**Prevalence of Alzheimer disease in individual US states**

**and the District of Columbia, 2010-2025**

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*e-Supplement*

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**BACKGROUND**

In 2010, approximately 4.7 million older adults in the United States (US) had Alzheimer disease dementia (AD), a number that is projected to triple by 2050.1 Quantifying the burden of AD on individual US states is critical, because states coordinate, administer, regulate, and fund many key programs and services for persons with AD and their families. Chief among these services is long-term nursing home care, a service that many, if not most, persons with AD require during the course of their illness.2-4 Federal and state governments jointly fund, but individual states manage Medicaid, the only public health insurance program that provides coverage for long-term nursing home care. By contrast, Medicare does not cover long-term care. Individuals who do not qualify for Medicaid can attain eligibility by sufficiently depleting their assets, which they can accomplish readily given the high costs of AD-associated health care, including $92,977 per year on average in 2013 for a private room in a nursing home.5 In 2008, annual per person Medicaid payments for services provided to persons with AD or another dementia were $47,000 (in 2013 dollars), nearly 20 times as great as payments for services delivered to other older Americans.5

Recognizing the high prevalence of AD and its predicted growth, many states have developed plans to address the needs of persons with AD, their caregivers, and the health care workforce.6, 7 Central to many plans is the coordination of care and caregiver services. Some states also promote the entry of more workers into the field of paid caregiving and geriatric care,7, 8 where existing shortages are projected to worsen. States have been settings for evidence-based AD caregiver interventions translated to the “real world” (e.g., 9, 10), because states have access to resources necessary for implementation such as Agencies on Aging and links to key local clinical services. Although state governments play a critical role in affecting the lives of persons with AD, their families, and the health care system and supports that serve these individuals, the burden of AD in each state is not uniform and will change over time according to its population size and age structure.

Although AD is common in older adults, a host of conceptual and logistical barriers make it difficult to count the number of people with this condition. By definition, Alzheimer disease is disease of gradual onset, meaning that diagnostic thresholds for Alzheimer disease *dementia* are necessarily arbitrary. Moreover, regular, standardized diagnostic assessments for AD are simply not a reality; by some estimates, half of older adults with AD do not have a documented diagnosis.11, 12 For these and other reasons, there are no AD surveillance systems, and it would be extremely difficult to devise mandatory reporting requirements for the condition. To estimate the number of older adults with AD in each state, we used an alternative approach, extrapolating to each state’s population the estimates of AD prevalence calculated from a study of a longitudinal, community-based population that systematically underwent standardized neurologic evaluation. These state-specific estimates pertain to the years 2010-2025 and update previous estimates that are a decade old.13

**METHODS**

We estimated the number of adults, ages 65 years old and older, with Alzheimer disease dementia (AD) in each US state and the District of Columbia (DC), by applying the annual AD incidence and AD mortality hazard identified in a systematically evaluated community to each state’s population, accounting for each state’s age structure, mortality patterns, and other demographic characteristics. Details of this procedure follow.

**AD data**. As previously described,1 we obtained AD incidence and mortality data from the Chicago Health and Aging Project (CHAP),14, 15 a longitudinal, population-based study of older adults (60% of whom were black, 40% of whom were white) living in a geographically defined area of Chicago. Briefly, the study began in 1993 with a census of individuals aged 65 years or older. Of those identified, 6,158 (79%) participated in a home interview. Additional people were recruited as they turned age 65 for a total of 10,802 participants through 2011. Participants were re-interviewed in 3-year cycles. Each data-collection cycle consisted of an in-home interview of all participants and clinical evaluation for AD dementia of a stratified, random sample. Between 1997 and 2010, 402 cases of incident AD dementia were identified in 2,577 evaluations among 1,913 individuals determined to be free of AD dementia at the previous cycle. All persons examined received identical structured clinical evaluations. Criteria for AD dementia were those of the Work Group of the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer’s Disease and Related Disorders Association for probable AD dementia,16 except that persons who met these criteria and had another condition impairing cognition were retained. There were 990 deaths.

From the CHAP data, we calculated separate annual incidence estimates for 432 groups defined by single year of age (65 to 100 plus years), sex, 2 race groups, and 3 education groups.

Individuals provided their informed consent to participate in CHAP. The study was approved by the Rush University Medical Center Institutional Review Board.

**State-specific prevalence estimation**. For each state and DC, we applied the incidence estimates computed from the CHAP data to the corresponding state subpopulation jointly defined by year of age (beginning with age 65), sex, education and calendar year. Thirty-four states and DC had populations of black residents that were large enough to compute these estimates within strata of race (white; black and all others). We started by computing a weighted average incidence across the education groups. For each calendar year and each state, we computed smoothed estimates of the proportion in the 3 education groups within each subpopulation jointly defined by age, sex, and (where possible) race using education data from the American Community Survey.17 Because we “age” the population to obtain future education estimates, we start the education calculations at the 25-29-year age group. This survey data contained sparse numbers of responses for a given single year of age. To compensate for this, we averaged the proportions in the 3 education groups over 5 years of age by first summing the survey responses in each education group and then dividing each education group-specific sum by the total count across all 3 groups. We assigned these proportions to the middle year of the age range (e.g., 27 or 32) and used linear interpolation to assign proportions to other ages (e.g., 28-31). This procedure generated the education distribution for 2010. For 2011, we shifted ages up by one year, and so on.

We then estimated the prevalence of AD dementia in each state and DC in each subpopulation jointly defined by year of age (beginning with age 65), sex, and calendar year. Each estimate incorporated information on the AD dementia and mortality experience of the corresponding birth cohort in previous years. We used National Center for Health Statistics (NCHS) life-table estimates of number of people alive (of a theoretical birth cohort of 100,000) and probability of death for the relevant age, sex, race and calendar year. We started with state-specific life tables for 2000.18 To estimate mortality rates for the years 1975-1999 and 2001-2025, we used the method of the Census Bureau:19 for each state, we took the difference between the state’s probability of mortality and the national probability for each sex, race and year of age, and then applied that difference to each historical or projected US mortality rate20 to obtain the state’s estimated rate.

Beginning at age 65 for each birth cohort (and assuming no disease before age 65), we obtained the number of people developing AD dementia at each subsequent age and, therefore, calendar year by multiplying the number of people alive without AD dementia at the beginning of the 1-year age interval by the probability of incident AD dementia for that age, sex, and race group. We added the new cases to the number with AD dementia carried over from the previous age in the previous calendar year and subtracted them from the disease-free number. Using 2.13 as the relative risk of dying with AD dementia21 and an iterative algorithm, we divided the total number of deaths in the age interval into those dying with and without AD dementia. We subtracted the deaths from the AD dementia and the AD dementia-free numbers to provide the new numbers of people with and without AD dementia for the next age in the subsequent year. We then divided the new number with AD dementia by the total number remaining alive to provide the proportion with prevalent disease. This was the process we used to compute the new cases of AD dementia before subtracting the deaths for the ensuing year. Because deaths occur throughout the year, we repeated the entire prevalence procedure, subtracting the deaths at each age before rather than after computing the new cases of AD dementia to provide a range for the prevalence proportion. We then averaged these 2 proportions for each age, sex, and race group.

In the final stage, we multiplied the proportion of prevalent AD dementia by the census estimate of number of people in each age, sex, and race group and summed across groups to obtain total numbers of people with AD dementia. For the 2010 estimates, we used 2010 US census state-specific populations.22 For AD prevalence projections, we used the US census estimates of state-specific population through 2025,23 the most recently available state-specific census population projections. The census projections lacked some detail that is present in current population data and national projections. Whereas the 2010 census provided counts for single years of age to 100 years, the state-specific projections grouped all ages over 85 years. To estimate numbers in single years of age from 85 to 100, we used the proportions in the US data by calendar year and sex. Finally, the projections generated from the 2000 census lacked race-specific numbers. We used older projections (from the 1990 census19) and the current black proportion of each age in 2010 (from the 2010 census) to estimate the future proportion of black individuals of each age in each of 34 states and DC.

**Sensitivity analysis.** Inaccuracies in the state-specific population projections24 may introduce errors into the state-specific projected AD prevalence. To show how prevalence estimates might vary depending on whether they are based on a current census versus a projected population from a previous census, we also computed state-specific AD prevalences using the 2010 population projected from 2000 census data.

**RESULTS**

In 2010, the number of older adults with AD in the populations of the states and DC ranged from 5.1 (Alaska) to 530 million (California). The size of a state’s older adult population is the strongest determinant of its estimate. For example, the states with the largest populations in 2010 – California, Florida, New York, and Texas – also had the largest older adult populations and, as expected, the largest estimated numbers of older adults with AD dementia (table 1).

Between 2010 and 2025, every state is expected to experience a double- to triple-digit percentage increase in the number of older adult residents with AD dementia (range, 19%-116%; e-table 1; figure 1). (By contrast, a small percentage decrease, 7%, is expected in DC because its older adult population is expected to decrease.) The largest predicted percentage increases are concentrated in western, southeastern, and mid-Atlantic states. In Arizona, Nevada and Alaska, the number of older adults with AD dementia is expected to double. Notably, some states with large predicted percentage increases—California, Florida, and Texas—already have large numbers of residents with the condition. In general, states in the Midwest and Northeast are projected to have lower predicted percentage increases.

Whereas a state’s number of older adult residents with AD describes the burden of this condition in absolute terms, this number as a percentage of a state’s total population roughly describes the burden of AD on the population without AD. A higher percentage suggests that AD may demand a larger fraction of resources (private and public) in a state. In 2010, older adults with AD dementia comprised a median of 1.6% of a given state’s total population (e-table 2). By 2025, in all states and DC, this proportion will be larger, by nearly one-third on average, with the largest percentage increases expected in Alaska (82%), Wyoming (66%), New Mexico (61%), and Vermont (58%).

The estimates of state-specific AD prevalence in 2010 that we computed using projected 2010 population data were slightly larger, by 3% on average (range, -12% to 12%), than estimates we computed using data from the 2010 census (e-table 3). However, when we used 2010 census data to compute the proportion of the total population with AD dementia, estimates were similar to those computed using the projected population data.

**DISCUSSION**

These estimates indicate that the number of older adults with AD in all US states (but not DC) will increase substantially by 2025. The population of older adults with AD will increase at a pace that exceeds increase in the total population: in every state, as well as DC, older adults with AD are expected to make up a substantially larger fraction of the population in 2025 than they did in 2010. Many states have developed their own Alzheimer’s disease plans in anticipation of the increasing burden on public resources, caregivers, and health care systems that the condition may entail. Yet some states, including some with the largest expected increases in AD prevalence, have not developed such a plan.6

The estimation approach we used circumvented the lack of systematic surveillance for AD and the severe problems inherent in relying on medical records or claims.11, 12 Nonetheless, our approach has several limitations that warrant mention. Most notable, we developed estimates of AD prevalence in each state in specific years from the observation of the incidence of AD dementia in a single community (the CHAP population) over the course of 18 years (1993-2010). Even within strata jointly defined by age, sex, education and race, the experience of the CHAP population might not generalize to state-specific populations or to different points in time. For example, although CHAP has numerous participants who are black or who are white, it has few participants of from other race or ethnic groups. This distinction is important if AD incidence or mortality among these groups is markedly higher or lower than the racial group to which our analyses assigned them. Estimates of future prevalence have the additional uncertainty that comes from uncertainty in estimates of the future population and, by extension, the future population at risk for AD dementia. By contrast, another study on the prevalence of dementia in the US—the Aging, Demographics, and Memory Study (ADAMS)—drew its participants from 42 states. However, ADAMS assessed less than half the number of older adults as CHAP did, and it included few participants from racial-ethnic groups not represented in CHAP (e.g., 84 of its 856 participants were Hispanic; 18 had AD).25 Thus, although this dataset could be the basis for reasonable alternative estimates of state-specific AD prevalences, even those estimates would hinge on at least as many assumptions entailed in using the CHAP data.

Compared with our national estimates of the number of people with AD,1 the state-specific estimates entail more measurement error. These estimates relied on state-specific projected population numbers made using 2000 census data for the years 2010-2025, and both the smaller scale and variably dynamic nature of state populations can make population counts challenging to estimate.26 Because the state-specific information also was not as detailed (e.g., ages older than 85 were grouped together), we made more assumptions about the missing detail in calculating each state’s AD prevalence. The populations counted by the 2010 census of the US and nearly all individual states were smaller than the estimates projected from the 2000 census. By extension, most of the state-specific AD cases for 2010 computed with projected population counts were higher than the corresponding estimates computed with 2010 census data. Further error may arise in projections of small segments of the population defined by age, sex and race. For example, the sum of the states’ population of 85+-year-old adults exceeded the US count for each projection year. As a result of this difference and of the additional uncertainty of the age distribution within that group, the sum of all states’ AD cases exceeded the US AD prevalence.1 These phenomena also contribute uncertainty to the estimation of each state’s AD cases as a proportion of its total population.

It is also worth emphasizing that our approach accounted only for key demographic features of each state (age, sex, race, education) but not for additional putative risk factors for AD, such as physical activity and diabetes. These data are not available at the level of detail required to incorporate them into our estimates. This means that differences in estimated prevalence across states can be explained only by these demographic factors. Yet advancing age is by far the strongest risk factor for AD. For example, among adults aged 85 and older both the incidence rate and prevalence of AD are about 10 times as great as among adults aged 65-74 years.1, 27

These limitations and discrepancies underscore that the exact number of individuals with AD in a given state is an estimate, one guided by reasonable but imperfect assumptions and data. Nonetheless, these uncertainties are small in comparison with the estimated trajectories that portend a substantial increase in the burden of AD on state populations.



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| **e-Table 2. Estimated number of older adults (65+ years) with Alzheimer disease dementia (AD), as a percentage of the total population in each US state and the District of Columbia, 2010-2025.** |
|   |   |   |   |   |   |
|   | **Older adults with AD as a percentage of the total population** |  | **Percentage change from 2010 to 2025** |   |
| **State** | **2010** | **2025** |  |   |
| Alaska | 0.7% | 1.3% |   | 82% |   |
| Alabama | 1.8% | 2.3% |   | 28% |   |
| Arkansas | 1.7% | 2.1% |   | 22% |   |
| Arizona | 1.5% | 2.1% |   | 39% |   |
| California | 1.4% | 1.9% |   | 36% |   |
| Colorado | 1.2% | 1.7% |   | 39% |   |
| Connecticut | 2.0% | 2.5% |   | 26% |   |
| District of Columbia | 1.8% | 2.0% |   | 8% |   |
| Delaware | 1.7% | 2.3% |   | 37% |   |
| Florida | 2.3% | 2.8% |   | 22% |   |
| Georgia | 1.3% | 1.7% |   | 33% |   |
| Hawaii | 1.8% | 2.4% |   | 36% |   |
| Iowa | 2.0% | 2.4% |   | 20% |   |
| Idaho | 1.3% | 1.8% |   | 35% |   |
| Illinois | 1.6% | 1.9% |   | 20% |   |
| Indiana | 1.6% | 1.9% |   | 24% |   |
| Kansas | 1.7% | 2.1% |   | 22% |   |
| Kentucky | 1.5% | 1.9% |   | 28% |   |
| Louisiana | 1.7% | 2.3% |   | 38% |   |
| Massachusetts | 1.8% | 2.2% |   | 20% |   |
| Maryland | 1.5% | 1.9% |   | 26% |   |
| Maine | 1.8% | 2.5% |   | 40% |   |
| Michigan | 1.6% | 2.1% |   | 26% |   |
| Minnesota | 1.5% | 2.0% |   | 27% |   |
| Missouri | 1.7% | 2.1% |   | 22% |   |
| Mississippi | 1.6% | 2.1% |   | 28% |   |
| Montana | 1.8% | 2.6% |   | 48% |   |
| North Carolina | 1.5% | 1.8% |   | 22% |   |
| North Dakota | 2.0% | 2.6% |   | 26% |   |
| Nebraska | 1.8% | 2.2% |   | 22% |   |
| New Hampshire | 1.4% | 2.0% |   | 40% |   |
| New Jersey | 1.8% | 2.2% |   | 23% |   |
| New Mexico | 1.6% | 2.5% |   | 61% |   |
| Nevada | 1.2% | 1.7% |   | 39% |   |
| New York | 1.9% | 2.4% |   | 27% |   |
| Ohio | 1.7% | 2.2% |   | 25% |   |
| Oklahoma | 1.6% | 2.0% |   | 23% |   |
| Oregon | 1.5% | 1.9% |   | 25% |   |
| Pennsylvania | 2.1% | 2.5% |   | 17% |   |
| Rhode Island | 2.0% | 2.3% |   | 18% |   |
| South Carolina | 1.6% | 2.4% |   | 46% |   |
| South Dakota | 2.0% | 2.5% |   | 23% |   |
| Tennessee | 1.6% | 2.0% |   | 26% |   |
| Texas | 1.2% | 1.6% |   | 30% |   |
| Utah | 1.0% | 1.3% |   | 35% |   |
| Virginia | 1.5% | 2.0% |   | 35% |   |
| Vermont | 1.5% | 2.4% |   | 58% |   |
| Washington | 1.4% | 1.8% |   | 27% |   |
| Wisconsin | 1.7% | 2.1% |   | 22% |   |
| West Virginia | 1.9% | 2.5% |   | 30% |   |
| Wyoming | 1.5% | 2.5% |   | 66% |   |

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| **e-Table 3. Comparison of 2010 estimated state-specific Alzheimer disease dementia (AD) prevalence computed with census data versus projected population data.** |
|   |   |   |   |   |   |   |   |
|  | **Number of older adults in 2010 with AD,****in thousands** |  | **Comparison with prevalence using 2010 census** |   |   |
| **State** | **Using 2010 census data** | **Using projected population data** |  | **Difference,in thousands** | **Percentage difference** |   |   |
| Alaska | 4.6 | 5.1 |   | 0.5 | 11% |   |   |
| Alabama | 78 | 82 |   | 4 | 5% |   |   |
| Arkansas | 49 | 50 |   | 1 | 2% |   |   |
| Arizona | 95 | 100 |   | 5 | 5% |   |   |
| California | 500 | 530 |   | 30 | 6% |   |   |
| Colorado | 58 | 58 |   | 0 | 0% |   |   |
| Connecticut | 66 | 70 |   | 4 | 6% |   |   |
| District of Columbia | 11 | 9.7 |   | -1.3 | -12% |   |   |
| Delaware | 15 | 15 |   | 0 | 0% |   |   |
| Florida | 400 | 440 |   | 40 | 10% |   |   |
| Georgia | 120 | 120 |   | 0 | 0% |   |   |
| Hawaii | 25 | 24 |   | -1 | -4% |   |   |
| Iowa | 59 | 61 |   | 2 | 3% |   |   |
| Idaho | 21 | 20 |   | -1 | -5% |   |   |
| Illinois | 200 | 210 |   | 10 | 5% |   |   |
| Indiana | 100 | 100 |   | 0 | 0% |   |   |
| Kansas | 47 | 49 |   | 2 | 4% |   |   |
| Kentucky | 64 | 64 |   | 0 | 0% |   |   |
| Louisiana | 69 | 77 |   | 8 | 12% |   |   |
| Massachusetts | 110 | 120 |   | 10 | 9% |   |   |
| Maryland | 87 | 90 |   | 3 | 3% |   |   |
| Maine | 23 | 24 |   | 1 | 4% |   |   |
| Michigan | 170 | 170 |   | 0 | 0% |   |   |
| Minnesota | 83 | 84 |   | 1 | 1% |   |   |
| Missouri | 100 | 100 |   | 0 | 0% |   |   |
| Mississippi | 47 | 49 |   | 2 | 4% |   |   |
| Montana | 16 | 17 |   | 1 | 6% |   |   |
| North Carolina | 140 | 140 |   | 0 | 0% |   |   |
| North Dakota | 13 | 13 |   | 0 | 0% |   |   |
| Nebraska | 31 | 32 |   | 1 | 3% |   |   |
| New Hampshire | 20 | 20 |   | 0 | 0% |   |   |
| New Jersey | 150 | 160 |   | 10 | 7% |   |   |
| New Mexico | 29 | 31 |   | 2 | 7% |   |   |
| Nevada | 30 | 32 |   | 2 | 7% |   |   |
| New York | 340 | 360 |   | 20 | 6% |   |   |
| Ohio | 200 | 200 |   | 0 | 0% |   |   |
| Oklahoma | 56 | 58 |   | 2 | 4% |   |   |
| Oregon | 58 | 56 |   | -2 | -3% |   |   |
| Pennsylvania | 260 | 270 |   | 10 | 4% |   |   |
| Rhode Island | 21 | 22 |   | 1 | 5% |   |   |
| South Carolina | 72 | 73 |   | 1 | 1% |   |   |
| South Dakota | 15 | 16 |   | 1 | 7% |   |   |
| Tennessee | 97 | 98 |   | 1 | 1% |   |   |
| Texas | 290 | 300 |   | 10 | 3% |   |   |
| Utah | 26 | 25 |   | -1 | -4% |   |   |
| Virginia | 110 | 120 |   | 10 | 9% |   |   |
| Vermont | 10 | 10 |   | 0 | 0% |   |   |
| Washington | 90 | 90 |   | 0 | 0% |   |   |
| Wisconsin | 98 | 100 |   | 2 | 2% |   |   |
| West Virginia | 34 | 35 |   | 1 | 3% |   |   |
| Wyoming | 7.1 | 7.7 |   | 0.6 | 8% |   |   |

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**Figure.** Percentage change from 2010 to 2025 in the number of older adults (65 years and older) with AD dementia, by state.