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# **Mobility Limitations and Cognitive Deficits as Predictors of Institutionalization among Community-Dwelling Older People**

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**Short title:** Co-occurring limitations and risk for institutionalization

**Key words:** mobility limitations, cognitive deficits, institutionalization, older people

## **Mobility Limitations and Cognitive Deficits as Predictors of Institutionalization among Community-Dwelling Older People**

### **ABSTRACT**

**Purpose.** Mobility limitations and cognitive disorders have often been observed as risks for institutionalization. However, their combined effects on risk of institutionalization among initially community-dwelling older people have been less reported.

**Design.** A prospective cohort study with 10-year surveillance on institutionalization.

**Subjects.** Study population (n= 476) consisted of 75- and 80-year-old people who were community-dwelling, had not been diagnosed with dementia, and participated in tests on walking speed and cognitive capacity at a research centre.

**Measures.** Cognitive capacity was measured with three validated psychometric tests that were from the Wechsler Adult Intelligence Scale, Wechsler Memory Scale and Schaie-Thurstone Adult Mental Abilities Test. Mobility was measured with walking speed over a 10 meter distance. Exclusive distribution based study groups were formed with cut-offs at the lowest third as follows: no limitation, solely mobility limitation, solely cognitive deficits, and combined mobility limitation and cognitive deficits. Cox proportional hazards model was used to determine the relative risks of institutionalization for the study groups.

**Results.** Eleven percent of the participants were institutionalized during the 10-year surveillance. The risk for institutionalization was 4.9 times greater (95 % confidence interval 2.1-11.2) for those who had co-existing mobility limitations and cognitive deficits than for those with no limitations.

**Conclusions.** The findings show that the accumulation of limitations in physical and cognitive performance substantially decrease the possibility for a person remaining at home. This might be due to a decreased reserve capacity and ineffective compensatory strategies. Therefore, interventions targeted to improve even one limitation or prevent accumulation of these risk factors could significantly reduce the risk of institutionalization.

## **INTRODUCTION**

Previous longitudinal research has identified several predictors of institutionalization for community-dwelling older persons. Some of the most frequently reported predictors are a greater age, [1] lower cognitive function and dementia [2-4], lower ADL or physical functioning [4-6], female gender [7], not being married or living alone [8], absence of informal or formal caregiver [9-10] and a higher number of illnesses and injuries [1,11].

The theoretical model of the disablement process [12] suggests that impairments lead via functional limitations to subsequent disability, which adds to the risk of institutionalization [13]. Mobility limitations increase the risk of institutionalization and other adverse outcomes for older persons [14-15]. In addition, cognitive disorders, such as mild cognitive impairment and dementia, have been shown to be strong predictors of institutionalization among older persons [2, 6]. Moreover, older people often tend to suffer from multiple impairments and limitations simultaneously, all of which increase the risk of institutional care. However, the combined effects of co-occurring impairments and limitations on institutionalization have not been studied to our knowledge. This prospective study examined the combined effects of mobility and cognitive capacity on the risk of institutionalization among initially community-dwelling 75- and 80-year-old people over a 10-year surveillance period.

## **METHODS**

The data come from a prospective cohort study called the Evergreen project described in detail elsewhere [16]. Target population, 617 persons, consisted of two whole birth-year cohorts (1914 and 1910) who were at baseline 75- and 80-year-old residents of the City of Jyväskylä, Finland. The current study population consisted of those 476 community-dwelling residents who participated in tests at the research centre and did not have a diagnosis of dementia. The 203 persons not included in the study population were either already institutionalized (n=21), did not come to the research centre (n= 180), or had a diagnosis of dementia (n= 2). They belonged more frequently to the older age cohort (50 % vs. 40 %, p=0.031) and had more long-term diseases (3.2, SD 1.5 vs. 2.5, SD 1.6, p=0.003) compared to the study population.

The outcome of this study was institutionalization. The date of institutionalization was the date when care in a hospital or nursing home staffed around the clock had exceeded 90 days and the subject was in need of continuous care. Dates of permanent institutionalization decisions were collected from local registers. Non-institutionalized participants were included in the analysis until the date of their death or the end of the surveillance period, whichever occurred first. Dates on deaths that occurred during the surveillance period were obtained from the national Population Register Centre. Recordings of institutionalizations and deaths covered the period between January 1, 1989, and December 31, 2000. The study was granted permission from the Ethical committee of Central Finland Health Care District. Each participant signed an informed consent.

At baseline, mobility limitation was assessed using a maximal walking speed test over a 10 meter distance timed with a stop-watch [17]. Participants were allowed 2-3 meters acceleration before

the start-line. They were encouraged to walk as fast as possible without risking their health and were allowed to use normal walking aids when necessary.

Cognitive capacity was evaluated with a battery of psychometric tests including 1) Digit Span from Wechsler Memory Scale [18] for testing short-term memory, 2) Digit Symbol from Wechsler Adult Intelligence Scale (WAIS) [19] for testing psychomotor speed affected by visual perception and learning, and 3) a modified oral version of Word Fluency from Schaie-Thurstone Adult Mental Abilities Test [20] for testing verbal fluency and flexibility. Psychometric tests were performed at the research centre by trained psychologists. For statistical analysis, a principal component was formed from the above mentioned three tests indicating cognitive capacity. The first principal component explained 65.4 % of the total variance and was selected for the analysis.

Age- and gender-specific distribution-based cut-off values were used to categorize participants into groups with impaired or normal function. The lowest third of each distribution was classified as having mobility limitations or cognitive deficits. Cut-offs for maximal walking speed for 75-year-old men and women were 1.59 and 1.26 m/s and for 80-year-old men and women 1.38 and 1.19 m/s, respectively. Our cut-offs are in line with those of Shinkai et al. [21] who divided their community-dwelling study participants into quartiles with 1.34 m/s and 1.08 m/s as cut-offs for the lowest quartile for over 75-year-old men and women, respectively. The cognitive capacity principal component was dichotomized into the lowest third vs. middle and highest thirds. Accordingly, four exclusive study groups were formed indicating 1) no limitation, 2) mobility limitation, 3) cognitive deficits, and 4) mobility limitation and cognitive deficits.

Potential confounders selected based on previous research findings included full-time education (6 years or less vs. more than 6 years) and living alone (yes/no). Comorbidity was indicated by

the number of long-term diseases at baseline. Information was collected in face-to-face interviews conducted at participants' homes. Participants underwent a half-hour physician consultation at the research centre where self-reported long-term diseases and medication were confirmed and a physical examination was performed. In the comorbidity index, the sum of all diagnoses of long-term conditions which had lasted over three months was calculated and dichotomized for the analysis (2 or less vs. 3 or more).

## **STATISTICAL ANALYSIS**

Comparisons between those who were institutionalized, who survived without being institutionalized and those who died without first being institutionalized were performed with cross-tabulation  $\chi^2$ -testing for dichotomous variables and with one-way analysis of variance for continuous variables. The institutionalization rates were calculated by dividing the number of institutionalizations by the number of person-years of follow-up. Relative risk of institutionalization was estimated using Cox proportional hazards models. Risk ratios and 95 % confidence intervals were estimated for each variable that was entered into the model with  $p < .10$ .



## RESULTS

The mean duration of the follow-up was 2728 days with a range of 58 to 4017 days. At the end of the 10-year surveillance period, of the 476 participants who were community-dwelling at baseline, 52 persons had been institutionalized, 209 remained community-dwelling and 215 had died without prior institutionalization.

Demographic and health characteristics of those who during the surveillance period remained community-dwelling, were institutionalized or died without institutionalization first are presented in Table 1. Almost 80 % of the institutionalized persons were women, while the corresponding number was 70 % for those who remained community-dwelling and 60 % for those who died without prior institutionalization. At baseline, about 60 % of those who stayed community-dwelling throughout the surveillance had three or more long-term diseases whereas the corresponding number was about 70 % for those who were institutionalized and more than 80 % for those who died. Those who remained community-dwelling had the highest average walking speed and those who died during the surveillance the slowest while those who were admitted to an institution were in the middle. For cognitive capacity, poorest baseline scores were observed among those who were later institutionalized and highest for those who survived and were still community-dwelling at the end of follow-up.

The institutionalization rate was 24.4/1000 person-years among those in the lowest third of walking speed and 10.1/1000 persons-years for those in the middle and highest thirds. For cognitive capacity principal score the corresponding figures were 21.0/1000 and 11.0/1000 person-years, respectively. To study the combined effects of mobility limitations and cognitive deficits, four exclusive study groups were formed. Institutionalization rate among those with both mobility limitations and cognitive deficits was 35.1/1000 persons-years, whereas the rate

among those with solely mobility limitation was 15.6/1000 and solely cognitive deficits 10.0/1000 person-years. The number of institutionalization cases and rates are presented in Figure 1.

Cox proportional hazards model was employed for estimating the relative risks of institutionalization. First, walking speed and cognitive capacity were entered into the model as independent variables as presented in Table 2. The crude risk for institutionalization was 2.55 (95 % confidence interval [CI] 1.45-4.49) higher for those in the lowest third of the dichotomized walking speed variable and 1.94 (95 % CI 1.11-4.00) higher for those in the lowest third of cognitive capacity variable compared to those in the middle and highest thirds, respectively. A significant interaction between the variables ( $p < 0.001$ ) was observed. Secondly, the combined effects of mobility and cognitive capacity were tested. The unadjusted relative risk of institutionalization was 3.80 times greater (95 % CI 1.85-7.77) among people with co-occurring mobility limitation and cognitive deficits compared to people with no limitations. Adjusting the model for education, living alone and comorbidity increased the risk to 4.89 (95 % CI 2.14-11.17). In this combined effects model, having solely mobility limitations or solely cognitive deficits increased the risk of institutionalization slightly but failed to reach statistical significance due to the small number of cases in the respective groups.

## **DISCUSSION**

Results of this study show that the presence of co-existing mobility limitations and cognitive deficits places older persons at a significantly higher risk for institutionalization compared to persons with no limitations or only a single limitation. The relative risk for institutionalization regarding combined mobility limitations and cognitive deficits was almost five-fold compared to those with no limitations.

Population-based studies have identified cognitive decline [2-4] and physical impairments [14] in non-demented populations as independent risk factors for institutionalization. However, previous research has not, to the best of our knowledge, addressed multiple co-existing limitations and impairments as predictors of institutionalization among older populations.

A sufficient mobility ability [22] and cognitive status [6] are prerequisites for independent community-dwelling. Moving about at home and its surroundings is essential for self-care and for maintaining a socially engaged lifestyle. Performing Instrumental Activities of Daily Living (IADLs) such as shopping and preparing food, and engaging in meaningful social interaction requires a sufficient cognitive capacity level. Moreover, physiologic [23] and cognitive reserves [24] help older persons withstand the deterioration of functional abilities which, upon depletion, might result in adverse health outcomes such as institutional care. In our study, it is most likely that persons who were classified at baseline into the highest and middle third in mobility and cognitive capacity had greater reserve capacity than those in the lowest thirds. Further, a person with decreased physical reserve capacity is more vulnerable to acute insults [23]. For instance, a person with substantial physiologic reserve would presumably be able to withstand the strain of for example an acute respiratory infection without losing functional independence or otherwise compensate for potential losses [25] with that reserve and thus avoid loss of independence.

Similarly, it is probable that many of those in the lowest third of cognitive capacity had a substantially decreased cognitive reserve. Consequently, it is possible that they already suffered from mild cognitive impairment or preclinical dementia and thus had an increased risk of manifest dementia and subsequent dependence. Unfortunately, we do not know the immediate precipitating events of institutionalization for our participants and thus cannot confirm their underlying situation. In addition to individual resources, environmental and social elements such as availability of caregivers contribute to the need for institutional care. However, we adjusted our model with living alone and thus were able to control for social elements, at least to some extent.

In the study, co-occurrence of slow walking speed and cognitive deficits was higher than expected by chance only, Kappa coefficient 0.173,  $p < 0.001$ . Furthermore, there is a growing body of evidence linking physical and cognitive decline [26-28], suggesting that they might share the same etiology or be causally related to each other so that one of the limitations precedes the other. A recent study found smoking and lower haemoglobin levels to be associated with combined physical and cognitive decline [28]. Decline in cognitive performance has been associated with decline in physical tasks such as walking at normal speed. Thus indicating that patterns of change in cognitive and physical performance are interrelated and that cognition plays a significant role in the execution of physical tasks [26]. On the other hand, inability to maintain a socially active lifestyle due to physical disability may accelerate cognitive decline [27]. In our study the causal nature of mobility limitations and cognitive decline cannot be determined.

The risk for institutionalization for persons with co-existing mobility limitations and cognitive decline increased in our study after adjusting for the comorbidity index. This may be related to the fact that problems inflicted by chronic diseases are often expressed through functional

difficulties which, in turn, predict development of disability [29] and subsequent loss of independence.

This population-based prospective study had a long surveillance period. As studies often rely on self-reported data or estimations of institutional care [4], the use of local registers with exact dates on institutionalization is a definite advantage of our study. Another strong point of the study was the use of a performance-based measure, walking speed, for assessing physical function [15] instead of self-rated measures, which might yield biased information. In addition, psychometric tests indicating cognitive capacity were performed by trained psychologists.

In the study, we used distribution based cut-off values for walking speed and cognitive capacity, given that there is lack of 'golden standards' for cut-off points. We used maximal walking speed to measure mobility limitations [15]. Our age- and gender-specific cut-offs, 1.59-1.19 m/s, are similar to those who use maximal walking speed as an indicator of functional capacity [21] but obviously higher than for example shown in a recent study [30], which measured usual walking speed instead of maximal speed. In our study, cognitive capacity was measured with three psychometric tests [18-20]. At 5-year follow-up among 80- and 85-year-old people, in addition to the psychometric tests used here the Mini-Mental State Examination MMSE test [31], a widely used test for screening people at increased risk of dementia, was done. A significant correlation was found,  $r=0.513$ ,  $p<0.001$ . Further, an effort was made to test the validity of cut-offs for the principal component indicating cognitive capacity. The cognitive capacity principal component and MMSE scores were dichotomized into the lowest third vs. middle and highest thirds. The cut-off values on the MMSE were 25 and 24 for the 80- and 85-year-olds, respectively [31]. The reliability for the dichotomized cognitive capacity principal component and MMSE was found to be moderate with a Kappa coefficient of 0.395,  $p<0.001$ . We thus

conclude that a substantial proportion of people in the cognitive deficits category could have been defined as having mild cognitive impairment or preclinical dementia.

Our study included persons who were community-dwelling, did not have a diagnosis of dementia and were able to come to the research centre for an entire day and participate in multiple physical and psychometric tests. Twenty three percent of the target group did not come to the research centre for testing and consequently, it is more likely that persons with poor mobility and/or cognitive decline dropped out rather than persons with no limitations. We performed basic analysis on non-participants and found them to be older and have a higher comorbidity index than our participants, which lends support to our assumption. Consequently, the present study might have underestimated the risk of institutionalization at population level, which should be considered when interpreting our results. Even though our study was relatively small scale it nevertheless had a long surveillance period and provides new information on co-existing risk factors for institutionalization.

In conclusion, results show that co-existing decline in physical and cognitive status poses a significant risk for institutionalization. On the other hand, it should be noted that a decision for institutionalization is not just a result of the functional status and individual qualities but, to some extent, also a social decision reflecting current policies and available resources [4]. At the moment, interventions for reducing or postponing adverse outcomes such as institutionalization should target modifiable risk factors, such as physical limitations. Consequently, our results indicate that interventions targeted to improve even one limitation or prevent accumulation of these risk factors could significantly reduce the risk of institutionalization.

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Table 1. Baseline characteristics of those who at the end of the follow-up were community-dwelling, institutionalized and those who died during the surveillance without first being institutionalized

	<u>Community-dwelling (1)</u>		<u>Institutionalized (2)</u>		<u>Died (3)</u>		P-value *			
	(n=209)		(n=52)		(n=215)					
	%		%		%					
Women	72		79		60		0.005			
80-year-olds	32		29		51		<0.001			
≥3 long-term diseases	60		69		83		<0.001			
Living alone	58		52		46		0.040			
≤6 years of education	71		68		72		0.811			
	Mean	SD	Mean	SD	Mean	SD	P-value †	Groups ‡		
								1,2	1,3	2,3
Cognitive capacity										
Digit Span, score	9.2	1.5	8.8	1.7	9.2	1.7	0.193	0.317	1.000	0.245
Digit Symbol, score	23.6	10.1	16.7	10.0	19.0	8.1	<0.001	<0.001	<0.001	0.363
Word Fluency, score	30.5	12.1	25.9	12.6	27.4	1.2	0.008	0.040	0.031	1.000
Principal Component, score	0.28	0.95	-0.29	1.05	-0.01	0.87	<0.001	<0.001	0.006	0.176
Walking speed, m/s	1.64	0.40	1.45	0.44	1.38	0.45	<0.001	0.018	<0.001	1.000
BMI	27.0	3.8	27.4	4.6	26.6	4.6	0.362	1.000	0.968	0.762

\*  $\chi^2$ -test.

† Based on one-way ANOVA F-test score.

‡ Paired comparisons with Bonferroni's test for homogenous and Tamhane's test for non-homogenous variances.

Table 2. Relative risks (RR) and 95 % confidence intervals (CI) of long-term care according to baseline mobility and cognitive capacity

	Model 1. Walking Speed		Model 2. Cognitive Capacity		Model 3. Walking Speed and Cognitive Capacity Unadjusted		Model 4. Walking Speed and Cognitive Capacity Adjusted*	
	RR	95 % CI	RR	95 % CI	RR	95 % CI	RR	95 % CI
Mobility limitation†	2.55	1.45-4.49						
Cognitive deficits ‡			1.94	1.11-4.00				
No limitation§					1		1	
Mobility limitation§					1.69	0.73-3.90	1.93	0.82-4.57
Cognitive deficits §					1.02	0.43-2.45	1.25	0.50-3.13
Mobility limitation and cognitive deficits §					3.80	1.85-7.77	4.89	2.14-11.17

\* Adjusted for education, living alone and co-morbidity.

†Lowest third of walking speed vs. middle and highest third.

‡ Lowest third of cognitive capacity principal component score vs. middle and highest third.

§Groups formed based on walking speed and cognitive capacity tests dichotomized according to distribution based cut-offs at the lowest third vs. middle and highest third.

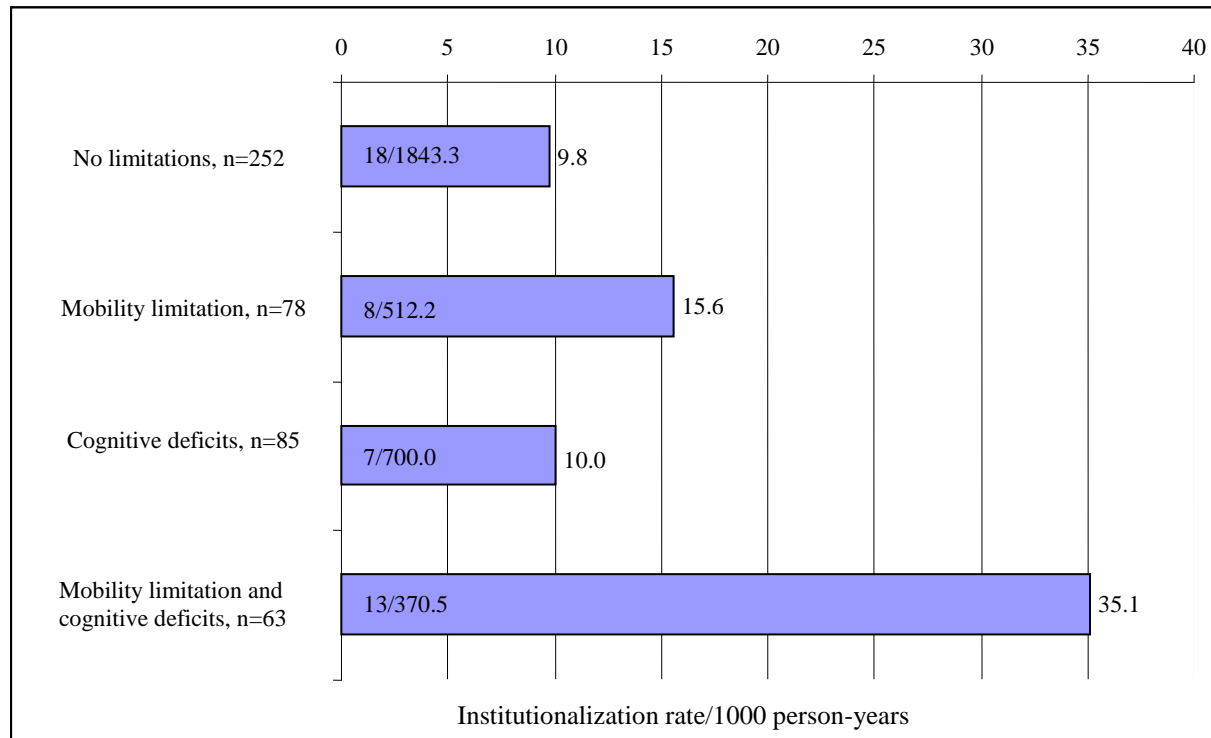


Figure 1. Institutionalization rates per 1000 person-years, long-term care cases and person-years according to study groups during the 10-year surveillance period. Groups were formed based on walking speed and cognitive capacity test dichotomized according to distribution based cut-offs at the lowest third vs. middle and highest third