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Hospital admissions, outpatient visits and healthcare costs of community-dwellers with Alzheimer's disease

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Abstract

Background: Detailed data on the health care service use of people with Alzheimer's disease (AD) are scarce.

Methods: We assessed the health care service use of all community-dwelling persons with clinically verified AD diagnosis, residing in Finland on December 31, 2005 (n = 27,948) in comparison to matched cohort without AD. Hospitalization data during 2006–2009 were extracted from the National Hospital Discharge Register.

Results: Comorbidity-adjusted incidence rate ratios; IRR (95% CI) were 1.25 (1.22–1.28) for inpatient admissions and 0.72 (0.68–0.77) for outpatient visits. People with AD had more general health care admissions (IRR, 95%CI 1.73, 1.67–1.80) but less admissions to specialty units 0.82 (0.79–0.85) than the non-AD group, with psychiatry being the only specialty with more admissions in the AD group. People with AD had 16 more hospital days/person-year.

Conclusions: It would be important to assess whether inpatient hospitalizations of AD patients could be decreased by better targeting of outpatient services and whether other conditions are underdiagnosed or undertreated among persons with AD.

Keywords: Alzheimer's disease; Cohort studies; Health services; Healthcare costs; Hospitalization

1. Introduction

Previous, mainly claims-based retrospective studies from the US have reported that people with dementia or Alzheimer's disease (AD; the most common form of dementia) have more hospitalizations than general aged population [1–5], leading to higher health care costs in this group [3,4]. Two recent studies found that persons with AD had more potentially avoidable hospitalizations than those with no AD [5,6]. Smaller cohort studies have reported lower admission rates to outpatient services [3], higher emergency admission rate [7], and higher hospitalization rate [5], partially because of higher admission rate due to infections [5,8]. In a small prospective study, majority of the emergency admissions among AD patients were due to behavioral problems and falls [9]. These studies have consistently shown that dementia is related to the increased risk of hospitalizations, and that some of the hospitalizations may be avoidable by better care management. However, detailed data on the possible differences in health care service use from large study populations of community-dwelling people are scarce and majority of the previous studies have been restricted to members of a particular insurance scheme, possibly limiting their generalizability.

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Competing Interests: None.

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Our aim was to investigate how the health care service use of community-dwelling persons with Alzheimer's disease differed from matched aged population without AD. More detailed aims were to assess the number of inpatient admissions and outpatient visits, number of hospital days, differences in general vs. special health care service utilization, and health care costs during 2006–2009 in a cohort including all 28,093 community-dwelling persons with AD who were alive on December 31, 2005.

2. Methods

2.1. Study cohort

The Medication and Alzheimer's Disease 2005 study is an exposure-matched cohort including all community-dwelling persons with a clinically verified diagnosis of Alzheimer's disease residing in Finland on 31 December 2005 (n = 28,093) and a single age-, sex-, and region of residence-matched comparison person for each individual with AD, leading to sample size of 56,186 [10]. The age range of the cohort was 42–101 years (mean 79.9 (SD 6.8) years) and 38,086 (67.8%) of the sample were women. Persons with AD were identified from the Finnish Special Reimbursement Register maintained by the Social Insurance Institution of Finland (SII). The Special Reimbursement Register contains records of all persons who are eligible for higher reimbursement due to certain chronic diseases, such as AD. This special reimbursement covers only the medication costs but not the use of health care or social services. To be eligible for reimbursement, the disease must be diagnosed according to specific criterion and diagnosis statement must be submitted to the SII by a physician. The comparison persons were identified from the register that contains all residents of Finland who are entitled to benefits by the SII, i.e. all citizens and residents living in Finland for at least 2 years. The formation of the study cohort is shown in Fig. 1. Altogether 145 comparison persons had been temporarily entitled to special reimbursement to AD medication before 2005 and thus these persons, together with their matched pairs were excluded from the analyses, leaving 27,948 matched pairs. Altogether 2015 comparison persons converted to AD during the 4-year follow-up and 18,257 participants died during the follow-up.

2.2. Finnish public health care system

Health care, provided by municipalities, is organized according to a national framework, set by Ministry of Social Affairs and Health. Finland is divided into five catchment areas (Helsinki, Kuopio, Oulu, Tampere, and Turku) for the provision of specialized level medical care. These catchment areas manage the common, centralized duties of the municipalities and social welfare and health care regions. All citizens/residents are covered by tax-supported public health service and have unrestricted access to health services, independent of socioeconomic status.

Each resident of Finland is assigned a unique social security number which was used to track prescription drug purchases and link the prescription data to national registers of hospital discharges and mortality from 2006 to 2009. Linking was performed by SII and all data were de-identified before submission to the research team. Ethics committee approval or informed consent were not required

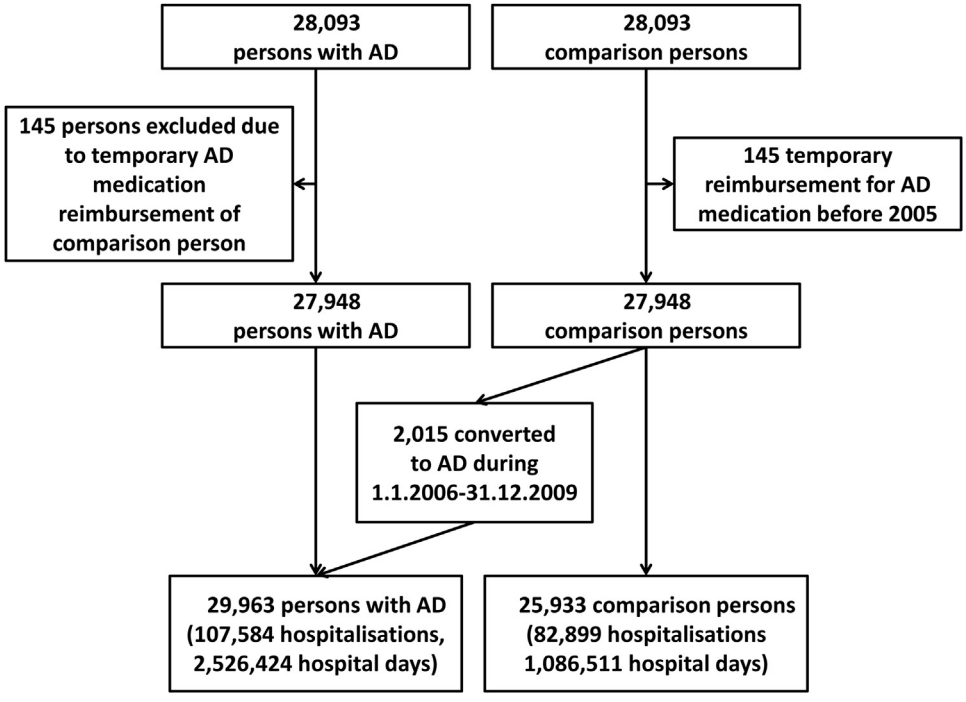

Fig. 1. Formation of the study cohort.

as only de-identified data were used and the study participants were not contacted.

2.3. Diagnosis criteria for Alzheimer's disease

The Finnish Clinical Care Guideline for cognitive disorders recommends that persons with cognitive problems should be further examined and referred to specialist care. If the diagnosis is AD or includes features of AD, treatment with antidementia drugs (i.e. acetylcholinesterase inhibitors or memantine) should be initiated [11]. To be eligible for reimbursed AD medication, a medical statement of the verified AD diagnosis must be submitted to the SII. The specific criterion is (1) symptoms consistent with mild or moderate AD, (2) a decrease in social capacity over a period of at least 3 months, (3) a computer tomography/magnetic resonance imaging scan, (4) exclusion of possible alternative diagnoses, and (5) confirmation of the diagnosis by a registered neurologist or geriatrician. The AD diagnosis was based on the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA) and *Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV)* criteria for Alzheimer's disease [12,13]. The special reimbursement for AD medication is not withdrawn when the disease progresses to a severe stage, and thus the cohort includes individuals with all stages of AD. No data are available on disease severity. Nearly all of the participants with AD (97%) used AD medication (acetylcholinesterase inhibitors or memantine) during the follow-up [14].

2.4. Outcomes

Data on hospital admissions during 2006–2009 were extracted from the Finnish National Hospital Discharge Register, a statutory register containing information on use of in- and outpatient health care services. The diagnoses for each admission are reported by the attending physician. The register contains the following information on each hospital visit: dates, reason for hospital admission (*International Classification of Diseases, 10th Edition;* [*ICD-10*] codes for etiological and symptomatic diagnosis) and specialty of the caring unit. Individual-level data are collected and updated continuously. Reliability and accuracy of register data, including dates, diagnostic codes, and specialty codes have been confirmed previously [15,16].

The main outcome was the number of hospital days during the 4-year follow-up. We also report the number of (1) hospitalizations and number of hospital days in general or special health care and in different specialty units, (2) number of hospital days according to main categories of *ICD-10* classification, (3) outpatient visits, and (4) total costs related to inpatient admissions and outpatient visits. The specialty units were categorized as follows: 'internal medicine', 'surgery', 'psychiatry', 'neurology', 'ophthalmology', 'pulmonary diseases', and 'other'. The 'other' category included specialties with too few admissions/days to be included as their own entity (i.e. audiology, gynecology, anesthesiology, otorhinolaryngology, oncology, physiatry, geriatrics, dermatology, and venereal diseases).

Costs were calculated according to Finnish health care system unit costs from 2006 [17]. These unit cost estimates were derived specifically for research purposes and they are adjusted for regional price differences. Hospitalization costs from the service provider's perspective are covered and operation and diagnostic costs, and the medication costs during the hospitalization are included. The costs were real-valued to Euros (€) in 2011 with the price index of public expenditure [18]. The prices can be converted to USD ($) or GBP (£) by using the European Central Bank annual bilateral exchange rates in 2011 (available at http://sdw.ecb.europa.eu/).

2.5. Confounders

The AD-comparison pairs were matched by age, sex, and region of residence so these factors were not taken into account in the analyses. A comorbidity score was calculated using the Charlson Comorbidity Index as a reference. [19] Data on chronic diseases were extracted from the special reimbursement register. The comorbidity score was calculated using the following diseases with corresponding scores: heart failure, coronary artery disease, type 1 or 2 diabetes, chronic asthma or chronic obstructive pulmonary disease, disseminated connective tissue diseases, rheumatoid arthritis, and other comparable conditions (score of 1); uremia requiring dialysis, severe anemia in connection with chronic renal failure, leukemia, other malignant diseases of blood, and bone marrow including malignant diseases of the lymphatic system and all cancers (score of 2). Due to the skewed distribution the score was categorized to "0", "1", "2" and "3," or more" and modeled as an ordinal variable. Date of AD special reimbursement decision was used as an estimate of duration of AD.

2.6. Statistical analyses

All statistical analyses were conducted with Stata 12.0 (Stata Corp LP, College Station, TX, USA). The association between AD and number of hospital days or hospital admissions were assessed with negative binomial regression due to large variation in the count variables. Matching was accounted for by estimating the variance with clustered sandwich estimator. We fitted both zero-inflated and simple negative binomial model to assess which one fitted the data better. The Vuong test statistic ($z = -38.5$, $P = .99$) indicated that negative binomial model fitted the data appropriately (i.e. the processes affecting between-subject heterogeneity and zero inflation were not likely to be different). The results are reported as incidence rate ratios, i.e. ratios of admission, day, or visit rate in AD group to non-AD group.

Altogether 2015 persons converted to AD during the follow-up. Therefore, AD was modeled as time-varying covariate, i.e. these 2015 persons contributed to the comparison group until the AD diagnosis date after which they

were included in the AD group. This approach avoids the bias that would result from restricting the non-AD group to those who remain AD-free for the entire follow-up period. We assessed the possible regional differences in the health care service use by including catchment area*AD interaction term in the statistical model.

3. Results

3.1. General characteristics

Total length of follow-up in the cohort was 187,206 person-years (92,268 and 94,939 person-years for AD and non-AD group, respectively). Altogether 190,483 hospital admissions (inpatient and outpatient) occurred during the follow-up and the whole cohort spent 3612,935 days in hospital. Median (interquartile range) length of follow-up was 4.0 (2.2–4.0 years) and 4.0 (3.3–4.0 years) in persons with and without AD, respectively. The study population is described in Supplementary Table 1. Persons with AD had slightly lower chronic comorbidity index, but they were more likely to be hospitalized during the follow-up. Altogether 83.0% of persons with AD were admitted to hospital at least once compared with 72.5% of persons without AD. Average length of hospital admission was 37 days for persons with AD and 15 days for persons without AD. Mortality during the 4-year follow-up was also higher among people with AD (41.8%, n = 11, 668) in comparison to the matched comparison group (23.6%, n = 6589).

3.2. Inpatient admissions

Differences in the inpatient admission rates are shown in Table 1. Persons with AD had 18–24% more inpatient admissions than those without AD, and the association strengthened to 22–28% increase after accounting for chronic diseases and AD duration. Persons with AD were more frequently admitted to general health care (67–80% increase in the adjusted model) but had 15–21% less admissions to specialized health care services. Inpatient admissions to psychiatry units were more common among the participants with AD, while people without AD were more frequently admitted to other specialty units except for neurology, where the admission rates were similar when other comorbidities and AD duration were taken into account.

3.3. Number of hospital days in general and specialized health care units

Differences in the total number of inpatient hospital days are shown in Table 2. Persons with AD had over twice as much hospital days per year in comparison to matched population without AD. The difference remained after adjustment for chronic comorbidities and duration of AD. When comorbidities and AD duration were taken into account, participants with AD spent 219–244% more days in general health care units and 2–15% more days in specialized units.

Participants with AD spent over three times more days in psychiatry units than general age-matched population. Persons with AD had less hospital days per year in wards specialized in surgery, ophthalmology or pulmonary diseases but more hospital days in internal medicine wards.

3.4. Number of hospital days and admissions according to disease categories

Number of hospital days according to disease categories is shown in Table 3 and the number of hospital admissions per category is listed in Supplementary Table 2. Nearly all hospital visits (99.99%) were accompanied by the main symptomatic diagnosis. Most of the inpatient admissions in both groups were due to diseases of the circulatory system, followed by mental and behavioral disorders, diseases of the nervous system, injuries, poisoning, and other external causes and genitourinary conditions in the AD group and to injuries, respiratory diseases, neoplasms and diseases of the

Table 1
Association of Alzheimer's disease with total number of hospital admissions and admissions to general and special health care by specialty units

Outcome	Admissions/100 person-years (n of admissions)		Model 1*		Model 2†		
	AD	No AD	IRR (95%CI)	*P*	IRR (95%CI)	*P*	P_{int}‡
All hospital admissions	117 (107,584)	87 (82,899)	1.21 (1.18 to 1.24)	<.001	1.25 (1.22 to 1.28)	<.001	.063
Admissions to general health care units	71 (65,485)	37 (35,192)	1.74 (1.68 to 1.79)	<.001	1.73 (1.67 to 1.80)	<.001	.020
Admissions to specialized health care units							
Any specialty	44 (40,541)	50 (47,707)	0.79 (0.77 to 0.81)	<.001	0.82 (0.79 to 0.85)	<.001	.004
Internal medicine	20 (18,231)	19 (18,416)	0.92 (0.89 to 0.96)	<.001	0.94 (0.89 to 0.99)	.025	.012
Surgery	14 (12,485)	17 (15,704)	0.74 (0.72 to 0.77)	<.001	0.76 (0.73 to 0.80)	<.001	.29
Psychiatry	1.7 (1560)	0.5 (482)	3.02 (2.44 to 3.73)	<.001	3.22 (2.58 to 4.02)	<.001	.030
Neurology	2.6 (2406)	2.7 (2519)	0.89 (0.83 to 0.96)	.001	0.96 (0.87 to 1.05)	.321	<.001
Ophthalmology	2.7 (2487)	5.8 (5473)	0.42 (0.40 to 0.45)	<.001	0.50 (0.47 to 0.54)	<.001	.11
Pulmonary diseases	1.9 (1778)	2.5 (2391)	0.69 (0.63 to 0.77)	<.001	0.71 (0.63 to 0.81)	<.001	.031
Other	1.7 (1594)	2.9 (2722)	0.55 (0.49 to 0.60)	<.001	0.54 (0.47 to 0.61)	<.001	.038

*Unadjusted.
†Adjusted for chronic comorbidities and duration of AD.
‡P_{int} *P*-value for catchment area*AD interaction term denoting regional differences in service use according to AD status.

Table 2
Total number of hospital days, number of days in general, and special health care wards by specialties in persons with and without Alzheimer's disease

Outcome	Days/100 person-years (n of days)		Model 1*		Model 2†		
	AD	No AD	IRR (95%CI)	*P*	IRR (95%CI)	*P*	P_{int}‡
All hospital days	2738 (2,526,424)	1144 (1,086,511)	2.17 (2.09 to 2.25)	<.001	1.97 (1.88 to 2.06)	<.001	.020
Days in general health care units	2359 (2,176,854)	823 (781,753)	2.60 (2.48 to 2.72)	<.001	2.31 (2.19 to 2.44)	<.001	.045
Days in specialized health care units							
Any specialty	379 (349,570)	321 (304,758)	1.07 (1.02 to 1.12)	.008	1.08 (1.02 to 1.15)	.015	<.001
Internal medicine	180 (166,472)	149 (141,283)	1.10 (1.02 to 1.19)	.02	1.08 (0.98 to 1.18)	.104	<.001
Surgery	83 (76,160)	94 (89,049)	0.80 (0.76 to 0.84)	<.001	0.86 (0.80 to 0.92)	<.001	.008
Psychiatry	59 (54,600)	17 (15,728)	3.24 (2.58 to 4.06)	<.001	3.42 (2.61 to 4.48)	<.001	.048
Neurology	18 (16,411)	19 (18,318)	0.84 (0.67 to 1.04)	.10	0.91 (0.67 to 1.24)	.564	<.001
Ophthalmology	4 (3241)	8 (7173)	0.42 (0.36 to 0.49)	<.001	0.48 (0.42 to 0.56)	<.001	.56
Pulmonary diseases	13 (11,537)	16 (15,642)	0.69 (0.62 to 0.77)	<.001	0.74 (0.64 to 0.85)	<.001	.15
Other	23 (21,149)	19 (17,565)	1.12 (0.78 to 1.61)	.53	0.89 (0.55 to 1.43)	.632	.007

*Unadjusted.
†Adjusted for chronic comorbidities and duration of AD.
‡P_{int} *P*-value for catchment area*AD interaction term denoting regional differences in service use according to AD status.

eye, adnexa, ear, and mastoid process in the non-AD group. The admission rates and number of hospital days due to skin diseases and diseases of the digestive system were comparable between the groups, but the admission rates and number of hospital days for diseases of circulatory and musculoskeletal systems, eye, adnexa, ear, and mastoid process, and neoplasms were lower in the AD group. Persons with AD had higher admission rate and more hospital days due to diseases of the nervous, respiratory, genitourinary and endocrine systems, mental, and behavioral disorders, injuries, infectious, and parasitic diseases.

3.5. Outpatient visits

Persons with AD had 23–32% less outpatient visits than persons without AD. They were less likely to visit specialized units, but had over twofold rate of outpatient visits to general health care units (Table 4). When admissions per different specialty units were investigated, persons with AD had more visits to neurology and psychiatry units and persons without AD had more visits to units specialized in internal medicine, surgery, ophthalmology, pulmonary diseases, and other specialties.

Table 3
Association of Alzheimer's disease with the number of hospital days due to main symptomatic diagnosis categories according to the *ICD-10* classification

Main symptomatic diagnosis	Days/100 person-years (n of days)		Model 1*		Model 2†		
	AD	No AD	IRR (95%CI)	*P*	IRR (95%CI)	*P*	P_{int}‡
Mental and behavioral disorders	789 (727,970)	140 (132,988)	5.11 (4.53 to 5.75)	<.001	4.42 (3.88 to 5.02)	<.001	<.001
Diseases of the nervous system	696 (641,879)	52 (49,057)	12.20 (10.26 to 14.52)	<.001	9.38 (7.85 to 11.21)	<.001	.38
Diseases of the circulatory system	303 (280,017)	324 (307,168)	0.85 (0.78 to 0.92)	<.001	0.88 (0.79 to 0.98)	.015	.09
Injury, poisoning, and certain other consequences of external causes	213 (196,757)	129 (122,081)	1.50 (1.36 to 1.66)	<.001	1.49 (1.33 to 1.67)	<.001	.27
Diseases of the respiratory system	241 (222,024)	98 (93,010)	2.23 (1.98 to 2.50)	<.001	2.00 (1.72 to 2.32)	<.001	.55
Diseases of the genitourinary system	85 (78,502)	51 (48,653)	1.51 (1.34 to 1.70)	<.001	1.55 (1.34 to 1.79)	<.001	.13
Neoplasms	62 (57,445)	77 (72,855)	0.74 (0.64 to 0.85)	.001	0.76 (0.64 to 0.90)	.001	.44
Infectious and parasitic diseases	49 (45,455)	36 (33,810)	1.25 (1.12 to 1.40)	<.001	1.31 (1.11 to 1.53)	.001	.49
Diseases of the digestive system	49 (45,268)	44 (42,204)	1.00 (0.87 to 1.15)	.99	1.10 (0.95 to 1.27)	.194	.22
Diseases of the musculoskeletal system and connective tissue	38 (35,271)	60 (56,846)	0.58 (0.50 to 0.67)	<.001	0.73 (0.63 to 0.85)	<.001	.19
Endocrine, nutritional and metabolic diseases	31 (28,690)	23 (21,716)	1.23 (0.99 to 1.54)	.07	1.73 (1.22 to 2.46)	.002	.84
Diseases of the blood, blood-forming organs and immune mechanism	18 (16,572)	21 (19,500)	0.79 (0.64 to 0.99)	.04	0.86 (0.65 to 1.13)	.273	.81
Diseases of the skin and subcutaneous tissue	10 (9607)	10 (9730)	0.92 (0.63 to 1.36)	.68	0.87 (0.58 to 1.30)	.496	.033
Diseases of the eye, adnexa, ear, and mastoid process	6 (5795)	13 (12,261)	0.44 (0.32 to 0.60)	<.001	0.52 (0.36 to 0.74)	<.001	.049
Congenital malformations, deformations, and chromosomal abnormalities	<1 (64)	1(542)	0.11 (0.03 to 0.47)	.003	0.39 (0.13 to 1.13)	.084	.16

*Unadjusted.
†Adjusted for chronic comorbidities and duration of AD.
‡P_{int} *P*-value for catchment area*AD interaction term denoting regional differences in service use according to AD status.

Table 4
Association of Alzheimer's disease with outpatient visits

Outcome	Visits/100 person-years (n of visits)		Model 1*		Model 2†		
	AD	No AD	IRR (95%CI)	*P*	IRR (95%CI)	*P*	P_{int}‡
All	139 (134,119)	195 (192,630)	0.65 (0.63 to 0.67)	<.001	0.72 (0.68 to 0.77)	<.001	<.001
Visits to general health care units	17 (16,919)	3 (3361)	2.88 (2.46 to 3.38)	<.001	2.16 (1.67 to 2.80)	<.001	<.001
Visits to specialized health care							
Any specialty	122 (117,200)	192 (189,269)	0.58 (0.56 to 0.60)	<.001	0.62 (0.58 to 0.66)	<.001	.020
Internal medicine	36 (35,100)	63 (62,013)	0.53 (0.48 to 0.58)	<.001	0.56 (0.49 to 0.64)	<.001	.064
Surgery	31 (29,532)	44 (43,208)	0.64 (0.62 to 0.66)	<.001	0.66 (0.62 to 0.71)	<.001	.038
Psychiatry	5 (5067)	4 (4147)	1.14 (0.85 to 1.53)	.39	1.94 (1.30 to 2.90)	<.001	.82
Neurology	11 (10,994)	9 (8749)	1.17 (1.11 to 1.23)	<.001	1.33 (1.22 to 1.44)	<.001	.028
Ophthalmology	9 (9117)	19 (18,315)	0.46 (0.44 to 0.49)	<.001	0.54 (0.48 tp 0.60)	<.001	.81
Pulmonary diseases	3 (2595)	6 (6190)	0.39 (0.35 to 0.43)	<.001	0.43 (0.37 to 0.52)	<.001	<.001
Wards of other specialties	26 (24,795)	47 (46,647)	0.50 (0.47 to 0.52)	<.001	0.57 (0.52 to 0.63)	<.001	.013

*Unadjusted.
†Adjusted for chronic comorbidities and duration of AD.
‡P_{int} *P*-value for catchment area*AD interaction term denoting regional differences in service use according to AD status.

3.6. Regional differences

Stratified analyses according to catchment area were performed when there was statistical evidence for regional difference (*P* for interaction between catchment area and AD $\leq$0.05). The results of the stratified analyses are shown in Supplementary Table 3. In most cases, the IRRs were within similar range, the only exceptions being the number of hospital days due to diseases of the skin (people with AD had less hospital days in Tampere catchment area and more hospital days in Kuopio catchment area) and outpatient admissions to general health care units (people with AD had less admissions in Turku and more admissions in Kuopio and Oulu region).

With regards of hospital days, no evident patterns were observed, while there was some indication that the Tampere catchment area, with the highest IRR for inpatient admissions to general health care units (i.e. persons with AD having relatively more admissions than in e.g. Kuopio or Turku catchment areas), also had the lowest IRR for inpatient admissions to specialized health care.

3.7. Health care costs

Health care costs for the whole cohort, per person and per person-year are listed in Table 5. During the follow-up, the average health care costs per person were €23,059 for an AD-affected person and €14,941 for comparison person. Costs per person-year were €7478 and €4384 in persons with and without AD, respectively. The outpatient care costs were somewhat higher in the non-AD group (difference €477 per person), while the inpatient costs were notably higher among the AD participants (€6770 and €1825 higher costs per person for general and specialized care, respectively). During the 4-year follow-up, the health care costs of AD group were 691M€ in comparison to 418M€ costs of the comparison group, although they contributed less person-years to the follow-up time (92,268 and 94,939 for AD and non-AD group, respectively).

4. Discussion

In our nationwide study the community-dwelling persons with AD had more inpatient admissions to both general and specialized inpatient care than matched community-dwelling population without clinically diagnosed AD. The participants with AD had less outpatient visits in total, although they had more outpatient visits to general health care units. Although the variation in health care costs on a personal level was large, the total health care costs were approximately €8118/person higher in the AD group, which translates into a difference of €3090/person-year. The relative difference in the costs per person (54%) was similar to

Table 5
Health care costs in persons with and without Alzheimer's disease during 2006–2009

	AD*		No AD*	
	Costs per person mean (SD)	Costs averaged over person-years	Costs per person mean (SD)	Costs averaged over person-years
Total costs	23,059 (40,851)	7478	14,941 (28,429)	4384
Outpatient care	776 (1475)	242	1253 (3468)	355
Inpatient care	22,283 (40,654)	7236	13,688 (27,604)	4029
General	11,861 (22,520)	3851	5091 (13,377)	1498
Specialized	10,422 (33,545)	3384	8597 (22,541)	2530

*Costs are reported in Euros () according to 2011 prices. The prices in USD and GBP can be obtained by multiplying the EUR prices by 0.868 and 1.392, respectively.

that observed in a recent study comparing Medicare expenditures (51%) [6]. The increased hospitalization rate is also in line and comparable with previous US studies [1–3,8]. In our study 83% of persons with AD were admitted to hospital at least once during 4-year follow-up. Previous studies have reported that 66% of persons with dementia were admitted to hospital during 3 years [20] and 86% during 8 years of follow-up [5]. Persons with AD had 117 admissions/100 person-years compared with 87 admissions/100 person-years among persons without AD while Phelan et al. reported 42 admissions for persons with dementia and 20 admissions for persons without dementia per 100 person years [5]. The higher hospital admission rate in our study may be due to differences in the definition of separate hospitalizations. We defined each inpatient admission to different hospital/ward as a new admission but these data are not available in the Phelan et al. study. Similar to our study, Hill et al. have previously reported lower outpatient visit rate among AD patients in a Medicare-based sample of New Yorkers [3].

The less frequent outpatient visits among persons with AD may reflect the suboptimal use of outpatient services, leading to more frequent inpatient admissions in the AD group. The validity of inpatient data is higher in comparison to outpatient data and thus the findings on outpatient care should be considered as tentative. However, it is unlikely that the outpatient service use would be differently recorded according to AD status and thus the relative estimates (i.e. IRRs) are likely to be more reliable than absolute estimates (number of days, costs of outpatient care). The average length of hospital stays was also longer for persons with AD. This may indicate the severity of diseases or conditions leading to the admission or alternatively, the time needed to evaluate the patient's ability to live at home and assess or organize the necessary home care services. Persons with AD were less often admitted to special health care units (except for psychiatry) than persons without AD. This could be due to lower number of chronic diseases demanding hospital admissions among persons with AD. However, we did not find evidence that persons with AD would be healthier than persons without AD. There were no evident differences in comorbidity score between the groups. Thus, the difference in the distribution of service use in terms of general and special health care may indicate suboptimal care of other diseases than dementia in persons with AD. However, this hypothesis cannot be assessed with our data. Another possibility is that individuals with AD (or their family members) may elect not to treat certain comorbidities. More frequent inpatient admissions and outpatient visits to psychiatry wards may reflect difficulties in the treatment of neuropsychiatric symptoms.

In our study the causes for hospitalization were somewhat different between the two groups: circulatory and respiratory diseases and injuries were among the most common reasons for admission in both groups, while persons with AD had more admissions due to diseases of the nervous system and mental and behavioral disorders. These are consistent with previous findings from a small prospective study that assessed the reasons for emergency admissions among 118 AD patients [9]. Lower admission rate due to musculoskeletal diseases and higher admission rate due to respiratory diseases and infectious diseases in the AD group are also consistent with previous findings [5,7,8]. Although there was no large difference in the incidence rate ratio for endocrine, nutritional and metabolic diseases, persons with AD accumulated considerably more hospital days due to these diseases than the comparison group. Thus, it is important to assess both the frequency and duration of hospital admissions. The previous studies [2–5,7–9,20,21] have provided data on admission rates, but they do not allow the detailed assessment of the duration of hospital stays.

Finnish administrative health care registers have good coverage and validity [22], thus providing unique opportunities for epidemiological research. Social security numbers enable reliable automated linkage and inpatient admissions are reliably recorded in the register. The Finnish special reimbursement register enables the identification of all clinically diagnosed AD patients in Finland. All citizens or long-term (at least 2 years) residents are covered by tax-supported public health service. They have unrestricted access to health services, independent of socioeconomic status [23]. Thus, our cohort is not selected on the basis of socioeconomic position. However, our sample included only community-dwelling persons so the estimates are not generalizable to those living in the institutionalized settings and the differences in the service use and health care costs in the institutionalized population are likely to be larger. Furthermore, as the national guidelines recommend the treatment of AD with antidementia drugs, and the special reimbursement register was used to capture the clinically verified AD cases, nearly the entire AD cohort used antidementia medication at some stage of the follow-up [14]. Thus, the results are representative of AD with antidementia medication, they may not be generalizable to untreated AD patients. However, our results were well comparable to those of previous studies [2–5,7–9,20,21] that included also AD cases who received no medication or gave no data on medication exposure. Finnish health care, provided by municipalities, is organized according to a national framework, set by Ministry of Social Affairs and Health. Despite this, there was some evidence for regional variation, although no evident patterns were identified. This regional variation may reflect small variations in treatment regimes or different availability of some special health care services due to number of specialized physicians.

In conclusion, the use of health care services was very different between persons with and without AD in our nationwide cohort from Finland. Similar to previous studies, persons with AD had higher number of hospital admissions. They used less outpatient services but had more inpatient admissions. The difference in inpatient admissions and hospital days was mainly driven by the admissions to general health care units. It would be important to assess whether hospitalizations could be decreased by better planning or

targeting of outpatient services and whether other diseases than AD are underdiagnosed or undertreated among AD patients. The optimization of primary care and development of better strategies for the care of AD patients could enable more efficient targeting of health care resources in a growing population affected with AD.

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Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jalz.2014.10.005.

RESEARCH IN CONTEXT

1. Systematic Review: We searched PubMed for English articles with terms Alzheimer* AND (hospitali* OR admission*) and identified nine relevant articles (1–9), comparing hospitalization rates in cohort studies or studies based on different health care insurance schemes from the US. None provided data on the number of hospital days.
2. Interpretation: Relative increase in hospitalizations and costs in this Finnish nationwide study were consistent and of comparable magnitude to the previous US studies. People with Alzheimer's disease (AD) used less outpatient services but had more inpatient admissions and longer hospitalizations. The differences were driven by general health care admissions. Persons with AD had more hospital days due to behavioral problems, diseases of the nervous system, injuries, respiratory and genitourinary conditions, and infectious diseases. Admissions due to neoplasms, circulatory, and musculoskeletal diseases were less frequent.
3. Future Directions: It would be important to assess whether hospitalizations could be decreased by better targeting of outpatient services and whether other conditions are underdiagnosed or undertreated among AD patients.

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