Association of Incident Dementia With Hospitalizations

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Context Dementia is associated with increased rates and often poorer outcomes of hospitalization, including worsening cognitive status. New evidence is needed to determine whether some admissions of persons with dementia might be potentially preventable.

Objective To determine whether dementia onset is associated with higher rates of or different reasons for hospitalization, particularly for ambulatory care–sensitive conditions (ACSCs), for which proactive outpatient care might prevent the need for a hospital stay.

Design, Setting, and Participants Retrospective analysis of hospitalizations among 3019 participants in Adult Changes in Thought (ACT), a longitudinal cohort study of adults aged 65 years or older enrolled in an integrated health care system. All participants had no dementia at baseline and those who had a dementia diagnosis during biennial screening contributed nondementia hospitalizations until diagnosis. Automated data were used to identify all hospitalizations of all participants from time of enrollment in ACT until death, disenrollment from the health plan, or end of follow-up, whichever came first. The study period spanned February 1, 1994, to December 31, 2007.

Main Outcome Measures Hospital admission rates for patients with and without dementia, for all causes, by type of admission, and for ACSCs.

Results Four hundred ninety-four individuals eventually developed dementia and 427 (86%) of these persons were admitted at least once; 2525 remained free of dementia and 1478 (59%) of those were admitted at least once. The unadjusted all-cause admission rate in the dementia group was 419 admissions per 1000 person-years vs 200 admissions per 1000 person-years in the dementia-free group. After adjustment for age, sex, and other potential confounders, the ratio of admission rates for all-cause admissions was 1.41 (95% confidence interval [CI], 1.23-1.61; $P<.001$), while for ACSCs, the adjusted ratio of admission rates was 1.78 (95% CI, 1.38-2.31; $P<.001$). Adjusted admission rates classified by body system were significantly higher in the dementia group for most categories. Adjusted admission rates for all types of ACSCs, including bacterial pneumonia, congestive heart failure, dehydration, duodenal ulcer, and urinary tract infection, were significantly higher among those with dementia.

Conclusion Among our cohort aged 65 years or older, incident dementia was significantly associated with increased risk of hospitalization, including hospitalization for ACSCs.

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CLAIMS-BASED, RETROSPECTIVE studies have long reported that dementia is associated with increased hospitalizations,[1-9] but empirical data to elucidate this finding are few. Suboptimal management in the outpatient setting may be a contributing factor, as suggested by lower prescription drug costs and fewer office visits after diagnosis.[4] Accomplishing adequate chronic disease management is more difficult in persons with dementia, which may lead to hospitalization for acute exacerbation of comorbid conditions.[4,5] Nonelective hospitalization of older people, particularly those with dementia, is not a trivial event. Among older persons without dementia, hospitalization for serious illness is associated with subsequent cognitive decline,[10] and frail elders, including those with dementia, are at increased risk of delirium, functional decline, and iatrogenic complications during an inpatient stay.[11-13] Identifying conditions that precipitate hospitalization of elderly individuals with dementia could focus clinical priorities on secondary and tertiary prevention in the outpatient setting and improve health care for this vulnerable and increasing population. We used a unique longitudinal data set to determine whether dementia onset is associated with higher rates of or different reasons for hospitalization, particularly for ambulatory care–sensitive conditions (ACSCs), for which proactive outpatient care might prevent the need for a hospital stay.

For editorial comment see p 197.

METHODS

Participants

Participants were from the Adult Changes in Thought (ACT) cohort. Begun in 1994, ACT is a population-based, longitudinal study of aging and the incidence of and risk factors for dementia involving more than 3500 members of Group Health Cooperative (GHC), a large integrated health care delivery system.[14,15] Eligible persons were aged 65 years or older, cognitively intact, and not residing in a

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nursing home at time of enrollment in the cohort (mean age at inception was 75.3 years). Participants have been followed up every 2 years with an in-person interview that includes dementia and health status assessment. Participation rates at follow-up visits are generally very high, as reflected in a completeness of follow-up index for ACT of more than 95%.[16] Detailed descriptions of study methods have been published previously.[10,15,17,18]

A biennial examination was conducted to identify cases of incident dementia. Participants who scored less than 86 on the Cognitive Abilities Screening Instrument (CASI) or had symptoms suggesting possible new onset of cognitive impairment underwent a standardized dementia diagnostic evaluation consisting of an examination by a study physician and detailed neuropsychological testing as described elsewhere.[15,17] Informants knowledgeable about participants were interviewed as part of the dementia diagnostic workup, and Jorm and Korten Informant Interviews[19] were conducted with all informants. The results were presented at a consensus conference attended by study physicians, a neuropsychologist, a research nurse, and interviewers and a consensus diagnosis was recorded based on standardized criteria (*Diagnostic and Statistical Manual of Mental Disorders* [Fourth Edition][20] and Neurological and Communicative Disorders and Stroke–Alzheimer Disease and Related Disorders Association[21] criteria). Primary care clinicians of ACT participants were notified by letter of a study diagnosis of dementia. Persons found not to have dementia returned to the cohort for biennial evaluations. Participants with incident dementia underwent 1 annual follow-up examination for verification of dementia status and dementia type. The ACT cohort was assembled to determine the incidence of dementia; it was not designed to evaluate dementia outcomes.

Study Design

We used a retrospective, longitudinal cohort design to assess inpatient admission rates in individuals from the ACT study. Follow-up for each participant began at first enrollment in ACT and ended at death, health plan disenrollment, or end of study follow-up (December 31, 2007), whichever came first. During follow-up, some participants developed dementia; most did not. Dementia was treated as a time-varying covariate so that those who developed dementia contributed time at risk to both the nondementia and dementia groups. This approach avoids the bias that results when the nondementia group is restricted to those who are dementia free through follow-up and is consistent with the design of nested case-control studies.[22,23]

Eligibility Criteria

ACT participants eligible for our analyses met the following selection criteria: (1) did not have dementia at the baseline ACT visit; (2) completed at least 1 ACT follow-up visit (to assess for incident dementia); and (3) were enrolled in GHC at the time of a follow-up visit (to ensure availability of hospitalization data postbaseline). This study was approved by the institutional review boards of GHC and the University of Washington. All ACT participants provided written informed consent for baseline and follow-up assessments at time of enrollment into ACT. The institutional review boards approved a waiver of consent for the present study.

Variables

Outcome Measures. The primary outcome measure was rate of hospitalization, measured as mean number of admissions per year of follow-up. An admission was defined as a hospitalization requiring an overnight stay. An automated hospitalizations file was used to identify admissions during the follow-up period. Hospitalization data from GHC have been validated and used extensively for research.[24]

The secondary outcome measure was the rate of hospitalization by type, classified by the principal discharge diagnosis (*International Classification of Diseases, Ninth Revision* [*ICD-9*] code). Large categories/groupings of discharge diagnoses were modeled after those used in the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project.[25] Classes of *ICD-9* codes comprising each category, along with examples of conditions in a category, are shown in the eTable (available at http://www.jama.com). We identified ACSCs among principal discharge diagnoses to count conditions for which hospitalization may potentially be prevented with timely, evidence-driven outpatient care.[26-29] The ACSCs included angina, asthma, bacterial pneumonia, cellulitis, congestive heart failure (CHF) exacerbation, chronic obstructive pulmonary disease exacerbation, dehydration, diabetes, duodenal ulcer, ear/nose/throat infection, gastric ulcer, gastroenteritis, hypertension, hypoglycemia, hypokalemia, influenza, malnutrition, peptic ulcer, seizure disorder, and urinary tract infection (UTI). We used previously described classification schemes for ACSCs to allow direct comparison with other studies.[30,31] Although not all admissions for ACSCs are avoidable, and although the concept of an ACSC as originally described[26,32,33] addressed the full spectrum of outpatient care recipients and not specifically older persons with dementia, the construct is useful for evaluating the potential effect of dementia on patterns of care. Because all patients were enrolled in the same delivery system, which has no care pathway for persons with dementia, access to care should be comparable and unlikely to confound any group differences. Furthermore, higher rates of hospitalization for ACSCs could pinpoint areas for improvement in the quality of care.[34]

Covariates. Potential confounders of the association between dementia and hospitalization, including sociodemographic characteristics, comorbid conditions, health behaviors, self-rated health, and place of residence, were ascertained from self-reported data collected at the baseline visit as well as at 2-year follow-up visits. Response options for self-report of race/ethnicity included white, black not of Hispanic ori-

gin, Asian or Pacific Islander, American Indian or Alaska Native, Hispanic, and other. Depression was defined as a score of 10 or more on the 10-item Center for Epidemiological Studies Depression Scale (score range, 0-30).[35] Comorbidity burden was estimated using the RxRisk score, a case-mix measure that uses automated outpatient pharmacy data to identify medications used to treat chronic conditions known to be associated with future health care cost and use.[36] When the score was initially developed,[37] an expert panel composed of physicians, pharmacists, and health services researchers selected medication classes and assigned weights to signify the predicted associated chronic disease severity. The RxRisk updates and expands the Chronic Disease Score[37] by creating a more complete drug assignment algorithm based on National Drug Codes (unique identifying numbers)[38] and expanding the set of conditions used to assess comorbidity. A regression model is used to relate medication classes to health care costs and is expressed in US dollars. The RxRisk score is the linear combination of an individual's age, sex, and set of conditions for which prescription drug dispenses have been observed over a 12-month period. The lowest possible risk score is one determined by age and sex, with scores increasing with age and with men having higher age-adjusted risk. The various versions of the RxRisk have been validated against case-mix models using diagnostic codes and found to perform statistically similarly in terms of population mean cost as well as among individuals likely to be future high users of health care. Important to the present study, no version of the RxRisk includes medications used to treat dementia. Global cognitive function was evaluated based on scores on the CASI (range, 0-100)[39] from the baseline ACT assessment. Participants with CASI scores of less than 86 at follow-up received comprehensive evaluations for dementia.

Statistical Analyses

Demographic and health-related characteristics were compared between those who developed dementia and those who did not using *t* tests (continuous variables) and χ^2 tests (categorical variables). Missing baseline data were infrequent; no single covariate had more than 1.6% missing. Our primary analyses compared the admission rates in the 2 groups, with dementia handled as a time-varying covariate. Rates were computed as the total number of admissions in each group divided by the number of years of follow-up in that group. For the dementia group, only admissions following the first dementia diagnosis were used in computing admission rates. In the nondementia group, the rate was computed as the total number of admissions among persons while free of dementia divided by the total years of dementia-free follow-up. (In the Tables, rates are presented as rates per 1000 person-years.) We then computed the ratio of the admission rates for the dementia and nondementia groups. To account for time-varying covariates (including dementia status), we divided each person's follow-up period into a series of periods averaging approximately 2 years in length, timed to start and end with the dates of each person's baseline and follow-up ACT visit dates. Since this analysis involved repeated observations for the same person, we used the generalized estimating equation version of Poisson regression to account for any within-person correlation. *P* values and confidence intervals for ratios were computed using empirical standard errors to account for overdispersion in Poisson regression models.[40,41] For key outcomes, we repeated the analysis using negative binomial regression; results were similar so are not reported herein. In fully adjusted models including all covariates, only 5% of observations were excluded because of missing baseline or follow-up information. Only 65 participants (2.2%) were excluded entirely from the fully adjusted analysis. Given this low frequency of missing data, we did not impute missing covariates.

Three sets of Poisson regression analyses were performed for each outcome: unadjusted, age- and sex-adjusted, and "fully" adjusted. In adjusted models, linear and quadratic terms for age for each sex were included to account for the nonlinear relationship between hospitalization rates and age. All tests were 2-sided and $P < .05$ was considered statistically significant. To account for the possibility that moving into a nursing home could alter patterns of medical care and influence decisions regarding hospitalization, we fit a fully adjusted model adding nursing home residence at follow-up. All analyses were carried out using SAS software, version 9.0 (SAS Institute Inc).

RESULTS

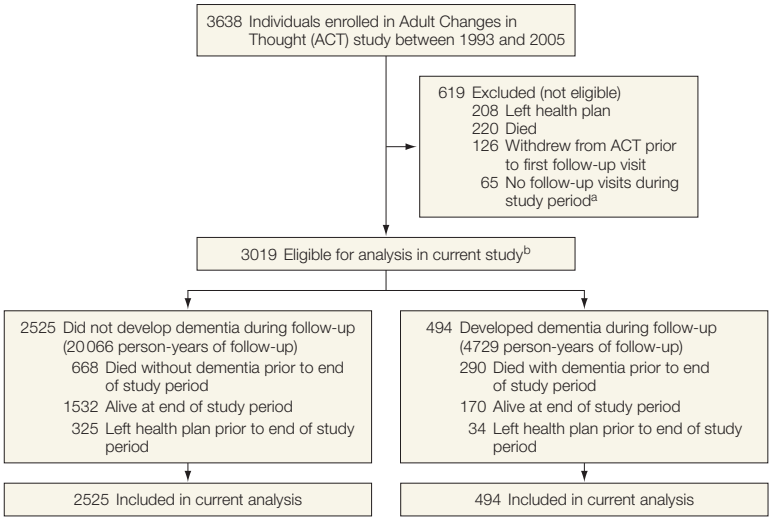
Participant Characteristics

A total of 3019 ACT participants met eligibility criteria and were included in the analyses (FIGURE). Thirty-four participants (6.9%) who developed dementia discontinued follow-up prior to the end of the study period because of disenrollment from the health plan and 290 (58.7%) died; 325 (12.9%) of the group that remained dementia-free left the health plan and 668 (26.5%) died prior to the end of the study (December 31, 2007).

TABLE 1 shows participant characteristics at ACT enrollment, grouped by dementia status ascertained through the entire follow-up period. Those in the group who eventually developed dementia were older at cohort entry by about 3 years and were less likely to have graduated from high school. Larger percentages reported having trouble dressing and reported a diagnosis of depression or Parkinson disease; their mean CASI score was a few points lower than for those who remained dementia free. Differences on race/ethnicity, RxRisk, and prior hospitalization were all due to the older age of the dementia group and were not significant after adjustment for age and sex.

The most frequent etiologic diagnoses in the dementia group were probable Alzheimer disease as a single cause (58%), vascular dementia alone (16%), and dementia of multiple etiologies

Figure. Participant Flow and Vital Status at End of Follow-up



[a]No follow-up visit during study period due to either not being due for follow-up or not presenting for follow-up visit when invited.
[b]Eligibility criteria included (1) enrolled in ACT between 1993 and 2005; (2) free of dementia at time of ACT enrollment; (3) completed baseline assessment as part of ACT; and (4) had at least 1 follow-up visit with ACT to assess dementia status while still enrolled in health plan.

(15%). Other etiologies included other medical (7%), substance-related (2%), and other/unknown (2%). The mean age at diagnosis was 84.3 (SD, 5.8) years, with 61% having diagnoses in their 80s. The mean CASI score at time of diagnosis (not time of enrollment) was 76 (SD, 10.7), consistent with mild dementia.

Follow-up totaled 24 795 person-years, including 1703 years of postdiagnosis follow-up among the 494 who developed dementia. Follow-up averaged 8 years (median, 7.8 years; interquartile range [IQR], 4.3-11.9 years) among those who never developed dementia and 9.6 years (median, 9.9 years; IQR, 6.6-12.0 years) among those who did (6.1 years before and 3.5 years after diagnosis, respectively, on average). Admissions totaled 5328. Among those who developed dementia, there were 689 admissions prior to diagnosis and 714 after dementia diagnosis. Of ACSC admissions for this group, 121 occurred before dementia diagnosis and 198 after. During follow-up, 427 individuals (86%) in the dementia group were hospitalized (96 once, 103 twice, and 228 ≥3 times) vs 1478 (59%) in the dementia-free group (548 once, 384 twice, and 546 ≥3 times). Forty percent (n=196) of the dementia group had at least 1 ACSC admission (118 had 1, 46 had 2, and 32 had ≥3) compared with 17% (n=424) of the dementia-free group (266 with 1, 99 with 2, and 59 with ≥3).

Rates of and Reasons for Hospitalization

Table 2 shows the all-cause rates of hospitalization and rates by major reasons for hospitalization, according to body system, by study group. The most common reasons for hospitalization, regardless of dementia status, were circulatory, respiratory, and digestive disorders. Among participants with dementia, the average annual admission rate was 419 admissions per 1000 persons, more than twice that of those without dementia, who averaged 200 admissions per 1000 persons each year (crude rate ratio, 2.10; 95% CI, 1.87-2.35; $P<.001$). After age/sex adjustment, the ratio of admission rates was 1.57 (95% CI, 1.39-1.78; $P<.001$) and was 1.41 (95% CI, 1.23-1.61; $P<.001$) after adjusting for additional covariates. This ratio changed very minimally with adjustment for residence in a nursing home prior to hospitalization (rate ratio, 1.39; 95% CI, 1.20-1.40; $P<.001$).

In the fully adjusted model, admission rates for 5 types of disorders (circulatory, genitourinary, infectious, neurological, and respiratory) were significantly higher among participants with dementia compared with those without dementia. Rates for the "other" category were also significantly higher. In contrast, those with dementia had significantly lower admission rates for musculoskeletal disorders (Table 2).

Admissions considered potentially preventable with timely and appropriate ambulatory care (ACSCs) were analyzed separately (Table 3).[26-29] The crude admission rate for ACSCs was higher among those with dementia (116 vs 37 admissions/1000 person-years; crude rate ratio, 3.18; 95% CI, 2.59-3.90; $P=.001$). After full adjustment for covariates, the rate ratio was 1.78 (95% CI, 1.38-2.31; $P<.001$). Three ACSCs, bacterial pneumonia, CHF, and UTI, accounted for two-thirds of all potentially preventable admissions, and admission rates among those with dementia were significantly higher for all 3 conditions. Admission rates for dehydration and duodenal ulcer, though low overall, were also significantly higher among those with dementia. Admissions for ACSCs accounted for 28% of all hospitalizations among those with dementia vs only 19% of all admissions among those who remained dementia free.

Examining all-cause and ACSC admission rates by dementia etiology (Alzheimer disease alone vs other etiologies) compared with the group that remained dementia free (Table 4) revealed that dementia was associated with higher rates of admission regardless of etiology.

Relationship Between Death and Hospitalization

To better understand to what extent the higher mortality rate among persons

with dementia might explain their higher hospitalization rates, multivariate analyses were repeated, excluding follow-up periods in which a person died. In these analyses, the association between dementia and admission rates remained significant and was attenuated for all-cause but not ACSC admissions (fully adjusted rate ratios, 1.21; 95% CI, 1.02-1.43; $P=.03$ for all-cause hospitalizations and 1.71; 95% CI, 1.24-2.34; $P=.001$ for ACSC hospitalizations).

COMMENT

We found significantly higher all-cause and ACSC admission rates for persons with dementia compared with those without dementia. Adjusted admission rates for most disease categories were significantly higher in the dementia group and also higher for all types of ACSCs, including bacterial pneumonia, CHF, dehydration, duodenal ulcer, and UTI. While higher mortality rates for persons with dementia accounted for about half of the difference in the all-cause admission rate, it accounted for very little of their higher rate of admissions for ACSCs.

Ours may be the first study to report rates of and reasons for hospitalization among persons from the time of an incident research-based dementia diagnosis and with follow-up of most individuals until death. Most prior studies have used claims diagnoses or registry data to construct dementia and control groups and a window of 1 year or less to establish hospitalization rates.[1-7,9,42] Many studies could not adequately adjust for comorbidities. Because of the frequency of missed and delayed dementia diagnoses in usual clinical practice,[43] claims and registry data from such studies of prevalent dementia are likely to identify hospitalizations predominantly during middle and later stages of cognitive decline. Studies relying on claims data to classify cases and controls are also susceptible to misclassification bias, which our study overcame with the research evaluation for dementia conducted biennially for all participants as part of the ACT follow-up protocol. The availability of prospectively collected ACT data along with GHC delivery system data allowed us to adjust for a number of potential confounders (age, sex, and measures of comorbidity) that have been found to be independent predictors for hospitalization among persons with Alzheimer-type dementia[42] as well as for place of residence, increasing confidence that the effect on hospitalizations is specific for the presence of dementia.

Our findings extend the small literature on hospitalizations in dementia that, as a whole, has not looked systematically or comprehensively at hospital discharge diagnoses.[1-7] Furthermore, by examining all forms of dementia developing within a population-based sample of community-dwelling elders, evaluated prospectively using research standards for diagnosis, our work extends prior studies that have examined only certain dementia diagnoses (eg, Alzheimer disease, vascular dementia)[1,4,5,7] and often lack information about diagnostic reliability.

Table 1. Baseline Characteristics of Cohorts Who Did and Did Not Develop Dementia in the Adult Changes in Thought Study[a]

Characteristics	Developed Dementia (n = 494)	Did Not Develop Dementia (n = 2525)	*P* Value	
			Unadjusted	Age- and Sex-Adjusted
Age, mean (SD), y	78.0 (6.0)	74.5 (6.1)	<.001	
Age distribution, y				
65-74	148 (30.0)	1429 (56.6)	<.001	
75-84	274 (55.5)	914 (36.2)		
≥85	72 (14.5)	182 (7.2)		
Female	305 (61.7)	1493 (59.1)	.28	
High school graduate	402 (81.4)	2200 (87.1)	<.001	.008
Nonwhite	35 (7.1)	257 (10.2)	.03	.18
Annual income, median, $[b]	23 820	27 478	.001	.001
Living alone	196 (39.7)	910 (36.0)	.13	.35
Current smoker	27 (5.5)	153 (6.1)	.79	.60
Exercise ≥3 times/wk	337 (68.2)	1813 (71.8)	.10	.32
Poor self-rated health	13 (2.6)	38 (1.5)	.08	.15
Difficulty with ADLs				
Bathing	25 (5.1)	109 (4.3)	.46	.62
Ambulating	40 (8.1)	146 (5.8)	.05	.45
Transferring	91 (18.4)	423 (16.8)	.37	.68
Dressing	39 (7.9)	106 (4.2)	<.001	.006
Feeding	3 (0.6)	23 (0.9)	.50	.26
Toileting	9 (1.8)	43 (1.7)	.85	.62
Chronic conditions				
Cancer, nonskin	80 (16.2)	444 (17.6)	.46	.07
Depression	75 (15.2)	246 (9.7)	<.001	.003
Heart disease	103 (20.9)	487 (19.3)	.42	.85
Hypertension	191 (38.7)	980 (38.8)	.95	.40
Congestive heart failure	23 (4.7)	96 (3.8)	.37	.98
Diabetes	52 (10.5)	239 (9.5)	.46	.24
Stroke	21 (4.3)	81 (3.2)	.24	.58
Parkinson disease	10 (2.0)	8 (0.3)	<.001	<.001
RxRisk score, mean (SD), $[c]	4872 (2707)	4336 (2890)	<.001	.18
CASI raw score, mean (SD)[d]	90.3 (5.7)	93.6 (4.4)	<.001	<.001
Hospitalized for medical condition in 2 y prior to baseline	112 (22.7)	455 (18.0)	.01	.17

Abbreviations: ADLs, activities of daily living; CASI, Cognitive Abilities Screening Instrument.
[a] Data are expressed as No. (%) of participants unless otherwise indicated.
[b] Interquartile range could not be computed because the highest income category was low (≥$30 000).
[c] Calculation of RxRisk scores used estimated health care costs based on prescription drug fills for the 12-month period prior to a participant's enrollment in the Adult Changes in Thought study.
[d] CASI score range, 0-100.

Why might dementia lead to more frequent hospitalization? The explanation is likely multifaceted. First, underlying conditions that increase the risk of dementia (eg, stroke) or that develop in the setting of dementia (eg, trouble swallowing, which increases the risk of pneumonia) may increase the risk of hospitalization. Second, because of its primary deleterious effects on global cognition, executive function, expressive language, symptom perception, and awareness of deficits, dementia impairs the ability to self-manage chronic conditions and to pinpoint symptoms and alert others to their presence, thereby creating substantial diagnostic and treatment challenges for primary care clinicians.[44] Situational factors might also contribute, including a change of living situation, or the temporary or permanent absence of a caregiver familiar with the person's usual habits, behaviors, and ongoing general medical management. Another potential explanation is that the threshold for hospitalizing such persons may

Table 2. Hospital Admission Rates per 1000 Person-Years for All Causes by Principal Discharge Diagnosis Category for Groups With and Without Dementia

Discharge Diagnosis Category	Crude Admission Rate (No. of Admissions)[a]		Unadjusted Rate Ratio (95% CI)	Unadjusted *P* Value	Age-/Sex-Adjusted Rate Ratio (95% CI)[b]	Age-/Sex-Adjusted *P* Value	Fully Adjusted Rate Ratio (95% CI)[c]	Fully Adjusted *P* Value
	Dementia	No Dementia						
All admissions	419 (714)	200 (4614)	2.10 (1.87-2.35)	<.001	1.57 (1.39-1.78)	<.001	1.41 (1.23-1.61)	<.001
Circulatory	112 (190)	58 (1345)	1.92 (1.60-2.29)	<.001	1.58 (1.30-1.93)	<.001	1.42 (1.16-1.75)	<.001
Digestive	40 (68)	23 (529)	1.71 (1.28-2.28)	<.001	1.21 (0.90-1.67)	.20	1.17 (0.84-1.61)	.35
Endocrine	10 (17)	4 (100)	2.31 (1.37-3.88)	.002	1.56 (0.86-2.72)	.15	1.03 (0.54-1.96)	.92
Genitourinary	37 (63)	9 (209)	4.09 (2.87-5.81)	<.001	3.00 (1.92-4.60)	<.001	2.46 (1.55-3.92)	<.001
Infections	15 (25)	4 (85)	3.99 (2.48-6.42)	<.001	2.17 (1.30-3.61)	.003	2.01 (1.15-3.52)	.02
Musculoskeletal	7 (11)	20 (468)	0.32 (0.18-0.58)	<.001	0.30 (0.16-0.54)	<.001	0.31 (0.17-0.57)	<.001
Nervous system	11 (18)	2 (54)	4.52 (2.24-9.12)	<.001	3.19 (1.49-6.87)	.003	2.91 (1.18-7.18)	.02
Respiratory	66 (112)	21 (486)	3.12 (3.13-2.43)	<.001	2.03 (1.53-2.69)	<.001	1.65 (1.21-2.25)	.002
Other[d]	123 (210)	58 (1328)	2.14 (1.80-2.56)	<.001	1.57 (1.30-1.90)	<.001	1.46 (1.19-1.79)	<.001

[a] Admission rate shown as mean number of admissions per 1000 persons per year. Total years of follow-up (used in computation of rates) were 23 092 years for the dementia-free group and 1703 for the dementia group.
[b] Adjusted for age (age modeled using linear and quadratic terms, 1 set for men and 1 set for women), sex, calendar year, and wave (ie, original or expansion)[10] of the Adult Changes in Thought study cohort.
[c] Adjusted for age, sex, race/ethnicity, education, living alone (all assessed only at baseline), and time-varying variables, including calendar year of admission, self-rating of health, count of number of activities of daily living performed with difficulty, and RxRisk (log transformed). Models for all admissions are adjusted for all of the preceding covariates plus cancer, diabetes, and heart disease.
[d] "Other" category includes liver disorders; skin disorders; mental health and substance abuse disorders; blood disorders; reproductive organ disorders; neoplasms; ear, nose, mouth, and throat disorders; eye disorders; and injuries.

Table 3. Hospital Admission Rates per 1000 Person-Years for ACSCs (Potentially Preventable) for Groups With and Without Dementia

Cause of Hospitalization	Crude Admission Rate (No. of Admissions)[a]		Unadjusted Rate Ratio (95% CI)	Unadjusted *P* Value	Age-/Sex-Adjusted Rate Ratio (95% CI)[b]	Age-/Sex-Adjusted *P* Value	Fully Adjusted Rate Ratio (95% CI)[c]	Fully Adjusted *P* Value
	Dementia	No Dementia						
All ACSC admissions[d]	116 (198)	37 (845)	3.18 (2.59-3.90)	<.001	2.19 (1.74-2.76)	<.001	1.78 (1.38-2.31)	<.001
Angina[e]	0	2 (46)		<.001	NA[f]	NA[f]	NA[f]	NA[f]
Bacterial pneumonia	34 (57)	10 (225)	3.44 (2.48-4.75)	<.001	2.16 (1.47-3.13)	<.001	1.88 (1.25-2.82)	.002
Cellulitis	4 (6)	3 (67)	1.21 (0.39-3.80)	.74	1.03 (0.34-3.10)	.95	0.78 (0.23-2.61)	.69
CHF exacerbation	33 (56)	10 (233)	3.26 (2.29-4.64)	<.001	2.10 (1.41-3.10)	<.001	1.73 (1.15-2.60)	.01
COPD exacerbation	7 (12)	3 (76)	2.14 (0.98-4.69)	.06	1.43 (0.62-5.91)	.40	1.15 (0.49-2.67)	.75
Dehydration	5 (8)	1 (21)	5.17 (2.26-11.81)	<.001	4.56 (1.51-13.89)	<.001	NA[f]	NA[f]
Duodenal ulcer	5 (8)	1 (15)	7.23 (3.07-17.04)	<.001	4.30 (1.63-11.32)	.003	4.39 (1.66-11.50)	.003
Gastric ulcer	4 (6)	1 (32)	2.54 (0.95-6.82)	.06	2.57 (0.77-8.25)	.12	2.42 (0.77-7.65)	.13
UTI	25 (42)	3 (76)	7.49 (4.94-11.37)	<.001	4.31 (2.53-7.28)	<.001	3.38 (1.93-5.93)	<.001

Abbreviations: ACSC, ambulatory care–sensitive condition (condition for which hospitalization may be preventable with adequate outpatient care); CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; UTI, urinary tract infection.
[a] Admission rate shown as mean number of admissions per 1000 persons per year. Total years of follow-up (used in computation of rates) were 23 092 years for the dementia-free group and 1703 for the dementia group.
[b] Adjusted for age (age modeled using linear and quadratic terms, 1 set for men and 1 set for women), sex, calendar year, and wave (ie, original or expansion)[10] of the Adult Changes in Thought study cohort.
[c] Adjusted for age, sex, race/ethnicity, education, living alone (all assessed only at baseline), and time-varying variables, including calendar year of admission, self-rating of health, count of number of activities of daily living performed with difficulty, and RxRisk (log transformed). Models for all ambulatory care–sensitive conditions admissions are adjusted for all of the preceding covariates plus cancer, diabetes, and heart disease.
[d] Admissions for ACSCs occurring in 20 or fewer instances were omitted from the table (asthma, diabetes, ear/nose/throat infection, gastroenteritis, hypertension, hypoglycemia, hypokalemia, influenza, malnutrition, peptic ulcer, and seizure disorder).
[e] Adjusted analyses could not be run for angina because there were 0 admissions in the dementia group.
[f] Data are not applicable (NA) because adjusted rate ratio and *P* value from Poisson regression could not be computed because of too few admissions.

Table 4. Hospital Admission Rates per 1000 Person-Years for All Causes and ACSCs (Potentially Preventable) by Dementia Type vs Group Without Dementia

	Crude Admission Rate (No. of Admissions)[a]			Adjusted Rate Ratio (95% CI)[b]		Adjusted *P* Value	
	Dementia Type						
	AD-Type	Other[c]	No Dementia	AD-Type vs No Dementia	Other vs No Dementia	AD-Type vs No Dementia	Other vs No Dementia
All admissions	358 (375)	518 (339)	200 (4614)	1.27 (0.93-1.50)[d]	1.61 (1.33-1.96)	.005	<.001
ACSC admissions	99 (104)	144 (94)	37 (845)	1.65 (1.21-2.24)	1.92 (1.39-2.66)	.002	<.001

Abbreviations: ACSC, ambulatory care–sensitive condition (condition for which hospitalization may be preventable with adequate outpatient care); AD, Alzheimer disease.
[a] Admission rate shown as mean number of admissions per 1000 persons per year. Total years of follow-up (used in computation of rates) were 23 092 years for the group without dementia, 1049 years for the group with AD-type dementia, and 654 years for the group with other dementia.
[b] Adjusted for age, sex, race/ethnicity, education, living alone (all assessed only at baseline), and time-varying variables, including calendar year of admission, self-rating of health, count of number of activities of daily living performed with difficulty, RxRisk (log transformed), cancer, diabetes, and heart disease.
[c] Other dementia includes non-AD etiologies and AD mixed with additional etiologies.
[d] Test of whether the rate ratio for AD vs no dementia differs from the rate ratio for other dementia vs no dementia: $P = .07$ for all admissions and $P = .50$ for ACSC admissions.

be lower because dementia increases central nervous system vulnerability to the metabolic effects of acute illness, such that for a comparable severity of illness, persons with dementia are in fact sicker (eg, more likely to develop delirium and functional impairments as a result of acute illness).[45]

Three ACSCs, pneumonia, CHF, and UTI, accounted for two-thirds of all potentially preventable admissions among persons with dementia. Knowledge of the ACSCs most likely to lead to hospitalization is important, as this information may help clinicians focus their differential diagnostic considerations and thereby permit proactive, early management for these conditions among patients with dementia. Early detection and outpatient management of acute illness when it is still in its early phases might minimize the need for hospitalization for these conditions and help health care organizations reduce their rates of ACSC admissions and associated costs.

The excess dementia-associated hospitalization rates in our study are somewhat lower than reported previously[46] but still considerable from the standpoint of burdened health care systems. Our results may reflect methodological refinements over prior work, including earlier, more reliable dementia diagnosis and comprehensive adjustment for confounders, including time-varying covariates (eg, comorbidities) assessed regularly during follow-up along with nondementia factors known to be associated with ACSC hospitalizations (eg, advanced age, impaired activities of daily living).[30] In addition, our longitudinal design more accurately represents the chronic, multiyear course of dementing diseases than do studies assessing admissions over 1 or 2 years. From a health systems planning perspective, our estimates of the risk of hospitalizations related to dementia can probably be considered a lower bound of risk.

Prior studies that have used claims diagnoses have found higher hospitalization rates for persons with other dementias compared with Alzheimer-type dementia.[4] In contrast, in our study, rates were not significantly different across these groups for either all-cause or ACSC admissions. The explanation for this discrepant finding is uncertain but may result from differences in how dementia etiology was ascertained.

Our work has some limitations. The study included only consenting GHC enrollees; ACT participants may have been younger and healthier at enrollment than the general population, indicated by their willingness to participate. As an integrated health plan and health care delivery system, GHC takes a proactive approach to health care to manage risk, and existing programs seek to anticipate and manage complications of chronic diseases.[47] Therefore, our observed rate of ACSC hospitalizations is likely to be lower than that in less-integrated, fee-for-service environments. In a study of ACSC hospitalizations in the Medicare+Choice (managed care) population,[31] a somewhat higher unadjusted rate (47 ACSC admissions/1000) than ours (42 ACSC admissions/1000) was observed; although the distribution of ACSCs was similar, dementia status and impact were not evaluated. In this study, we were not able to determine how many of the individual ACSCs were actually preventable. Verification of preventability would have required chart review and adjudication of the preventability of each admission, activities that were beyond the scope of our study. Last, we did not examine discharge diagnoses according to other potentially relevant groupings (eg, medical vs surgical diagnoses, elective vs emergency admissions).

These limitations not withstanding, this study has several noteworthy strengths: incident research-based dementia diagnosis; follow-up of most participants until death; a large sample size; a control group from the same population-based, longitudinal cohort of community-dwelling elders as dementia cases; average follow-up of more than 8 years and a relatively long duration of follow-up (>3 years on average) after dementia diagnosis; complete capture of hospitalizations through GHC's automated data warehouse[24]; a comprehensive assessment of discharge diagnoses across the spectrum of diagnostic codes, which permits comparisons with other studies[25]; a complete spectrum of dementia types, rather than a single etiology; and high completeness of follow-up for the overall cohort, which minimizes misclassification bias.

In summary, our findings that persons with dementia have higher rates of

hospitalizations for most categories of medical illness and for ACSCs suggest that there may be important opportunities for improving care of demented older persons, including developing better strategies for delivering anticipatory, proactive primary care to this population. The characteristic feature of late-life dementia—cognitive impairment in the face of multiple other comorbidities—presents a special challenge not currently addressed in models of chronic disease care.

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Study concept and design: Phelan, Borson, Grothaus.
Acquisition of data: Larson.
Analysis and interpretation of data: Phelan, Borson, Grothaus, Balch, Larson.
Drafting of the manuscript: Phelan.
Critical revision of the manuscript for important intellectual content: Borson, Grothaus, Balch, Larson.
Statistical analysis: Grothaus, Balch.
Obtained funding: Phelan, Larson.
Study supervision: Borson, Larson.
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