their risk for falling and subsequent injuries<sup>25</sup>. Another possibility is the elimination of outdoor environmental hazards involving sidewalks, curbs, and streets, such as by promptly repairing uneven surfaces, removing debris, and painting curbs<sup>26,27</sup>. Furthermore, promotion of measures which can reduce the severity of injuries following a fall, such as bicycle helmets, should also be considered<sup>28</sup>.

It should be noted that in the Netherlands about 27% of all travel is done by bicycle. As a consequence, the data presented is more relevant in countries where cycling is common. Other western countries where cycling is a common mode of transportation are, Denmark (18% of all travel), Finland (11%), Germany (10%), and Sweden (10%)<sup>29</sup>. Whereas in the United States and the United Kingdom only 1% of all trips are by bicycle<sup>29</sup>.

In this study, most falls occurred during summer (31%), and the least during winter (21%), this differed from other studies<sup>30-32</sup>, where most falls occurred during winter, and a recent study which showed seasons had no effect on fall rates<sup>33</sup>. Possibly more falls occurred during summer due to people being more active during the warm summer months compared to winter. Furthermore, snow and ice might not have been a major factor as in previous studies, due to the relatively mild winters in urban areas of the Netherlands. The most common indoor and outdoor activities leading to a fall during the four seasons were similar, noteworthy were the rates for walking outdoors during winter (77%), and cycling outdoors during summer (22%).

Various studies have investigated circumstances surrounding falls in older adults<sup>25-27,34-45</sup>. However, these studies investigated falls in general and not falls resulting in major injuries. Furthermore, the study population of two of the latest studies consisted of older

adults dwelling in care-facilities, an older and frailer population, in which the majority of falls occurred indoors<sup>33,44</sup>. Two recent studies suggest that different types of fall-risk assessment are needed for indoor and outdoor fallers. And propose that, prevention recommendations would be more effective if targeted differently for frail, inactive older people at risk for indoor falls and relatively active healthy older people at risk for outdoor falls<sup>41,42</sup>.

The following limitations should be acknowledged when interpreting the results of this study. First, all data were gathered from ED records, we did not include persons who visited a general practitioner or persons who did not seek medical attention after a fall. Therefore, this is not a report on circumstances surrounding all falls in older adults. Nevertheless, our objective was to investigate falls resulting in injuries, not falls in general. Second, the Netherlands has more bicyclists and pedestrians than most Western countries, reducing the generalizability. Third, part of the data regarding either the location or the activity at time of fall was missing from ED records, which may have introduced bias into the results. Overall, the patient characteristics of the missing records differed slightly regarding age, gender and dwelling. However, the most significant difference was the hospital where data was gathered, possibly due to differences in recordkeeping methods. Furthermore, these results are otherwise scarce and remain valuable, especially for the subgroup of older men and women with 'higher level' activities. Strengths of this study include the study population size, and that data was collected from ED records and thus included detailed information concerning injuries sustained.

In conclusion, in the present study we found distinct fall and injury patterns, *i.e.* where and how, leading to TBIs and hip fractures in older men and women. Notably, about half of the traumatic brain injuries and hip fractures in men and women aged 65-79 years occurred outdoors. This study provides new insights into patterns leading to injurious falls by age,

gender and injury type, and may guide the targeting of falls prevention at specific activities and risk groups, including highly functional older men and women.

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### **Conflict of Interest Statement**

The authors declare no conflict of interest.

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**Table 1.** Circumstances surrounding injurious falls stratified by gender and age

|                           | Total     | Men       |          |           | Women     |           |           |
|---------------------------|-----------|-----------|----------|-----------|-----------|-----------|-----------|
|                           |           | 65-79y    | ≥ 80y    | Total     | 65-79y    | ≥ 80y     | Total     |
|                           | n = 5880  | n = 1095  | n = 729  | n = 1824  | n = 1851  | n = 2205  | n = 4056  |
| <b>Dwelling</b>           | n = 5489  | n = 1065  | n = 673  | n = 1738  | n = 1753  | n = 1998  | n = 3751  |
| Community                 | 4734 (86) | 1013 (95) | 561 (83) | 1574 (91) | 1663 (95) | 1497 (75) | 3160 (84) |
| Care facility             | 755 (14)  | 52 (5)    | 112 (17) | 164 (9)   | 90 (5)    | 501 (25)  | 591 (16)  |
| <b>Location</b>           | n = 4279  | n = 815   | n = 562  | n = 1377  | n = 1306  | n = 1596  | n = 2902  |
| Indoor                    | 2773 (65) | 428 (53)  | 390 (69) | 818 (59)  | 673 (52)  | 1282 (80) | 1955 (67) |
| Outdoor                   | 1506 (35) | 387 (48)  | 172 (31) | 559 (41)  | 633 (48)  | 314 (20)  | 947 (33)  |
| <b>Activity</b>           | n = 3871  | n = 818   | n = 472  | n = 1290  | n = 1302  | n = 1279  | n = 2581  |
| Walking                   | 1898 (49) | 314 (38)  | 232 (49) | 546 (42)  | 690 (53)  | 662 (52)  | 1352 (52) |
| Sitting & Standing        | 371 (10)  | 63 (8)    | 56 (12)  | 119 (9)   | 90 (7)    | 162 (13)  | 252 (10)  |
| Walking up or down stairs | 409 (11)  | 142 (17)  | 45 (10)  | 187 (15)  | 142 (11)  | 80 (6)    | 222 (9)   |
| Lavatory visit            | 161 (4)   | 22 (3)    | 21 (4)   | 43 (3)    | 42 (3)    | 76 (6)    | 118 (5)   |
| Sports & Recreation       | 51 (1)    | 21 (3)    | 3 (1)    | 24 (2)    | 20 (2)    | 7 (1)     | 27 (1)    |
| Out of bed                | 107 (3)   | 15 (2)    | 18 (4)   | 33 (3)    | 19 (2)    | 55 (4)    | 74 (3)    |
| Housekeeping              | 331 (9)   | 85 (10)   | 38 (8)   | 123 (10)  | 88 (7)    | 120 (9)   | 208 (8)   |
| Cycling                   | 200 (5)   | 74 (9)    | 13 (3)   | 87 (7)    | 88 (7)    | 25 (2)    | 113 (4)   |
| Other                     | 343 (9)   | 82 (10)   | 46 (10)  | 128 (10)  | 123 (9)   | 92 (7)    | 215 (8)   |
| <b>Season</b>             | n = 5880  | n = 1095  | n = 729  | n = 1824  | n = 1851  | n = 2205  | n = 4056  |
| Winter                    | 1258 (21) | 265 (24)  | 160 (22) | 425 (23)  | 437 (24)  | 396 (18)  | 833 (21)  |
| Spring                    | 1472 (25) | 292 (27)  | 194 (27) | 486 (27)  | 448 (24)  | 538 (24)  | 986 (24)  |
| Summer                    | 1802 (31) | 306 (28)  | 201 (28) | 507 (28)  | 549 (30)  | 746 (34)  | 1295 (32) |
| Autumn                    | 1348 (23) | 232 (21)  | 174 (24) | 406 (22)  | 417 (23)  | 525 (24)  | 942 (23)  |

Data are given as number (percentages).

**Table 2.** Injuries following a fall stratified by gender and age

|                             | Total     | Men      |          |          | Women    |           |           |
|-----------------------------|-----------|----------|----------|----------|----------|-----------|-----------|
|                             |           | 65-79y   | ≥ 80y    | Total    | 65-79y   | ≥ 80y     | Total     |
|                             | n = 5880  | n = 1095 | n = 729  | n = 1824 | n = 1851 | n = 2205  | n = 4056  |
| <b>Superficial injury</b>   | 1951 (33) | 385 (35) | 244 (34) | 629 (35) | 603 (33) | 719 (33)  | 1322 (33) |
| <b>Open wound</b>           | 461 (8)   | 103 (9)  | 96 (13)  | 199 (11) | 109 (6)  | 153 (7)   | 262 (7)   |
| <b>Injuries to the head</b> |           |          |          |          |          |           |           |
| SI head                     | 629 (11)  | 150 (14) | 97 (13)  | 247 (14) | 160 (9)  | 222 (10)  | 382 (9)   |
| Open wound of head          | 289 (5)   | 69 (6)   | 74 (10)  | 143 (8)  | 66 (4)   | 79 (4)    | 145 (4)   |
| Skull/facial fracture       | 82 (1)    | 19 (2)   | 8 (1)    | 27 (2)   | 26 (1)   | 29 (1)    | 55 (1)    |
| Traumatic brain injury      | 254 (4)   | 81 (7)   | 42 (6)   | 123 (7)  | 67 (4)   | 64 (3)    | 131 (3)   |
| <b>Fractures</b>            |           |          |          |          |          |           |           |
| <i>All fractures</i>        | 2700 (46) | 349 (32) | 274 (38) | 623 (34) | 929 (50) | 1148 (52) | 2077 (51) |
| Spine                       | 127 (2)   | 24 (2)   | 12 (2)   | 36 (2)   | 37 (2)   | 54 (2)    | 91 (2)    |
| Rib                         | 92 (2)    | 35 (3)   | 14 (2)   | 49 (3)   | 13 (1)   | 30 (1)    | 43 (1)    |
| Shoulder and upper arm      | 400 (7)   | 53 (5)   | 38 (5)   | 91 (5)   | 160 (9)  | 149 (7)   | 309 (8)   |
| Elbow and forearm           | 517 (9)   | 57 (5)   | 19 (3)   | 76 (4)   | 248 (13) | 193 (9)   | 441 (11)  |
| Wrist and hand              | 289 (5)   | 42 (4)   | 20 (3)   | 62 (3)   | 139 (8)  | 88 (4)    | 227 (6)   |
| Pelvis                      | 133 (2)   | 9 (1)    | 10 (1)   | 19 (1)   | 33 (2)   | 81 (4)    | 114 (3)   |
| Hip                         | 883 (15)  | 86 (8)   | 143 (20) | 229 (13) | 170 (9)  | 484 (22)  | 654 (16)  |
| Knee and lower leg          | 106 (2)   | 15 (1)   | 9 (1)    | 24 (1)   | 43 (2)   | 39 (2)    | 82 (2)    |
| Ankle and foot              | 174 (3)   | 22 (2)   | 9 (1)    | 31 (2)   | 93 (5)   | 50 (2)    | 143 (4)   |

Data are given as number (percentages). SI: superficial injury.

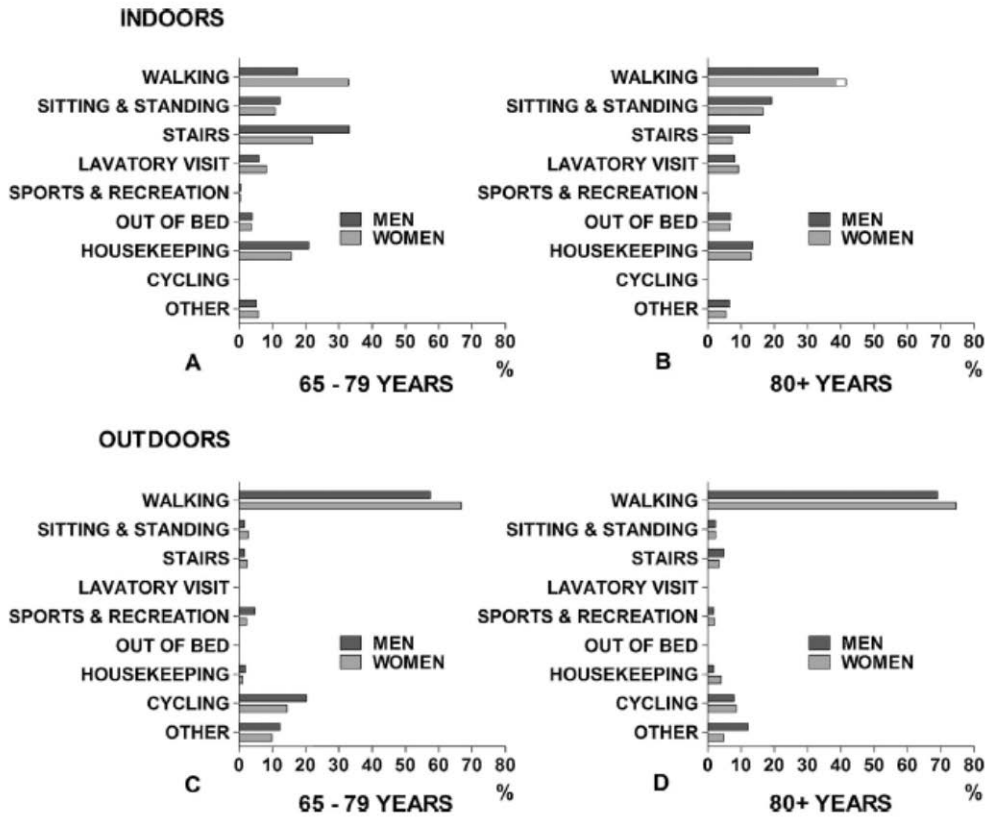
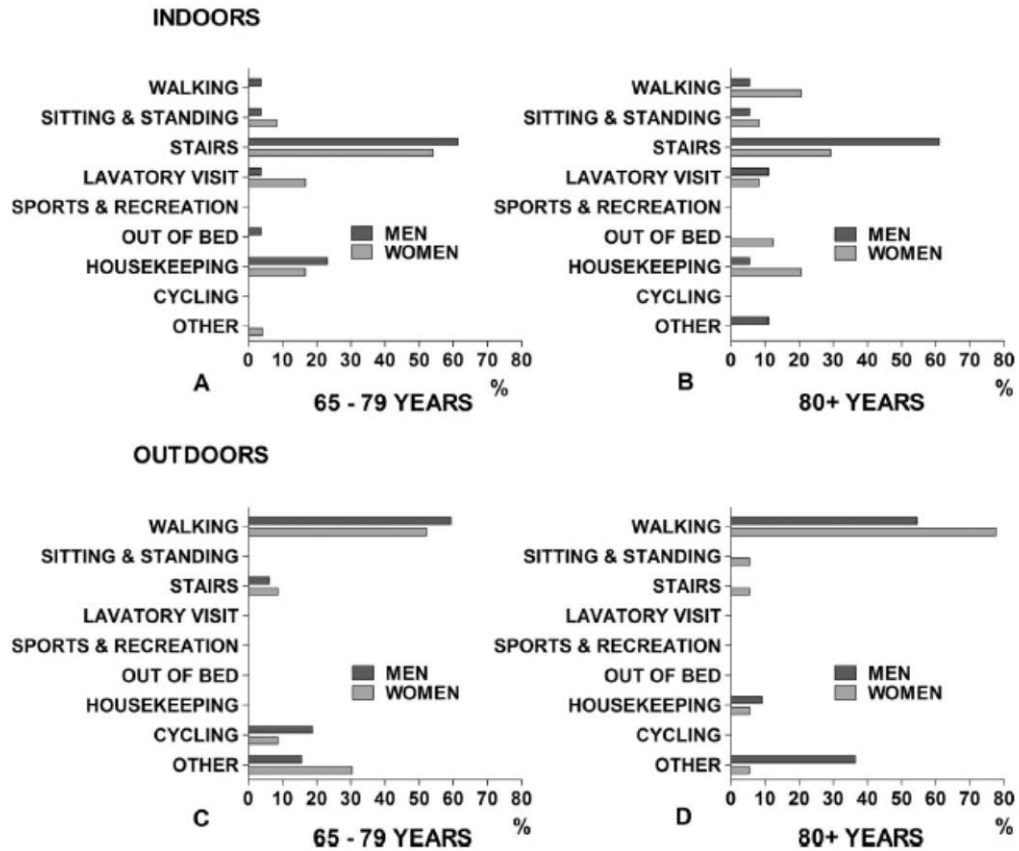
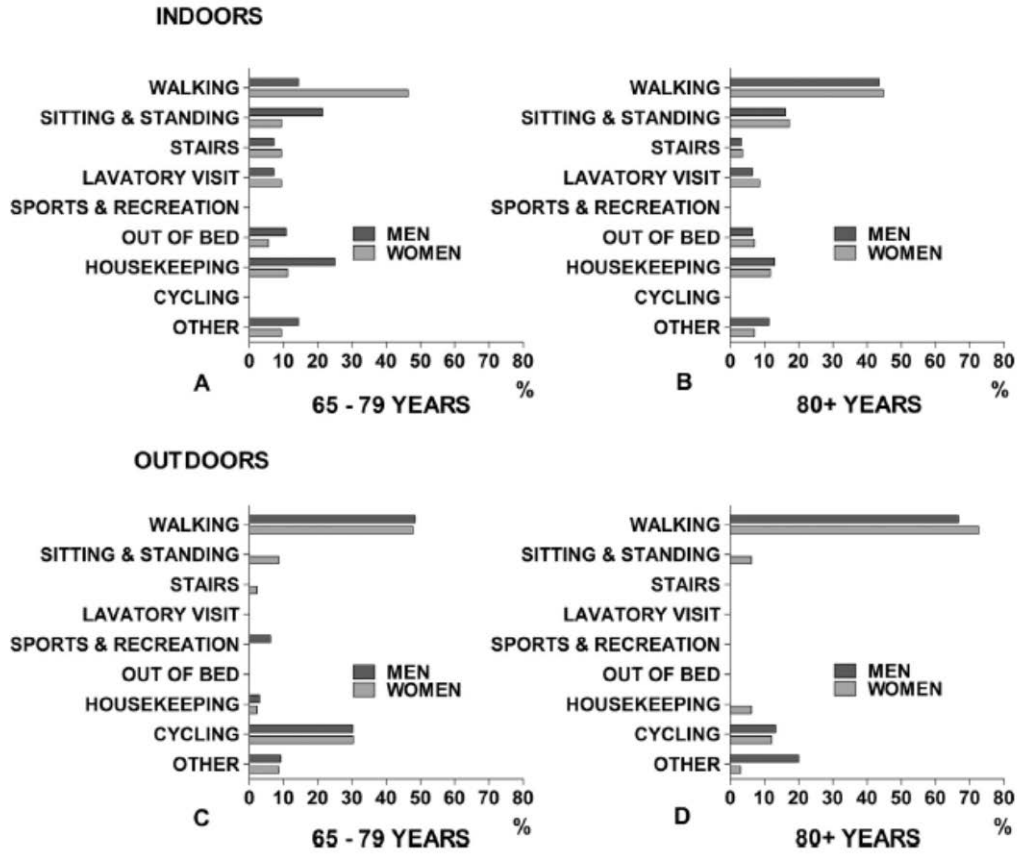


Fig. 1. Circumstances leading to all injurious falls, stratified by age and gender. Indoor (A and B) and outdoor (C and D) activities leading to a fall requiring an emergency department visit, stratified by the age categories 65–79 years (A and C) and 80+ years (B and D). Data are shown in percentages.





**Fig. 2.** Circumstances surrounding falls leading to traumatic brain injury, stratified by age and gender. Indoor (A and B) and outdoor (C and D) activities leading to a traumatic brain injury, stratified by the age categories 65–79 years (A and C) and 80+ years (B and D). Data are shown in percentages.



**Fig. 3.** Circumstances surrounding falls leading to a hip fracture, stratified by age and gender. Indoor (A and B) and outdoor (C and D) activities leading to a hip fracture, stratified by the age categories 65–79 years (A and C) and 80+ years (B and D). Data are shown in percentages.

**SUPPLEMENTARY**

**Figure X.** Circumstances surrounding all falls, stratified by location and season.

Activities leading to a fall stratified by the seasons, winter (A), spring (B), summer (C), autumn (D), and location (indoor and outdoor). Data are shown in percentages.

