2018 ALZHEIMER'S DISEASE FACTS AND FIGURES

Includes a Special Report on the Financial and Personal Benefits of Early Diagnosis

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About this report

2018 Alzheimer's Disease Facts and Figures is a statistical resource for U.S. data related to Alzheimer's disease, the most common cause of dementia. Background and context for interpretating the data are contained in the Overview. Additional sections address prevalence, mortality and morbidity, caregiving and use and costs of health care and services. A Special Report discusses the financial and personal benefits of diagnosing earlier in the disease process, in the stage of mild cognitive impairment.

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Specific information in this year's *Alzheimer's Disease Facts and Figures* includes:

- Brain changes that occur with Alzheimer's disease (page 8).
- Revised guidelines for diagnosing Alzheimer's disease (page 15).
- Number of Americans with Alzheimer's dementia nationally (page 17) and for each state (page 19).
- Proportion of women and men with Alzheimer's and other dementias (page 18).
- Lifetime risk for developing Alzheimer's dementia (page 22).
- Number of deaths due to Alzheimer's disease nationally (page 25) and for each state (page 27), and death rates by age (page 29).
- Number of family caregivers, hours of care provided, and economic value of unpaid care nationally and for each state (page 34).
- The impact of caregiving on caregivers (page 34).
- National cost of care for individuals with Alzheimer's or other dementias, including costs paid by Medicare and Medicaid and costs paid out of pocket (page 43).
- Medicare payments for people with dementia compared with people without dementia (page 46).
- Benefits of earlier detection of Alzheimer's disease. (page 62).
- Cost savings of diagnosing during the earlier mild cognitive impairment stage rather than the dementia stage (page 64).

The Appendices detail sources and methods used to derive statistics in this report.

When possible, specific information about Alzheimer's disease is provided; in other cases, the reference may be a more general one of "Alzheimer's or other dementias."

What Is "Alzheimer's Dementia"?

A Note About Terminology

As discussed in the Overview (page 4), under the 1984 diagnostic guidelines, only individuals with symptoms such as significant problems with learning, thinking or memory could receive a diagnosis of Alzheimer's disease. Under the 2011 guidelines, however, individuals could receive a diagnosis of Alzheimer's disease if they had the brain changes of Alzheimer's that precede the onset of symptoms; if they had the subtle symptoms of mild cognitive impairment due to the brain changes of Alzheimer's; and if they had significant problems with learning, thinking or memory (dementia) due to the brain changes of Alzheimer's. The 2011 guidelines build upon research suggesting that Alzheimer's disease encompasses a continuum beginning with the initial brain changes of Alzheimer's that start years before symptoms appear, continuing with years of symptoms that affect cognitive and physical function, and ending with severe Alzheimer's, when brain changes are so extensive that individuals can no longer walk and struggle to communicate. As a result, what was "Alzheimer's disease" under the 1984 guidelines is called "dementia due to Alzheimer's" or "Alzheimer's dementia" under the 2011 guidelines — one stage in the continuum of the disease.

This edition of *Alzheimer's Disease Facts and Figures* reflects this change in understanding and terminology. That is, the term "Alzheimer's disease" is now used only in those instances that refer to the underlying disease or the entire continuum of the disease. The term "Alzheimer's dementia" is used to describe the dementia stage of the continuum. Thus, in most instances where past editions of the report used "Alzheimer's disease," the current edition uses "Alzheimer's dementia." The data examined are comparable across editions — only the way of describing the affected population has changed.

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OVERVIEW

20
or more
years

before symptoms appear,
brain changes associated with
Alzheimer's disease may begin.

Alzheimer's disease is a degenerative brain disease and the most common cause of dementia.[1-2] Dementia is a syndrome — a group of symptoms — that has a number of causes. The characteristic symptoms of dementia are difficulties with memory, language, problem-solving and other cognitive skills that affect a person's ability to perform everyday activities. These difficulties occur because nerve cells (neurons) in parts of the brain involved in cognitive function have been damaged or destroyed. In Alzheimer's disease, neurons in other parts of the brain are eventually damaged or destroyed as well, including those that enable a person to carry out basic bodily functions such as walking and swallowing. People in the final stages of the disease are bed-bound and require around-the-clock care. Alzheimer's disease is ultimately fatal.

Dementia

When an individual has symptoms of dementia, a physician will conduct tests to identify the cause. Different causes of dementia are associated with distinct symptom patterns and brain abnormalities, as described in Table 1 (see page 6). Studies show that many people with dementia symptoms have brain abnormalities associated with more than one cause of dementia.[3-7] For example, studies report that about half of people who had the brain changes of Alzheimer's dementia on autopsy also had the brain changes of a second cause of dementia, most commonly vascular dementia.[4-5] This is called mixed dementia.

In some cases, individuals have dementia-like symptoms without the progressive brain changes of Alzheimer's or other degenerative brain diseases. Common causes of dementia-like symptoms are depression, delirium, side effects from medications, thyroid problems, certain vitamin deficiencies and excessive use of alcohol. Unlike Alzheimer's and other brain diseases, these conditions often may be reversed with treatment.

Alzheimer's Disease

Alzheimer's disease was first described in 1906, but about 70 years passed before it was recognized as a common cause of dementia and a major cause of death.[8] Only then did Alzheimer's disease become a significant focus of research. The research that followed has revealed a great deal, including the fact that Alzheimer's disease begins years before the symptoms of Alzheimer's dementia are present. Much is yet to be discovered about the precise biological changes of Alzheimer's disease that lead to the symptoms of Alzheimer's dementia, why the disease and its symptoms progress more quickly in some than in others, and how the disease can be prevented, slowed or stopped.

Symptoms of Alzheimer's Dementia

Symptoms vary among people with Alzheimer's dementia, and the differences between typical age-related cognitive changes and early signs of Alzheimer's dementia can be subtle (see Table 2, page 9).

Individuals with Alzheimer's dementia experience multiple symptoms that change over a period of years. These symptoms reflect the degree of damage to neurons in different parts of the brain. The pace at which symptoms advance from mild to moderate to severe varies from person to person.

In the mild stage, most people are able to function independently in many areas but are likely to require assistance with some activities to maximize independence and remain safe. They may still be able to drive, work and participate in favorite activities. In the moderate

TABLE 1

Causes of Dementia and Associated Characteristics*

Cause	Characteristics
Alzheimer's disease	Most common cause of dementia; accounts for an estimated 60 percent to 80 percent of cases. Autopsy studies show that about half of these cases involve solely Alzheimer's pathology; many of the remaining cases have evidence of additional pathologic changes related to other dementias. This is called mixed pathology, and if recognized during life is called mixed dementia. Difficulty remembering recent conversations, names or events is often an early clinical symptom; apathy and depression are also often early symptoms. Later symptoms include impaired communication, disorientation, confusion, poor judgment, behavioral changes and, ultimately, difficulty speaking, swallowing and walking. Revised guidelines for diagnosing Alzheimer's were proposed and published in 2011 (see page 15). They recommend that Alzheimer's be considered a slowly progressive brain disease that begins well before clinical symptoms emerge. The hallmark pathologies of Alzheimer's are the progressive accumulation of the protein fragment beta-amyloid (plaques) outside neurons in the brain and twisted strands of the protein tau (tangles) inside neurons. These changes are eventually accompanied by the damage and death of neurons.
Vascular dementia	The brain changes of vascular dementia are found in about 40 percent of brains from individuals with dementia.[4-5] About 10 percent of brains from individuals with dementia show evidence of vascular dementia alone. However, it is very common as a mixed pathology in older individuals with Alzheimer's dementia, about 50 percent of whom have pathologic evidence of infarcts (silent strokes).[9] Impaired judgment or impaired ability to make decisions, plan or organize is more likely to be the initial symptom, as opposed to the memory loss often associated with the initial symptoms of Alzheimer's. In addition to changes in cognition, people with vascular dementia can have difficulty with motor function, especially slow gait and poor balance. Vascular dementia occurs most commonly from blood vessel blockage or damage leading to infarcts (strokes) or bleeding in the brain. The location, number and size of the brain injuries determine whether dementia will result and how the individual's thinking and physical functioning will be affected. In the past, evidence of vascular dementia was used to exclude a diagnosis of Alzheimer's (and vice versa). That practice is no longer considered consistent with the pathologic evidence, which shows that the brain changes of Alzheimer's and vascular dementia commonly coexist. When there is clinical evidence of two or more causes of dementia, the individual is considered to have mixed dementia.
Dementia with Lewy bodies (DLB)	People with DLB have some of the symptoms common in Alzheimer's, but are more likely to have initial or early symptoms of sleep disturbances, well-formed visual hallucinations, and slowness, gait imbalance or other parkinsonian movement features. These features, as well as early visuospatial impairment, may occur in the absence of significant memory impairment. Lewy bodies are abnormal aggregations (or clumps) of the protein alpha-synuclein in neurons. When they develop in a part of the brain called the cortex, dementia can result. Alpha-synuclein also aggregates in the brains of people with Parkinson's disease (PD), in which it is accompanied by severe neuronal loss in a part of the brain called the substantia nigra. While people with DLB and PD both have Lewy bodies, the onset of the disease is marked by motor impairment in PD and cognitive impairment in DLB. The brain changes of DLB alone can cause dementia, but very commonly people with DLB have coexisting Alzheimer's pathology. In people with both DLB and Alzheimer's pathology, symptoms of both diseases may emerge and lead to some confusion in diagnosis. Vascular dementia can also coexist and contribute to the dementia. When evidence of more than one dementia is recognized during life, the individual is said to have mixed dementia.

TABLE 1 (cont.)

Causes of Dementia and Associated Characteristics*

Cause	Characteristics
Mixed dementia	Characterized by the hallmark abnormalities of more than one cause of dementia — most commonly Alzheimer's combined with vascular dementia, followed by Alzheimer's with DLB, and Alzheimer's with vascular dementia and DLB. Vascular dementia with DLB is much less common.[4-5] Recent studies suggest that mixed dementia is more common than previously recognized, with about half of older people with dementia having pathologic evidence of more than one cause of dementia.[4-5] Recent studies also show that the likelihood of having mixed dementia increases with age and is highest in the oldest-old (people age 85 or older).
Fronto-temporal lobar degeneration (FTLD)	Includes dementias such as behavioral-variant FTLD, primary progressive aphasia, Pick's disease, corticobasal degeneration and progressive supranuclear palsy. Typical early symptoms include marked changes in personality and behavior and/or difficulty with producing or comprehending language. Unlike Alzheimer's, memory is typically spared in the early stages of disease. Nerve cells in the front (frontal lobe) and side regions (temporal lobes) of the brain are especially affected, and these regions become markedly atrophied (shrunken). In addition, the upper layers of the cortex typically become soft and spongy and have abnormal protein inclusions (usually tau protein or the transactive response DNA-binding protein). The symptoms of FTLD may occur in those age 65 years and older, similar to Alzheimer's, but most people with FTLD develop symptoms at a younger age. About 60 percent of people with FTLD are ages 45 to 60. FTLD accounts for about 10 percent of dementia cases.
Parkinson's disease (PD)	Problems with movement (slowness, rigidity, tremor and changes in gait) are common symptoms of PD. In PD, alpha-synuclein aggregates appear in an area deep in the brain called the substantia nigra. The aggregates are thought to cause degeneration of the nerve cells that produce dopamine. The incidence of PD is about one-tenth that of Alzheimer's. As PD progresses, it often results in dementia secondary to the accumulation of Lewy bodies in the cortex (similar to DLB) or the accumulation of beta-amyloid clumps and tau tangles (similar to Alzheimer's).
Creutzfeldt-Jakob disease	This very rare and rapidly fatal disorder impairs memory and coordination and causes behavior changes. Results from a misfolded protein (prion) that causes other proteins throughout the brain to misfold and malfunction. May be hereditary (caused by a gene that runs in one's family), sporadic (unknown cause) or caused by a known prion infection. A specific form called variant Creutzfeldt-Jakob disease is believed to be caused by consumption of products from cattle affected by mad cow disease.
Normal pressure hydrocephalus	Symptoms include difficulty walking, memory loss and inability to control urination. Accounts for less than 5 percent of dementia cases.[10] Caused by impaired reabsorption of cerebrospinal fluid and the consequent buildup of fluid in the brain, increasing pressure in the brain. People with a history of brain hemorrhage (particularly subarachnoid hemorrhage) and meningitis are at increased risk. Can sometimes be corrected with surgical installation of a shunt in the brain to drain excess fluid.

* For more information on these and other causes of dementia, visit alz.org/dementia.

The Alzheimer's Association acknowledges the assistance of Julie A. Schneider, M.D., in the preparation of Table 1.

stage, which for some is the longest, individuals may have difficulty performing routine tasks, become confused about where they are and begin wandering, and start having personality and behavioral changes, including suspiciousness and agitation. In the severe stage, individuals require help with basic activities of daily living, such as bathing, dressing and using the bathroom. Eventually, their ability to verbally communicate is limited.

It is in the severe stage of the disease that the effects of Alzheimer's on an individual's physical health become especially apparent. Because of damage to areas of the brain involved in movement, individuals become bed-bound. Being bed-bound makes them vulnerable to conditions including blood clots, skin infections and sepsis, in which infection-fighting chemicals in the bloodstream trigger body-wide inflammation that can result in organ failure. Damage to areas of the brain that control swallowing makes it difficult to eat and drink. This can result in individuals swallowing food into the trachea (windpipe) instead of the esophagus (food pipe). Food particles may be deposited in the lungs and cause lung infection. This type of infection is called aspiration pneumonia, and it is a contributing cause of death among many individuals with Alzheimer's.

Diagnosis of Alzheimer's Dementia

There is no single test for Alzheimer's dementia. Instead, physicians (often with the help of specialists such as neurologists and geriatricians) use a variety of approaches and tools to help make a diagnosis. They include the following:

- Obtaining a medical and family history from the individual, including psychiatric history and history of cognitive and behavioral changes.
- Asking a family member to provide input about changes in thinking skills and behavior.
- Conducting cognitive tests and physical and neurologic examinations.
- Having the individual undergo blood tests and brain imaging to rule out other potential causes of dementia symptoms, such as a tumor or certain vitamin deficiencies.
- In some circumstances, using brain imaging to find out if the individual has high levels of beta-amyloid, a hallmark of Alzheimer's; normal levels would suggest Alzheimer's is not the cause of dementia.

Diagnosing Alzheimer's dementia requires a careful and comprehensive medical evaluation. Although physicians can almost always determine if a person has dementia, it may be difficult to identify the exact cause. Several days or weeks may be needed for an individual to complete the required tests and examinations and for the physician to interpret the results and make a diagnosis.

Brain Changes Associated with Alzheimer's Disease

A healthy adult brain has about 100 billion neurons, each with long, branching extensions. These extensions enable individual neurons to form connections with other neurons. At such connections, called synapses, information flows in tiny bursts of chemicals that are released by one neuron and detected by a receiving neuron. The brain contains about 100 trillion synapses. They allow signals to travel rapidly through the brain's neuronal circuits, creating the cellular basis of memories, thoughts, sensations, emotions, movements and skills.

The accumulation of the protein fragment beta-amyloid (called beta-amyloid plaques) *outside* neurons and the accumulation of an abnormal form of the protein tau (called tau tangles) *inside* neurons are two of several brain changes associated with Alzheimer's. Beta-amyloid plaques are believed to contribute to cell death by interfering with neuron-to-neuron communication at synapses, while tau tangles block the transport of nutrients and other essential molecules inside neurons. As the amount of beta-amyloid increases, a tipping point is reached at which abnormal tau spreads throughout the brain.[11]

Other brain changes include inflammation and atrophy. The presence of toxic beta-amyloid and tau proteins activates immune system cells in the brain called microglia. Microglia try to clear the toxic proteins as well as widespread debris from dead and dying cells. Chronic inflammation is believed to set in when the microglia can't keep up with all that needs to be cleared. Atrophy, or shrinkage, of the brain occurs because of cell loss. Normal brain function is further compromised by the decreased ability of the brain to metabolize glucose, its main fuel.

Research suggests that the brain changes associated with Alzheimer's may begin 20 or more years before symptoms appear.[12-15] When the initial changes occur, the brain compensates for them, enabling individuals to continue to function normally. As neuronal damage increases, the brain can no longer compensate for the changes and individuals show subtle cognitive decline. Later, neuronal damage is so significant that individuals show obvious cognitive decline, including symptoms such as memory loss or confusion as to time or place. Later still, basic bodily functions such as swallowing are impaired.

While research settings have the tools and expertise to identify some of the early brain changes of Alzheimer's, additional research is needed to fine-tune the tools' accuracy before they become available for clinical use. In addition, treatments to prevent, slow or stop these changes are not yet available, although many are being tested in clinical trials.

TABLE 2

Signs of Alzheimer's or Other Dementias Compared with Typical Age-Related Changes*

Signs of Alzheimer's or Other Dementias	Typical Age-Related Changes
Memory loss that disrupts daily life: One of the most common signs of Alzheimer's is memory loss, especially forgetting recently learned information. Others include forgetting important dates or events, asking for the same information over and over, and increasingly needing to rely on memory aids (for example, reminder notes or electronic devices) or family members for things that used to be handled on one's own.	Sometimes forgetting names or appointments, but remembering them later.
Challenges in planning or solving problems: Some people experience changes in their ability to develop and follow a plan or work with numbers. They may have trouble following a familiar recipe, keeping track of monthly bills or counting change. They may have difficulty concentrating and take much longer to do things than they did before.	Making occasional errors when balancing a checkbook.
Difficulty completing familiar tasks at home, at work or at leisure: People with Alzheimer's often find it hard to complete daily tasks. Sometimes, people have trouble driving to a familiar location, managing a budget at work or remembering the rules of a favorite game.	Occasionally needing help to use the settings on a microwave or record a television show.
Confusion with time or place: People with Alzheimer's can lose track of dates, seasons and the passage of time. They may have trouble understanding something if it is not happening immediately. Sometimes they forget where they are or how they got there.	Getting confused about the day of the week but figuring it out later.
Trouble understanding visual images and spatial relationships: For some people, having vision problems is a sign of Alzheimer's. They may have difficulty reading, judging distance and determining color or contrast, which may cause problems with driving.	Vision changes related to cataracts, glaucoma or age-related macular degeneration.
New problems with words in speaking or writing: People with Alzheimer's may have trouble following or joining a conversation. They may stop in the middle of a conversation and have no idea how to continue or they may repeat themselves. They may struggle with vocabulary, have problems finding the right word or call things by the wrong name (e.g., calling a watch a "hand clock").	Sometimes having trouble finding the right word.
Misplacing things and losing the ability to retrace steps: People with Alzheimer's may put things in unusual places, and lose things and be unable to go back over their steps to find them again. Sometimes, they accuse others of stealing. This may occur more frequently over time.	Misplacing things from time to time and retracing steps to find them.
Decreased or poor judgment: People with Alzheimer's may experience changes in judgment or decision-making. For example, they may use poor judgment when dealing with money, giving large amounts to telemarketers. They may pay less attention to grooming or keeping themselves clean.	Making a bad decision once in a while.
Withdrawal from work or social activities: People with Alzheimer's may start to remove themselves from hobbies, social activities, work projects or sports. They may have trouble keeping up with a favorite sports team or remembering how to complete a favorite hobby. They may also avoid being social because of the changes they have experienced.	Sometimes feeling weary of work, family and social obligations.
Changes in mood and personality: The mood and personalities of people with Alzheimer's can change. They can become confused, suspicious, depressed, fearful or anxious. They may be easily upset at home, at work, with friends or in places where they are out of their comfort zones.	Developing very specific ways of doing things and becoming irritable when a routine is disrupted.

* For more information about the symptoms of Alzheimer's, visit alz.org/10signs.

Mild Cognitive Impairment (MCI): A Potential Precursor to Alzheimer's and Other Dementias

MCI is a condition in which an individual has mild but measurable changes in thinking abilities that are noticeable to the person affected and to family members and friends, but the individual is still able to carry out everyday activities. Approximately 15 percent to 20 percent of people age 65 or older have MCI.[16] People with MCI, especially MCI involving memory problems, are more likely to develop Alzheimer's or other dementias than people without MCI.[17-18] A systematic review (a comprehensive evaluation of published literature on a topic) of 32 studies found that an average of 32 percent of individuals with MCI developed Alzheimer's dementia within 5 years' follow-up.[19] A meta-analysis (a method of analysis in which results of multiple studies are pooled and analyzed) of 41 studies found that among individuals with MCI who were tracked for 5 years or longer, an average of 38 percent developed dementia.[18] Identifying which individuals with MCI are more likely to develop Alzheimer's or other dementias is a major goal of current research.

Revised guidelines for diagnosing Alzheimer's disease that were published in 2011[20-23] (see page 15) suggest that when MCI symptoms are accompanied by elevated levels of beta-amyloid, the individual may be in an early stage of Alzheimer's (called MCI due to Alzheimer's disease). However, MCI can develop for reasons other than Alzheimer's, and MCI does not always lead to dementia. In some individuals, MCI reverts to normal cognition or remains stable. In other cases, such as when a medication causes cognitive impairment, MCI is mistakenly diagnosed. Therefore, it is important that people experiencing cognitive impairment seek medical help for diagnosis and possible treatment.

In recent years, researchers have begun to recognize the importance of older adults reporting their own experience of memory and thinking problems, without (or before) a formal examination by a doctor. This personal experience of problems with cognitive ability is called subjective cognitive decline. One reason researchers are interested in subjective cognitive decline is that in some instances it may indicate an early stage of Alzheimer's disease. Many (but not all) people with subjective cognitive decline go on to develop MCI and dementia (see Prevalence section, page 16).

Genetic Abnormalities Associated with Alzheimer's Disease

Certain genetic mutations and the extra copy of chromosome 21 that characterizes Down syndrome are uncommon genetic changes that affect the risk of Alzheimer's. There are also common variations in genes that affect the risk of Alzheimer's.

Genetic Mutations

A small percentage of Alzheimer's cases (an estimated 1 percent or less)[24] develop as a result of mutations to any of three specific genes. A genetic mutation is an abnormal change in the sequence of chemical pairs that make up genes. These mutations involve the gene for the amyloid precursor protein (APP) and the genes for the presenilin 1 and presenilin 2 proteins. Those inheriting an Alzheimer's mutation to the APP or presenilin 1 genes are guaranteed to develop the disease. Those inheriting an Alzheimer's mutation to the presenilin 2 gene have a 95 percent chance of developing the disease.[25] Individuals with Alzheimer's mutations in any of these three genes tend to develop symptoms before age 65, sometimes as young as age 30, while the vast majority of individuals with Alzheimer's have late-onset disease, in which symptoms appear at age 65 or older.

Down Syndrome

In Down syndrome, an individual is born with an additional copy of chromosome 21, one of the 23 human chromosomes. Scientists are not certain why people with Down syndrome are at higher risk of developing Alzheimer's, but it may be related to the additional copy of chromosome 21. This chromosome includes the gene that encodes for the production of APP, which in people with Alzheimer's is cut into beta-amyloid fragments that accumulate into plaques. Having an extra copy of chromosome 21 may increase the number of beta-amyloid fragments in the brain.

By age 40, most people with Down syndrome have significant levels of beta-amyloid plaques and tau tangles in their brains.[26] As with all adults, advancing age increases the likelihood that a person with Down syndrome will exhibit symptoms of Alzheimer's. According to the National Down Syndrome Society, about 30 percent of people with Down syndrome who are in their 50s have Alzheimer's dementia.[27] Fifty percent or more of people with Down syndrome will develop Alzheimer's dementia in their lifetimes.[28]

Risk Factors for Alzheimer's Disease

With the exception of cases of Alzheimer's caused by genetic abnormalities, experts believe that Alzheimer's, like other common chronic diseases, develops as a result of multiple factors rather than a single cause.

Age, Family History and the Apolipoprotein E (APOE)-e4 Gene

The greatest risk factors for late-onset Alzheimer's are older age,[29-30] having a family history of Alzheimer's[31-34] and carrying the APOE-e4 gene.[35-36]

Age

Age is the greatest of these three risk factors, with the vast majority of people with Alzheimer's dementia being age 65 or older. As noted in the Prevalence section (see page 17), the percentage of people with Alzheimer's dementia increases dramatically with age: 3 percent of people age 65-74, 17 percent of people age 75-84 and 32 percent of people age 85 or older have Alzheimer's dementia.[30] It is important to note that Alzheimer's dementia is not a normal part of aging, and older age alone is not sufficient to cause Alzheimer's dementia.

Family History

A family history of Alzheimer's is not necessary for an individual to develop the disease. However, individuals who have a parent, brother or sister with Alzheimer's are more likely to develop the disease than those who do not have a first-degree relative with Alzheimer's.[31,37] Those who have more than one first-degree relative with Alzheimer's are at even higher risk.[34] When diseases run in families, heredity (genetics) and shared environmental and lifestyle factors (for example, access to healthy foods and habits related to physical activity) may play a role. The increased risk associated with having a family history of Alzheimer's is not entirely explained by whether the individual has inherited the APOE-e4 risk gene.

APOE-e4 Gene

The APOE gene provides the blueprint for a protein that transports cholesterol in the bloodstream. Everyone inherits one of three forms of the APOE gene — e2, e3 or e4 — from each parent. The e3 form is the most common.[38] The e4 form is the next most common, and the e2 form is the least common.[38] The estimated distribution of the six possible e2, e3 and e4 pairs is shown in Table 3.[39]

Having the e4 form increases one's risk of developing Alzheimer's compared with having the e3 form, while having the e2 form may decrease one's risk compared with having the e3 form. Those who inherit one copy of the e4 form have three times the risk of developing Alzheimer's compared with those with two copies of the e3 form, while those who inherit two copies of the e4 form have an eight- to 12-fold risk.[37,40-41] In addition, those with the e4 form are more likely to develop Alzheimer's at a younger age than those with the e2 or e3 forms of the APOE gene.[42] A meta-analysis including 20 published articles describing the frequency of the e4 form among people in the United States who had been diagnosed with Alzheimer's found that 56 percent had one copy of the APOE-e4 gene, and 11 percent had two copies of the APOE-e4 gene.[43]

TABLE 3

Estimated Percentages of the U.S. Population with the Six Possible e2, e3 and e4 Pairs of the Apolipoprotein E (APOE) Gene

APOE Pair	Percentage
e2/e2	0.5
e2/e3	11
e2/e4	2
e3/e3	61
e3/e4	23
e4/e4	2

Created from data from Raber et al.[39]

Percentages do not total 100 due to rounding.

Another study found that among 1,770 diagnosed individuals from 26 Alzheimer's Disease Centers across the United States, 65 percent had at least one copy of the APOE-e4 gene.[44]

Unlike inheriting a genetic mutation that causes Alzheimer's, inheriting the APOE-e4 gene does not guarantee that an individual will develop Alzheimer's. This is also true for more than 20 recently identified genes that appear to affect the risk of Alzheimer's. These genes are believed to have a limited effect on the overall prevalence of Alzheimer's because they are rare or only slightly increase risk.[45]

Modifiable Risk Factors

Although risk factors such as age and family history cannot be changed, other risk factors can be changed, or modified, to reduce risk of cognitive decline and dementia. A report[46] evaluating the state of the evidence on the effects of modifiable risk factors on cognitive decline and dementia concluded that there is sufficiently strong evidence, from a population-based perspective, that regular physical activity and management of cardiovascular risk factors (especially diabetes, obesity, smoking and hypertension) reduce the risk of cognitive decline and may reduce the risk of dementia. It also concluded that there is sufficiently strong evidence that a healthy diet and lifelong learning/cognitive training may reduce the risk of cognitive decline. A report from the National Academy of Medicine (formerly the Institute of Medicine) examined the evidence regarding modifiable risk factors for cognitive decline and reached similar conclusions.[47]

Cardiovascular Disease Risk Factors

Brain health is affected by the health of the heart and blood vessels. Although it makes up just 2 percent of body weight, the brain consumes 20 percent of the body's oxygen and energy supplies.[48] A healthy heart ensures that enough blood is pumped to the brain, while healthy blood vessels enable the oxygen- and nutrient-rich blood to reach the brain so it can function normally.

Many factors that increase the risk of cardiovascular disease are also associated with a higher risk of dementia. These factors include smoking[49-52] and diabetes.[53-56] Some studies propose that impaired glucose processing (a precursor to diabetes) may also result in an increased risk for dementia.[57-59] The age at which some risk factors develop appears to affect dementia risk. For example, in midlife, obesity,[57,60-62] hypertension,[57,63-67] prehypertension (systolic blood pressure from 120 to 139 mm Hg or diastolic pressure from 80 to 89 mm Hg)[67] and high cholesterol[68-69] are associated with an increased risk of dementia. However, late-life obesity[70] and hypertension onset after age 80[71] are associated with decreased risk of dementia. Hypertension after age 80 may be the body's way of attempting to increase blood supply to the brain when blood supply is compromised by comorbidities such as vascular disease.[71] More research is needed to understand why the effects of some modifiable risk factors change with age.

Building on the connection between heart health and brain health, researchers have found that factors that protect the heart may also protect the brain and reduce the risk of developing Alzheimer's or other dementias. Physical activity[72-78] appears to be one of these factors. Although researchers have studied a wide variety of exercises, they do not yet know which specific types of exercises, what frequency of exercise or what duration of activity may be most effective in reducing risk. In addition to physical activity, emerging evidence suggests that consuming a heart-healthy diet may be associated with reduced dementia risk.[79-83] A heart-healthy diet emphasizes fruits, vegetables, whole grains, fish, chicken, nuts and legumes while limiting saturated fats, red meat and sugar.

Researchers have begun studying combinations of health factors and lifestyle behaviors (for example, blood pressure and physical activity) to learn whether combinations of risk factors better identify Alzheimer's and dementia risk than individual risk factors. They are also studying whether intervening on multiple risk factors simultaneously has a greater chance of reducing risk than addressing a single risk factor.[84]

Education

People with more years of formal education are at lower risk for Alzheimer's and other dementias than those with fewer years of formal education.[85-89] Some researchers believe that having more years of education builds "cognitive reserve." Cognitive reserve refers to the brain's ability to make flexible and efficient use of cognitive networks (networks of neuron-to-neuron connections) to enable a person to continue to carry out cognitive tasks despite damaging brain changes,[90] such as beta-amyloid and tau accumulation. The number of years of formal education is not the only determinant of cognitive reserve. Having a mentally stimulating job and engaging in other mentally stimulating activities may also help build cognitive reserve.

Some scientists believe factors other than the number of years of formal education may contribute to or explain the increased risk of dementia among those with fewer years of formal education. These factors include an increased likelihood of having occupations that are less mentally stimulating.[91-94] In addition, having fewer years of formal education is associated with lower socioeconomic status,[95] which in turn may increase one's likelihood of experiencing poor nutrition and decrease one's ability to afford health care or medical treatments, such as treatments for cardiovascular risk factors. Finally, in the United States, people with fewer years of education tend to have more cardiovascular risk factors for Alzheimer's, including being less physically active[96] and having a higher risk of diabetes[97-99] and cardiovascular disease.[100]

Social and Cognitive Engagement

Additional studies suggest that remaining socially and mentally active throughout life may support brain health and possibly reduce the risk of Alzheimer's and other dementias.[101-111] Remaining socially and mentally active may help build cognitive reserve, but the exact mechanism by which this may occur is unknown. More research is needed to better understand how social and cognitive engagement may affect biological processes to reduce risk.

Traumatic Brain Injury (TBI)

TBI is the disruption of normal brain function caused by a blow or jolt to the head or penetration of the skull by a foreign object. According to the Centers for Disease Control and Prevention (CDC), an estimated 1.7 million Americans will sustain a TBI in any given year.[112] The leading causes of TBIs are falls, being struck by an object and motor vehicle crashes.[112]

Two ways to classify the severity of TBI are by the duration of loss of consciousness or post-traumatic amnesia[113] and by the individual's initial score on the 15-point Glasgow Coma Scale.[114]

- *Mild TBI* (also known as a concussion) is characterized by loss of consciousness or post-traumatic amnesia lasting 30 minutes or less, or an initial Glasgow score of 13-15; about 75 percent of TBIs are mild.[115]
- *Moderate TBI* is characterized by loss of consciousness or post-traumatic amnesia lasting more than 30 minutes but less than 24 hours, or an initial Glasgow score of 9-12.
- *Severe TBI* is characterized by loss of consciousness or post-traumatic amnesia lasting 24 hours or more, or an initial Glasgow score of 8 or less.

Solid evidence indicates that moderate and severe TBIs increase the risk of developing certain forms of dementia.[113,116-119] Those who experience repeated head injuries (such as boxers, football players and combat veterans) may be at an even higher risk of dementia, cognitive impairment and neurodegenerative disease.[120-129]

Chronic traumatic encephalopathy (CTE) is a neuropathologic diagnosis (meaning it is characterized by brain changes that can only be identified at autopsy) associated with repeated blows to the head, such as those that may occur while playing contact sports. It is also associated with the development of dementia. Currently, there is no test to determine if someone has CTE-related brain changes during life. A recent review of available literature indicates that the greatest risk factor for developing CTE-related brain changes is repetitive brain trauma — repeated, forceful blows to the head that do not, individually, result in symptoms.[130] Like Alzheimer's dementia, CTE is characterized by tangles of an abnormal form of the protein tau in the brain. Unlike Alzheimer's dementia, these tangles typically appear around small blood vessels, and beta-amyloid plaques are only present in certain circumstances.[131-132] How the brain changes associated with CTE are linked to cognitive or behavioral dysfunction is unclear.

Individuals can decrease their risk of repeated head trauma or TBI by ensuring their living environments are well lit and free of tripping hazards, wearing seatbelts while traveling, and wearing helmets when on a bicycle, a snowmobile or another open, unrestrained vehicle.

Treatment of Alzheimer's Dementia

Pharmacologic Treatment

None of the pharmacologic treatments (medications) available today for Alzheimer's dementia slow or stop the damage and destruction of neurons that cause Alzheimer's symptoms and make the disease fatal. The U.S. Food and Drug Administration (FDA) has approved six drugs for the treatment of Alzheimer's — rivastigmine, galantamine, donepezil, memantine, memantine combined with donepezil, and tacrine (tacrine is now discontinued in the United States). These drugs temporarily improve symptoms by increasing the amount of chemicals called neurotransmitters in the brain. The effectiveness of these drugs varies from person to person and is limited in duration.

In the decade of 2002-2012, 244 drugs for Alzheimer's were tested in clinical trials registered with clinicaltrials.gov, a National Institutes of Health registry of publicly and privately funded clinical studies.[133] Only one of the 244 drugs (memantine) successfully completed clinical trials and went on to receive approval from the FDA. Many factors contribute to the difficulty of developing effective treatments for Alzheimer's. These factors include the inability of animal models to reliably predict whether an experimental treatment will be effective in humans, the slow pace of clinical study recruitment, and the relatively long time needed to observe whether an investigational treatment affects disease progression.

Non-Pharmacologic Therapy

Non-pharmacologic therapies are those that do not involve medication. Non-pharmacologic therapies are often used with the goal of maintaining or improving cognitive function, the ability to perform activities of daily living or overall quality of life. They also may be used with the goal of reducing behavioral symptoms such as depression, apathy, wandering, sleep disturbances, agitation and aggression. Examples include computerized memory training, listening to favorite music as a way to stir recall and incorporating special lighting to lessen sleep disorders. As with current pharmacologic therapies, non-pharmacologic therapies do not slow or stop the damage and destruction of neurons that cause Alzheimer's symptoms and make the disease fatal.

Reviews and meta-analyses of non-pharmacologic therapies tested in randomized controlled trials (in which participants are randomly assigned to either receive or not receive a therapy, and the results for the two groups are compared) have found that some are beneficial to people with Alzheimer's dementia. Among these are exercise[134-135] and cognitive stimulation.[136] Specifically, a meta-analysis[134] found that aerobic exercise and a combination of aerobic and non-aerobic exercise had positive effects on cognitive function, while a systematic review[135] found that exercise has a positive effect on overall cognitive function and may have a positive effect on the rate of cognitive decline in people with Alzheimer's. However, researchers caution that additional randomized controlled trials involving larger

numbers of participants are needed to understand to what extent exercise may slow cognitive decline. A second systematic review[136] found that cognitive stimulation had beneficial effects on cognitive function and some aspects of well-being. Cognitive stimulation ranged from object categorization activities to reality orientation exercises. No single type of cognitive stimulation was identified as being more effective than another. Benefits to cognitive function lasted up to 3 months after cognitive stimulation activities ended. Cognitive stimulation did not impact mood, challenging behaviors or ability to perform activities of daily living.

Living with Alzheimer's Dementia

Despite the lack of therapies that slow or stop Alzheimer's, studies have consistently shown that active management of Alzheimer's and other dementias can improve quality of life for affected individuals and their caregivers.[137-139] Active management includes:

- Appropriate use of available treatment options.
- Effective management of coexisting conditions.
- Coordination of care among physicians, other health care professionals and lay caregivers.
- Participation in activities that are meaningful and bring purpose to one's life.
- Having opportunities to connect with others living with dementia; support groups and supportive services are examples of such opportunities.
- Becoming educated about the disease.
- Planning for the future.

To learn more about managing Alzheimer's dementia, as well as practical information for living with dementia and being a caregiver, visit alz.org.

In 2011, the National Institute on Aging (NIA) and the Alzheimer's Association proposed revised guidelines for diagnosing Alzheimer's disease.[20-23] These guidelines updated diagnostic criteria and guidelines published in 1984 by the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Association, then known as the Alzheimer's Disease and Related Disorders Association (ADRDA).[140] In 2012, the NIA and the Alzheimer's Association also developed new guidelines to help pathologists describe and categorize the brain changes associated with Alzheimer's and other dementias on autopsy.[141]

Differences Between the Original and Revised Guidelines

The 1984 diagnostic criteria and guidelines were based chiefly on a doctor's clinical judgment about the cause of an individual's symptoms, taking into account reports from the individual, family members and friends; results of cognitive tests; and general neurological assessments. The revised guidelines incorporate the same steps for diagnosis, but also incorporate biomarker tests.

A biomarker is a biological factor that can be measured to indicate the presence or absence of a disease, or the risk of developing a disease. For example, blood glucose level is a biomarker of diabetes, and high blood pressure is a biomarker of heart disease risk. Among several factors being studied as possible biomarkers for Alzheimer's are the amount of beta-amyloid in the brain as shown on positron emission tomography (PET) imaging, levels of certain proteins in fluid (for example, levels of beta-amyloid and tau in the cerebrospinal fluid and levels of particular groups of proteins in blood), and level of glucose metabolism in the brain as shown on PET imaging using the radiotracer fluorodeoxyglucose. Finding a simple and inexpensive test, such as a blood test, to diagnose Alzheimer's would be ideal for patients, physicians and scientists. Research is underway to develop such a test, and some biomarker tests, including beta-amyloid PET imaging and cerebrospinal fluid testing, are already being used in some locations to aid in diagnosis. Given the importance of developing biomarker tests, it is critical that people without symptoms who are at increased risk participate in the clinical studies needed to evaluate biomarker tests. (For information on participating in clinical studies, visit alz.org/TrialMatch.)

Another difference is that the revised guidelines identify three stages of Alzheimer's disease: one stage with dementia — dementia due to Alzheimer's disease; two stages in which symptoms are present — mild cognitive impairment (MCI) due to Alzheimer's disease and dementia due to Alzheimer's disease; and one stage without symptoms — preclinical Alzheimer's disease.

Dementia Due to Alzheimer's Disease

This stage is characterized by noticeable memory, thinking and behavioral symptoms that impair a person's ability to function in daily life, along with evidence of an Alzheimer's-related biomarker change.

MCI Due to Alzheimer's Disease

People with MCI due to Alzheimer's disease have evidence of an Alzheimer's-related biomarker change and show cognitive decline greater than expected for their age and education level, but this decline does not significantly interfere with everyday activities.[16]

Preclinical Alzheimer's Disease

In this proposed stage, which must be validated with additional research, individuals have measurable changes in the brain, cerebrospinal fluid and/or blood (biomarkers) that indicate the earliest signs of disease, but they have not yet developed symptoms such as memory loss. The preclinical stage reflects current thinking that Alzheimer's-related brain changes may begin 20 years or more before symptoms occur.[12-15]

These revisions contrast with the 1984 criteria, which identify Alzheimer's as a disease that begins when symptoms of dementia such as memory loss are already present and have impaired an individual's ability to carry out daily tasks.

Looking to the Future

Many researchers believe that future treatments to slow or stop the progression of Alzheimer's disease and preserve brain function will be most effective when administered early in the disease process, either at the MCI due to Alzheimer's or preclinical stage. Today we recognize that diseases begin many years before symptoms appear, and Alzheimer's is no different. The revised guidelines acknowledge that the disease begins decades prior to symptom onset, allowing for the early identification of those with Alzheimer's disease biomarkers who may be at risk for symptoms of Alzheimer's dementia and who should be treated with experimental therapies aimed at delaying or preventing symptoms.

Biomarker tests will be essential to identify which individuals are in these early stages and should receive treatments that slow or stop the disease when such treatments are available. They also will be critical for monitoring the effects of treatment. Furthermore, biomarkers will play an important role in developing treatments because they will enable researchers to identify which individuals to enroll in clinical trials of potential new therapies. By using biomarkers, researchers can enroll only those individuals with the brain changes that treatments target.[142]

It is important to note that the most effective biomarker test or combination of tests may differ depending on the stage of the disease and other factors.[143]

PREVALENCE

Every

65

seconds

someone in the United States develops Alzheimer's disease.

Millions of Americans have Alzheimer's or other dementias. As the size and proportion of the U.S. population age 65 and older continue to increase, the number of Americans with Alzheimer's or other dementias will grow. This number will escalate rapidly in coming years, as the population of Americans age 65 and older is projected to grow from 53 million in 2018 to 88 million by 2050.[144-145] The baby boom generation has already begun to reach age 65 and beyond,[146] the age range of greatest risk of Alzheimer's; in fact, the oldest members of the baby boom generation turned age 72 in 2018.

This section reports on the number and proportion of people with Alzheimer's dementia to describe the magnitude of the burden of Alzheimer's on the community and health care system. The prevalence of Alzheimer's dementia refers to the number and proportion of people in a population who have Alzheimer's dementia at a given point in time. Incidence refers to the number of new cases per year. Estimates from selected studies on the number and proportion of people with Alzheimer's or other dementias vary depending on how each study was conducted. Data from several studies are used in this section.

Prevalence of Alzheimer's and Other Dementias in the United States

An estimated 5.7 million Americans of all ages are living with Alzheimer's dementia in 2018. This number includes an estimated 5.5 million people age 65 and older[A1,30] and approximately 200,000 individuals under age 65 who have younger-onset Alzheimer's, though there is greater uncertainty about the younger-onset estimate.[147]

- One in 10 people (10 percent) age 65 and older has Alzheimer's dementia.[A2,30,145]
- The percentage of people with Alzheimer's dementia increases with age: 3 percent of people age 65-74, 17 percent of people age 75-84, and 32 percent of people age 85 and older have Alzheimer's dementia.[30]
- Of people who have Alzheimer's dementia, 81 percent are age 75 or older (Figure 1).[A3,30]

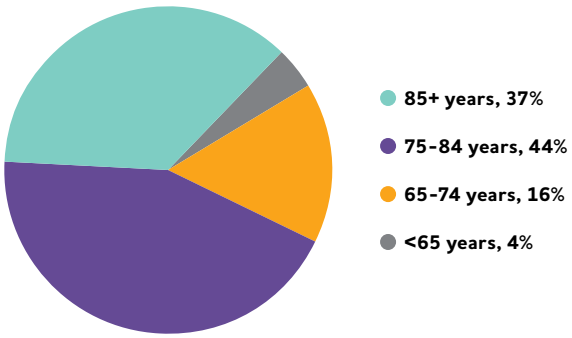
The estimated number of people age 65 and older with Alzheimer's dementia comes from a study using the latest data from the 2010 U.S. Census and the Chicago Health and Aging Project (CHAP), a population-based study of chronic health conditions of older people.[30]

National estimates of the prevalence of all dementias are not available from CHAP, but they are available from other population-based studies including the Aging, Demographics, and Memory Study (ADAMS), a nationally representative sample of older adults.[A4,148-149] Based on estimates from ADAMS, 14 percent of people age 71 and older in the United States have dementia.[148]

Prevalence studies such as CHAP and ADAMS are designed so that everyone in the study is tested for dementia.

FIGURE 1

Ages of People with Alzheimer's Dementia in the United States, 2018



Created from data from Hebert et al.[A3,30]

Percentages do not total 100 because of rounding.

But outside of research settings, a substantial portion of those who would meet the diagnostic criteria for Alzheimer's and other dementias are not diagnosed with dementia by a physician.[150-153] Furthermore, fewer than half of Medicare beneficiaries who have a diagnosis of Alzheimer's or another dementia in their Medicare records (or their caregiver, if the beneficiary's cognitive impairment prevented him or her from responding) report being told of the diagnosis.[154-157] Because Alzheimer's dementia is underdiagnosed and underreported, a large portion of Americans with Alzheimer's may not know they have it.

The estimates of the number and proportion of people who have Alzheimer's in this section refer to people who have Alzheimer's dementia. However, as described in the Overview (see page 15) and Special Report (see page 58), revised diagnostic guidelines[20-23] recognize that Alzheimer's disease begins many years before the onset of dementia.

While more research is needed to estimate how many people may have MCI due to Alzheimer's disease and how many people may be in the proposed preclinical stage of Alzheimer's disease, some recent studies have begun to address these topics. For example, a new report from the American Academy of Neurology[158] estimates that 15.8 percent of people in the United States age 60 and older have MCI. Using U.S. Census population estimates, that equates to 11.6 million people in 2018. However, because this estimate is not based on biomarker evidence, researchers do not yet know how many of these people have MCI due to Alzheimer's and how many have MCI due to other causes. Regarding the proposed preclinical stage of Alzheimer's disease, another recent article[159] estimated that in 2017 there were 38.4 million people in the United States age 30 and older who had elevated levels of beta-amyloid in the brain, but who did not yet have MCI.

It is important to note that not all people with MCI or people who are in the proposed preclinical stage of Alzheimer's disease will go on to develop Alzheimer's dementia. In addition, further research using biomarkers in large, representative samples is still needed to obtain reliable estimates of the true prevalence of MCI due to Alzheimer's disease and the number of people in the proposed preclinical stage of the disease.

Subjective Cognitive Decline

The experience of worsening or more frequent confusion or memory loss (often referred to as subjective cognitive decline) is one of the earliest warning signs of Alzheimer's disease and may be a way to identify people who are at high risk of developing Alzheimer's or other dementias as well as MCI.[160-164] Subjective cognitive decline does not refer to someone occasionally forgetting their keys or the name of someone they recently met; it refers to more serious issues such as having trouble remembering how to do things one has always done or forgetting things that one would normally know. Not all of those who experience subjective cognitive decline go on to develop MCI or dementia, but many do.[165-167] According to a recent study, only those who over time consistently reported subjective cognitive decline that they found worrisome were at higher risk for developing Alzheimer's dementia.[168] The Behavioral Risk Factor Surveillance System (BRFSS) survey, which includes questions on self-perceived confusion and memory loss, found that in 2015-2016, 11 percent of Americans age 45 and older reported subjective cognitive decline, but 55 percent of those who reported it had not consulted a health care professional about it.[169] Individuals concerned about declines in memory and other cognitive abilities should consult a health care professional.

Differences Between Women and Men in the Prevalence of Alzheimer's and Other Dementias

More women than men have Alzheimer's or other dementias. Almost two-thirds of Americans with Alzheimer's are women.[A5,30] Of the 5.5 million people age 65 and older with Alzheimer's in the United States, 3.4 million are women and 2.0 million are men.[A5,30] Based on estimates from ADAMS, among people age 71 and older, 16 percent of women have Alzheimer's or other dementias compared with 11 percent of men.[148]

There are a number of potential biological and social reasons why more women than men have Alzheimer's or other dementias.[170] The prevailing view has been that this discrepancy is due to the fact that women live longer than men on average, and older age is the greatest risk factor for Alzheimer's.[171-173] Many studies of incidence (which indicates risk of developing disease) of Alzheimer's or any dementia have found no significant difference between men and women in the proportion who develop Alzheimer's or other dementias at any given age.[172,174-175] A recent study using data from the Framingham Heart Study suggests that because men in middle age have a higher rate of death from cardiovascular disease than women in middle age, men who survive beyond age 65 may have a healthier cardiovascular risk profile and thus an apparent lower risk for dementia than women of the same age.[173] Epidemiologists call this "survival bias" because the men who survive to older ages and are included in studies tend to be the healthiest men; as a result, they may have a lower risk of developing Alzheimer's and other dementia than the men who died at an earlier age from cardiovascular disease. More research is needed to support this finding.

TABLE 4

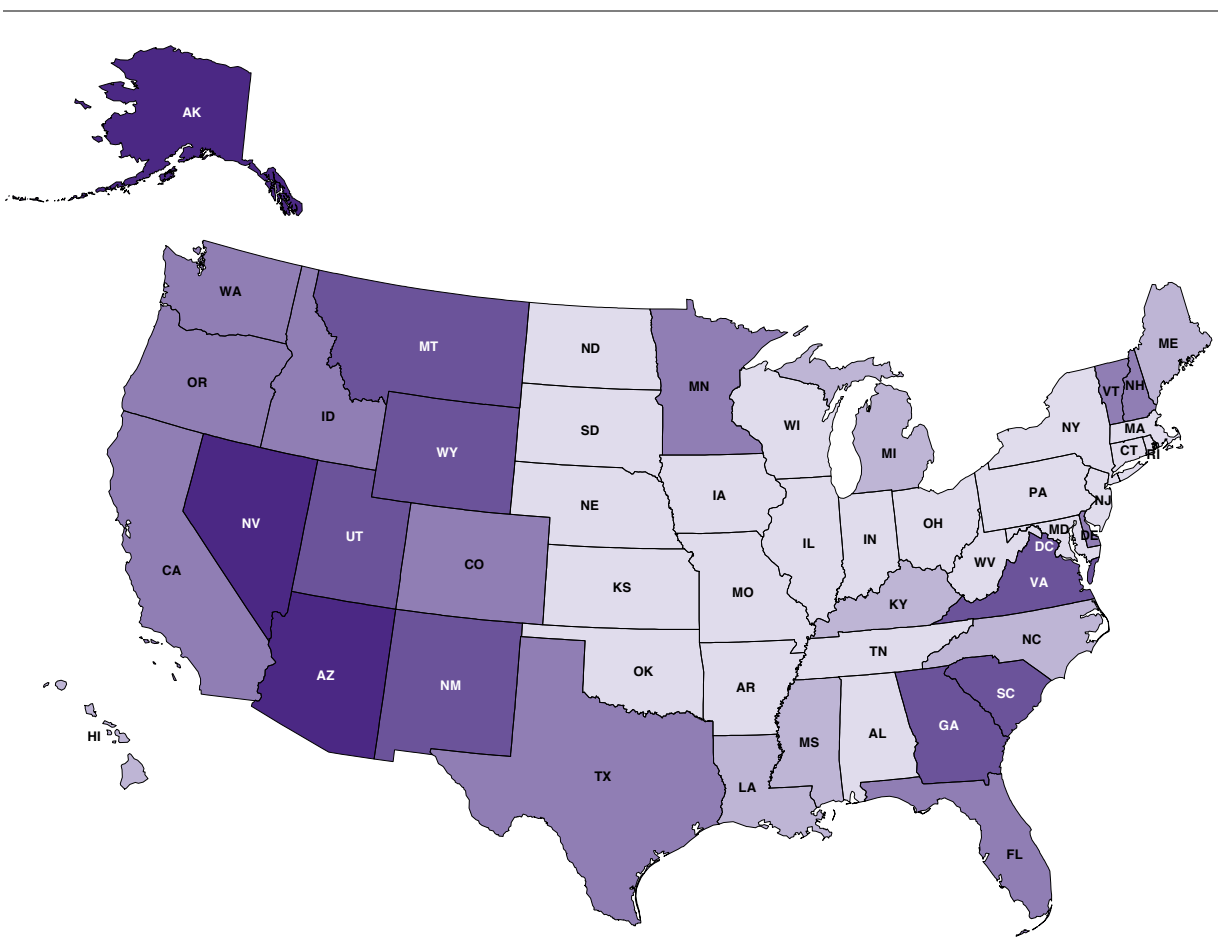
Projections of Total Numbers of Americans Age 65 and Older with Alzheimer's Dementia by State

State	Projected Number with Alzheimer's (in thousands) 2018	2025	Percentage Increase 2018–2025
Alabama	92	110	19.6
Alaska	7.5	11	46.7
Arizona	140	200	42.9
Arkansas	56	67	19.6
California	650	840	29.2
Colorado	71	92	29.6
Connecticut	77	91	18.2
Delaware	18	23	27.8
District of Columbia	8.9	9	1.1
Florida	540	720	33.3
Georgia	140	190	35.7
Hawaii	28	35	25.0
Idaho	25	33	32.0
Illinois	220	260	18.2
Indiana	110	130	18.2
Iowa	64	73	14.1
Kansas	53	62	17.0
Kentucky	71	86	21.1
Louisiana	87	110	26.4
Maine	28	35	25.0
Maryland	110	130	18.2
Massachusetts	130	150	15.4
Michigan	180	220	22.2
Minnesota	94	120	27.7
Mississippi	54	65	20.4
Missouri	110	130	18.2
Montana	20	27	35.0
Nebraska	34	40	17.6
Nevada	45	64	42.2
New Hampshire	24	32	33.3
New Jersey	180	210	16.7
New Mexico	39	53	35.9
New York	400	460	15.0
North Carolina	170	210	23.5
North Dakota	14	16	14.3
Ohio	220	250	13.6
Oklahoma	64	76	18.8
Oregon	65	84	29.2
Pennsylvania	280	320	14.3
Rhode Island	23	27	17.4
South Carolina	89	120	34.8
South Dakota	17	20	17.6
Tennessee	120	140	16.7
Texas	380	490	28.9
Utah	31	42	35.5
Vermont	13	17	30.8
Virginia	140	190	35.7
Washington	110	140	27.3
West Virginia	38	44	15.8
Wisconsin	110	130	18.2
Wyoming	9.7	13	34.0

Created from data provided to the Alzheimer's Association by Weuve et al.[A7,209]

FIGURE 2

Projected Increases Between 2018 and 2025 in Alzheimer's Dementia Prevalence by State



Change from 2018 to 2025 for Washington, D.C.: 1.1%

Created from data provided to the Alzheimer's Association by Weuve et al.[A7,209]

Researchers are now questioning whether the risk of Alzheimer's could actually be higher for women at any given age due to biological or genetic variations or differences in life experiences.[176] A number of studies have shown that the APOE-e4 genotype (see the Overview, page 11), the best known genetic risk factor for Alzheimer's dementia, may have a stronger association with Alzheimer's dementia in women than in men.[177-178] However, a recent meta-analysis, which combined data from a number of independent studies, found no difference between men and women in the association between APOE genotype and Alzheimer's dementia except for a slightly elevated risk for women with the APOE-e3/e4 genotype compared with men with the same genotype between ages 65 and 75.[179]

It is unknown why the APOE gene could convey different risk for women, but some evidence suggests that it may be due to an interaction between the APOE-e4 genotype and the sex hormone estrogen.[180-181] Finally, because low education is a risk factor for dementia,[88-89,95,174,182-183] it is possible that lower educational attainment in women than in men born in the first half of the 20th century could account for a higher risk of Alzheimer's and other dementias in women.[184]

Racial and Ethnic Differences in the Prevalence of Alzheimer's and Other Dementias

Although there are more non-Hispanic whites living with Alzheimer's and other dementias than any other racial or ethnic group in the United States, older African-

Americans and Hispanics are more likely, on a per-capita basis, than older whites to have Alzheimer's or other dementias.[185-191] Most studies indicate that older African-Americans are about twice as likely to have Alzheimer's or other dementias as older whites.[192-193] Some studies indicate Hispanics are about one and one-half times as likely to have Alzheimer's or other dementias as older whites.[A6,193-195] Recent studies suggest the increased likelihood for Hispanics may be slightly lower than this, depending upon the specific Hispanic ethnic group observed (for example, Mexican-Americans compared with Caribbean-Americans).[196]

There are fewer data from population-based cohort studies regarding the national prevalence of Alzheimer's and other dementias in racial and ethnic groups other than whites, African-Americans, and Hispanics. However, a study examining electronic medical records of members of a large health plan in California indicated that dementia incidence — determined by the presence of a dementia diagnosis in members' medical records — was highest in African-Americans, intermediate for Latinos (the term used in the study for those who self-reported as Latino or Hispanic) and whites, and lowest for Asian-Americans.[197] A follow-up study with the same cohort showed heterogeneity within Asian-American subgroups, but all subgroups studied had lower dementia incidence than whites.[198] A recent systematic review of the literature found that Japanese-Americans were the only Asian-American subgroup with reliable prevalence data, and that they had the lowest prevalence of dementia compared with all other ethnic groups.[196] More studies, especially those involving population-based cohorts, are necessary to draw conclusions about the prevalence of Alzheimer's and other dementias in Asian-Americans and how it may differ by subgroup.

Variations in health, lifestyle and socioeconomic risk factors across racial groups likely account for most of the differences in risk of Alzheimer's and other dementias by race.[199] Despite some evidence that the influence of genetic risk factors on Alzheimer's and other dementias may differ by race,[191,200-201] genetic factors do not appear to account for the large prevalence differences among racial groups.[199,202] Instead, health conditions such as cardiovascular disease and diabetes, which are associated with an increased risk for Alzheimer's and other dementias, are believed to account for these differences, as they are more prevalent in African-American and Hispanic people.[203-204] Socioeconomic characteristics, including lower levels of education, higher rates of poverty, and greater exposure to early life adversity and discrimination may also increase risk in African-American and Hispanic communities.[191,203-205] Some studies suggest that differences based on race and ethnicity do not persist in rigorous analyses that account for such factors.[86,148,199]

There is evidence that missed diagnoses of Alzheimer's and other dementias are more common among older African-Americans and Hispanics than among older whites.[206-207] Based on data for Medicare beneficiaries age 65 and older, Alzheimer's or another dementia had been diagnosed in 6.9 percent of whites, 9.4 percent of African-Americans and 11.5 percent of Hispanics.[208] Although rates of diagnosis were higher among African-Americans than among whites, according to prevalence studies that detect all people who have dementia irrespective of their use of the health care system, the rates should be even higher for African-Americans.

Estimates of the Number of People with Alzheimer's Dementia by State

Table 4 (see page 19) lists the estimated number of people age 65 and older with Alzheimer's dementia by state for 2018, the projected number for 2025, and the projected percentage change in the number of people with Alzheimer's between 2018 and 2025.[A7,209]

As shown in Figure 2, between 2018 and 2025 every state across the country is expected to experience an increase of at least 13 percent in the number of people with Alzheimer's. These projected increases in the number of people with Alzheimer's are due to projected increases in the population age 65 and older in these states. The West and Southeast are expected to experience the largest percentage increases in people with Alzheimer's between 2018 and 2025. These increases will have a marked impact on states' health care systems, as well as the Medicaid program, which covers the costs of long-term care and support for some older residents with dementia.

Incidence of Alzheimer's Dementia

While prevalence refers to existing cases of a disease in a population at a given time, incidence refers to new cases of a disease that develop in a given period of time in a defined population — in this case, the U.S. population age 65 or older. Incidence provides a measure of risk for developing a disease. According to one study using data from the Established Populations for Epidemiologic Study of the Elderly (EPESE), approximately 484,000 people age 65 or older will develop Alzheimer's dementia in the United States in 2018.[A8] The number of new cases of Alzheimer's increases dramatically with age: in 2018, there will be approximately 66,000 new cases among people age 65 to 74, 173,000 new cases among people age 75 to 84, and 245,000 new cases among people age 85 and older

(the "oldest-old").[A8,210] This translates to approximately two new cases per 1,000 people age 65 to 74, 11 new cases per 1,000 people age 75 to 84, and 37 new cases per 1,000 people age 85 and older.[A8] A study using more recent data from the Adult Changes in Thought (ACT) study, a cohort of members of the Group Health health care delivery system in the Northwest United States, reported even higher incidence rates for Alzheimer's dementia.[174] Because of the increasing number of people age 65 and older in the United States, particularly the oldest-old, the annual number of new cases of Alzheimer's and other dementias is projected to double by 2050.[210]

- Every 65 seconds, someone in the United States develops Alzheimer's dementia.[A9]
- By 2050, someone in the United States will develop Alzheimer's dementia every 33 seconds.[A9]

Lifetime Risk of Alzheimer's Dementia

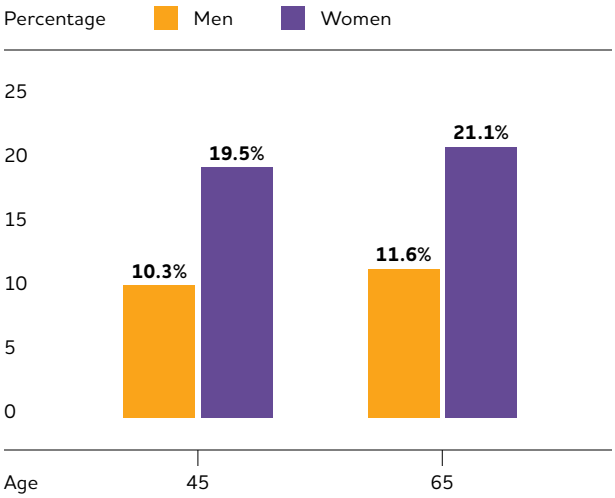
Lifetime risk is the probability that someone of a given age will develop a condition during his or her remaining life span. Data from the Framingham Heart Study were used to estimate lifetime risks of Alzheimer's dementia by age and sex.[A10,173] As shown in Figure 3, the study found that the estimated lifetime risk for Alzheimer's dementia at age 45 was approximately one in five (20 percent) for women and one in 10 (10 percent) for men. The risks for both sexes were slightly higher at age 65.[173]

Trends in the Prevalence and Incidence of Alzheimer's Dementia

A growing number of studies indicate that the age-specific risk of Alzheimer's and other dementias in the United States and other higher-income Western countries may have declined in the past 25 years,[211-224] though results are mixed.[29,225] These declines have been attributed to increasing levels of education and improved control of cardiovascular risk factors.[211,214,217-218] Such findings are promising and suggest that identifying and reducing risk factors for Alzheimer's and other dementias may be effective. Although these findings indicate that a person's risk of dementia at any given age may be decreasing slightly, it should be noted that the total number of people with Alzheimer's or other dementias in the United States and other high-income Western countries is expected to continue to increase dramatically because of the increase in the number of people at the oldest ages. Furthermore, it is unclear whether these positive trends will continue into the future given worldwide trends showing increases in diabetes and obesity — potential risk factors for Alzheimer's dementia — which may lead to a rebound in dementia risk in coming years.[60,215,226-227] Thus, while recent findings are promising, the social and economic burden of Alzheimer's and other dementias will continue to grow. Moreover, 68 percent of the projected increase in the global prevalence and burden of dementia by 2050 will take place in low- and middle-income countries, where there is no evidence that the risk of Alzheimer's and other dementias has been declining.[228]

FIGURE 3

Estimated Lifetime Risk for Alzheimer's Dementia, by Sex, at Age 45 and Age 65



Created from data from Chene et al.[173]

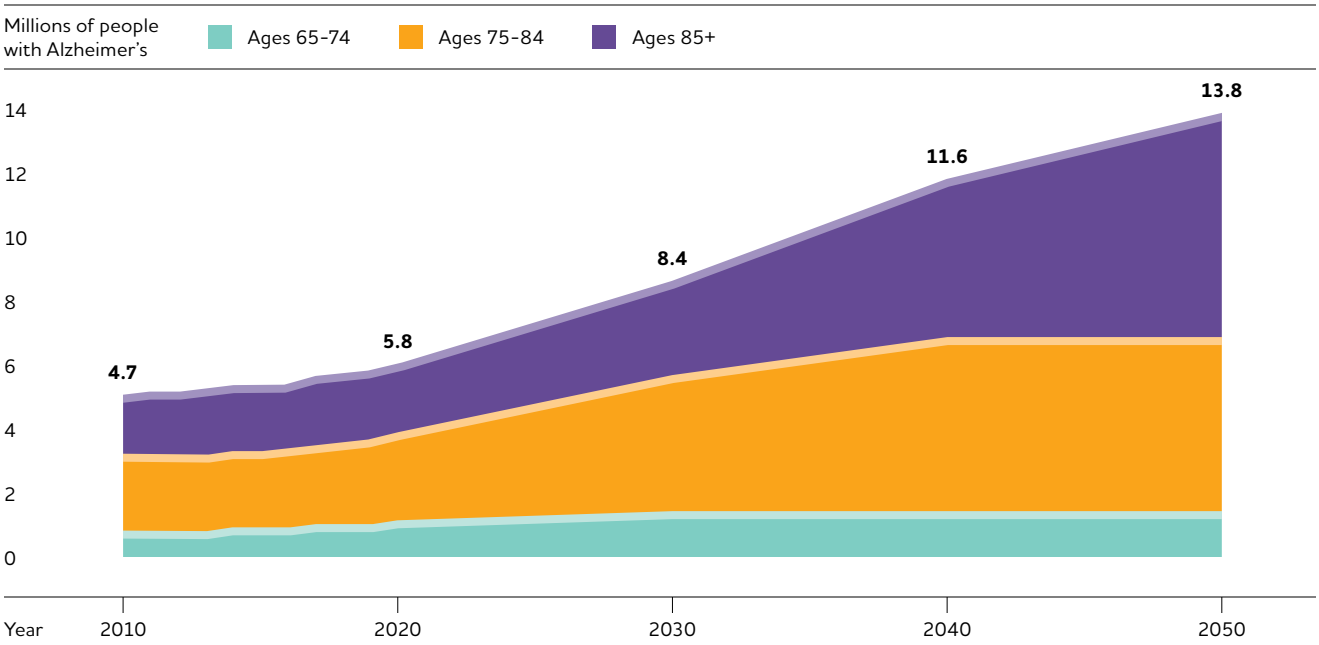
Looking to the Future

A large segment of the American population — the baby boom generation — has begun to reach age 65 and older, ages when the risk for Alzheimer's and other dementias is elevated. By 2030, the segment of the U.S. population age 65 and older will increase substantially, and the projected 74 million older Americans will make up over 20 percent of the total population (up from 16 percent in 2018).[145,229] As the number of older Americans grows rapidly, so too will the numbers of new and existing cases of Alzheimer's dementia, as shown in Figure 4.[A11,30]

- In 2010, there were an estimated 454,000 new cases of Alzheimer's dementia. By 2030, that number is projected to be 615,000 (a 35 percent increase), and by 2050, 959,000 (a 110 percent increase from 2010).[210]
- By 2025, the number of people age 65 and older with Alzheimer's dementia is projected to reach 7.1 million — almost a 29 percent increase from the 5.5 million age 65 and older affected in 2018.[A12,30]
- By 2050, the number of people age 65 and older with Alzheimer's dementia may grow from 5.5 million to a projected 13.8 million, barring the development of medical breakthroughs to prevent, slow, or cure Alzheimer's disease.[A11,30]

FIGURE 4

Projected Number of People Age 65 and Older (Total and by Age) in the U.S. Population with Alzheimer's Dementia, 2010 to 2050



Created from data from Hebert et al.[A11,30]

Growth of the Oldest-Old Population

The number of Americans surviving into their 80s, 90s and beyond is expected to grow dramatically due to medical advances, as well as social and environmental conditions.[229] Longer life expectancies and aging baby boomers will lead to an increase in the number and percentage of Americans who will be 85 and older, the oldest-old. Between 2012 and 2050, the oldest-old are expected to comprise an increasing proportion of the U.S. population age 65 and older — from 14 percent in 2012 to 22 percent in 2050.[229] This will result in an additional 12 million oldest-old people — individuals at the highest risk for developing Alzheimer's dementia.[229]

- In 2018, about 2.1 million people who have Alzheimer's dementia are age 85 or older, accounting for 37 percent of all people with Alzheimer's dementia.[30]
- When the first wave of baby boomers reaches age 85 (in 2031), it is projected that more than 3 million people age 85 and older will have Alzheimer's dementia.[30]
- By 2050, 7 million people age 85 and older are projected to have Alzheimer's dementia, accounting for half (51 percent) of all people 65 and older with Alzheimer's dementia.[30]

MORTALITY AND MORBIDITY

1 in 3

seniors dies with Alzheimer's or another dementia.

Alzheimer's disease is officially listed as the sixth-leading cause of death in the United States.[230] It is the fifth-leading cause of death for those age 65 and older.[231] However, it may cause even more deaths than official sources recognize. Alzheimer's is also a leading cause of disability and poor health (morbidity). Before a person with Alzheimer's dies, he or she lives through years of morbidity as the disease progresses.

Deaths from Alzheimer's Disease

In this section, the term "Alzheimer's disease" is used rather than "Alzheimer's dementia" to reflect terminology used by the Centers for Disease Control and Prevention (CDC).

It is difficult to determine how many deaths are caused by Alzheimer's disease each year because of the way causes of death are recorded. According to data from the National Center for Health Statistics of the CDC, 110,561 people died from Alzheimer's disease in 2015.[232] The CDC considers a person to have died from Alzheimer's if the death certificate lists Alzheimer's as the underlying cause of death, defined by the World Health Organization as "the disease or injury which initiated the train of events leading directly to death."[233]

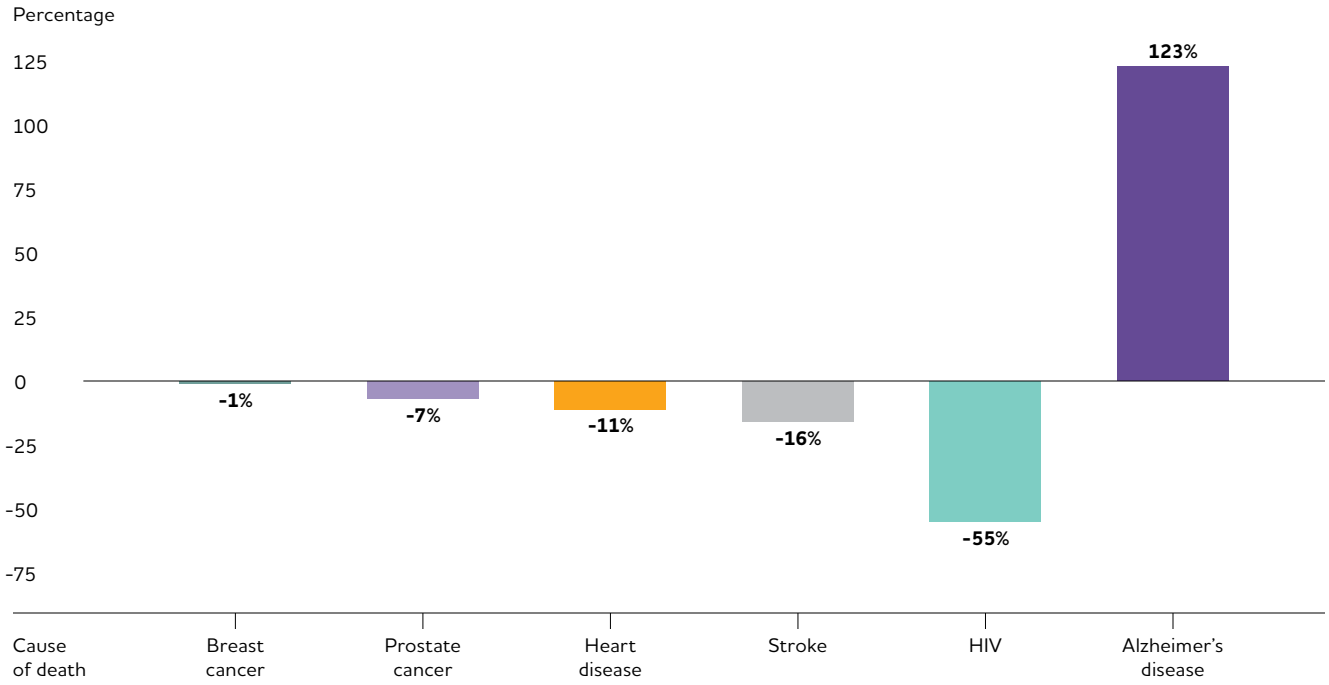
Severe dementia frequently causes complications such as immobility, swallowing disorders and malnutrition that significantly increase the risk of serious acute conditions that can cause death. One such condition is pneumonia (infection of the lungs), which is the most commonly identified cause of death among elderly people with Alzheimer's or other dementias.[234-235] One autopsy study found that respiratory system diseases were the immediate cause of death in more than half of people with Alzheimer's dementia, followed by circulatory system disease in about a quarter.[235] Death certificates for individuals with Alzheimer's often list acute conditions such as pneumonia as the primary cause of death rather than Alzheimer's.[236-238] As a result, people with Alzheimer's disease who die due to these acute conditions may not be counted among the number of people who die from Alzheimer's disease according to the World Health Organization definition, even though Alzheimer's disease may well have caused the acute condition listed on the death certificate. This difficulty in using death certificates to accurately determine the number of deaths from Alzheimer's has been referred to as a "blurred distinction between death with dementia and death from dementia."[239]

Another way to determine the number of deaths from Alzheimer's disease is through calculations that compare the estimated risk of death in those who have Alzheimer's with the estimated risk of death in those who do not have Alzheimer's. A study using data from the Rush Memory and Aging Project and the Religious Orders Study estimated that 500,000 deaths among people age 75 and older in the United States in 2010 could be attributed to Alzheimer's (estimates for people age 65 to 74 were not available), meaning that those deaths would not be expected to occur in that year if those individuals did not have Alzheimer's.[240]

The true number of deaths caused by Alzheimer's is somewhere between the number of deaths from Alzheimer's recorded on death certificates and the number of people who have Alzheimer's disease when

FIGURE 5

Percentage Changes in Selected Causes of Death (All Ages) Between 2000 and 2015



Created from data from the National Center for Health Statistics.[232,243]

they die. According to 2014 Medicare claims data, about one-third of all Medicare beneficiaries who die in a given year have been diagnosed with Alzheimer's or another dementia.[208] Based on data from the Chicago Health and Aging Project (CHAP) study, in 2018 an estimated 700,000 people age 65 and older in the United States will have Alzheimer's when they die.[241] Although some seniors who have Alzheimer's disease at the time of death die from causes that are unrelated to Alzheimer's, many of them die from Alzheimer's disease itself or from conditions in which Alzheimer's was a contributing cause, such as pneumonia.

Irrespective of the cause of death, among people age 70, 61 percent of those with Alzheimer's are expected to die before age 80 compared with 30 percent of people without Alzheimer's.[242]

Public Health Impact of Deaths from Alzheimer's Disease

As the population of the United States ages, Alzheimer's is becoming a more common cause of death, and it is the only top 10 cause of death that cannot be prevented, cured or even slowed. Although deaths from other major causes have *decreased* significantly, official records indicate that deaths from Alzheimer's disease have *increased* significantly. Between 2000 and 2015, the number of deaths from Alzheimer's disease as recorded on death certificates have more than doubled, increasing 123 percent, while the number of deaths from the number one cause of death (heart disease) decreased 11 percent (Figure 5).[243] The increase in the number of death certificates listing Alzheimer's as the underlying cause of death reflects both changes in patterns of reporting deaths on death certificates over time as well as an increase in the actual number of deaths attributable to Alzheimer's.

State-by-State Deaths from Alzheimer's Disease

Table 5 provides information on the number of deaths due to Alzheimer's by state in 2015, the most recent year for which state-by-state data are available. This information was obtained from death certificates and reflects the condition identified by the physician as the underlying cause of death. The table also provides annual mortality rates by state to compare the risk of death due to Alzheimer's disease across states with varying population sizes. For the United States as a whole, in 2015, the mortality rate for Alzheimer's disease was 34 deaths per 100,000 people.[A13,232]

TABLE 5

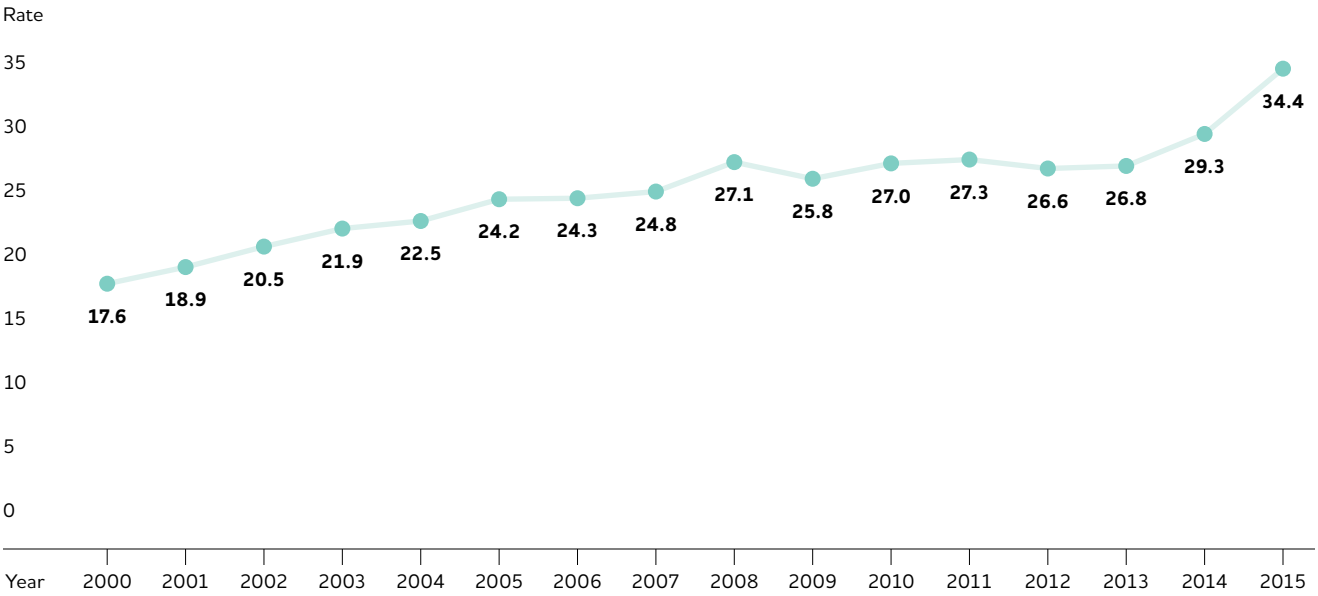
Number of Deaths and Annual Mortality Rate (per 100,000 People) Due to Alzheimer's Disease by State, 2015

State	Number of Deaths	Mortality Rate	State	Number of Deaths	Mortality Rate
Alabama	2,282	47.0	Montana	277	26.8
Alaska	68	9.2	Nebraska	598	31.5
Arizona	2,943	43.1	Nevada	874	30.2
Arkansas	1,457	48.9	New Hampshire	432	32.5
California	15,065	38.5	New Jersey	2,260	25.2
Colorado	1,612	29.5	New Mexico	483	23.2
Connecticut	966	26.9	New York	3,174	16.0
Delaware	264	27.9	North Carolina	3,803	37.9
District of Columbia	129	19.2	North Dakota	376	49.7
Florida	7,031	34.7	Ohio	4,643	40.0
Georgia	3,714	36.4	Oklahoma	1,498	38.3
Hawaii	422	29.5	Oregon	1,652	41.0
Idaho	552	33.4	Pennsylvania	4,012	31.3
Illinois	3,686	28.7	Rhode Island	453	42.9
Indiana	2,513	38.0	South Carolina	2,453	50.1
Iowa	1,339	42.9	South Dakota	421	49.0
Kansas	865	29.7	Tennessee	3,122	47.3
Kentucky	1,694	38.3	Texas	8,903	32.4
Louisiana	2,018	43.2	Utah	906	30.2
Maine	544	40.9	Vermont	298	47.6
Maryland	1,095	18.2	Virginia	2,248	26.8
Massachusetts	1,815	26.7	Washington	3,490	48.7
Michigan	3,771	38.0	West Virginia	738	40.0
Minnesota	1,789	32.6	Wisconsin	2,087	36.2
Mississippi	1,402	46.9	Wyoming	151	25.8
Missouri	2,173	35.7	**U.S. Total**	**110,561**	**34.4**

Created from data from the National Vital Statistics Report.[A13,232]

FIGURE 6

U.S. Annual Alzheimer's Death Rate (per 100,000 People) by Year



Created from data from the National Vital Statistics Report.[232]

Alzheimer's Disease Death Rates

As shown in Figure 6, the rate of deaths due to Alzheimer's has risen substantially since 2000.[232] Table 6 shows that the rate of death from Alzheimer's increases dramatically with age, especially after age 65.[A13,232] The increase in the Alzheimer's death rate over time has disproportionately affected the oldest-old.[244] Between 2000 and 2015, the death rate from Alzheimer's increased only 20 percent for people age 65 to 74, but increased 52 percent for people age 75 to 84, and 76 percent for people age 85 and older. A recent report by the CDC determined that even after adjusting for differences in age distributions over time, the annual Alzheimer's death rate in the United States increased substantially over the last decade and a half.[245] Therefore, the growing proportion of older adults in the country is not the only explanation for the increase in Alzheimer's death rates. Other possible reasons include fewer deaths from other common causes of deaths in old age such as heart disease and stroke; increased diagnosis of Alzheimer's especially at earlier stages; and increased reporting of Alzheimer's as a cause of death by physicians and others who fill out death certificates.[245]

Duration of Illness from Diagnosis to Death

Studies indicate that people age 65 and older survive an average of 4 to 8 years after a diagnosis of Alzheimer's dementia, yet some live as long as 20 years with Alzheimer's dementia.[174,246-253] This reflects the slow, insidious progression of Alzheimer's. Of the total number of years that they live with Alzheimer's dementia, individuals will spend an average of 40 percent of this time in dementia's most severe stage.[242] Much of the time will be spent in a nursing home. At age 80, approximately 75 percent of people living with Alzheimer's dementia are expected to be in a nursing home compared with only 4 percent of the general population at age 80.[242] In all, an estimated two-thirds of those who die of dementia do so in nursing homes, compared with 20 percent of people with cancer and 28 percent of people dying from all other conditions.[254]

Burden of Alzheimer's Disease

The long duration of illness before death contributes significantly to the public health impact of Alzheimer's disease because much of that time is spent in a state of disability and dependence. Scientists have developed methods to measure and compare the burden of different diseases on a population in a way that takes into account not only the number of people with the condition, but also both the number of years of life lost due to that disease as well as the number of healthy years of life lost by virtue of being in a state of disability. These measures indicate that Alzheimer's is a very burdensome disease, not only to the patients but also to their families and informal caregivers, and that the burden of Alzheimer's has increased more dramatically in the United States

TABLE 6

U.S. Annual Alzheimer's Death Rates (per 100,000 People) by Age and Year

Age	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
45-54	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2	0.2
55-64	2.0	2.1	1.9	2.0	1.8	2.1	2.1	2.2	2.2	2.0	2.1	2.2	2.2	2.2	2.1	2.4
65-74	18.7	18.6	19.6	20.7	19.5	20.2	19.9	20.2	21.1	19.4	19.8	19.2	17.9	18.1	19.6	22.4
75-84	139.6	147.2	157.7	164.1	168.5	177.0	175.0	175.8	192.5	179.1	184.5	183.9	175.4	171.6	185.6	211.9
85+	667.7	725.4	790.9	846.8	875.3	935.5	923.4	928.7	1,002.2	945.3	987.1	967.1	936.1	929.5	1,006.8	1,174.2

Created from data from the National Vital Statistics Report.[232]

than other diseases in recent years. The primary measure of disease burden is called disability-adjusted life years (DALYs), which is the sum of the number of years of life lost due to premature mortality and the number of years lived with disability, totaled across all those with the disease or injury. Using age-standardized DALYs, Alzheimer's rose from the 25th most burdensome disease or injury in the United States in 1990 to the 12th in 2015.[255] In terms of years of life lost, Alzheimer's disease rose from 32nd to 9th, the largest increase for any disease. In terms of years lived with disability, Alzheimer's disease went from ranking 17th to 12th; only kidney disease equaled Alzheimer's in as high a jump in rank.

Taken together, these statistics indicate that not only is Alzheimer's disease responsible for the deaths of more and more Americans, but also that the disease is contributing to more and more cases of poor health and disability in the United States.

CAREGIVING

18.4

billion

hours of care, valued at over $232 billion, are provided by family and other unpaid caregivers.

Caregiving refers to attending to another person's health needs. Caregiving often includes assistance with one or more activities of daily living (ADLs), such as bathing and dressing, as well as multiple instrumental activities of daily living (IADLs), such as paying bills, shopping and using transportation.[256-257] Caregivers also provide emotional support to people with Alzheimer's. More than 16 million Americans provide unpaid care for people with Alzheimer's or other dementias.[A14] In addition to providing descriptive information, this section compares caregivers of people with dementia to either caregivers of people with other medical conditions, or if that comparison is not available, to non-caregivers.

Unpaid Caregivers

Eighty-three percent of the help provided to older adults in the United States comes from family members, friends or other unpaid caregivers.[258] Nearly half of all caregivers (48 percent) who provide help to older adults do so for someone with Alzheimer's or another dementia.[259] In 2017, caregivers of people with Alzheimer's or other dementias provided an estimated 18.4 billion hours of informal (that is, unpaid) assistance, a contribution to the nation valued at $232.1 billion. This is approximately 48 percent of the net value of Walmart sales in 2017 ($481.3 billion)[260] and nine times the total revenue of McDonald's in 2016 ($24.6 billion).[261] The total lifetime cost of care (including Medicare, Medicaid, out-of-pocket expenditures, and the value of informal care) for someone with dementia was estimated at $341,840 in 2017 dollars. The costs associated with family care are 70 percent of lifetime dementia care costs ($143,735 in the value of informal care, and $95,441 in out-of-pocket expenses related to care in 2017 dollars).[262]

The three primary reasons caregivers provide care and assistance to a person with Alzheimer's are (1) the desire to keep a family member or friend at home (65 percent), (2) proximity to the person with dementia (48 percent) and (3) the caregiver's perceived obligation as a spouse or partner (38 percent).[A15] Individuals with dementia living in the community are more likely than older adults without dementia to rely on multiple unpaid caregivers (often family members); 30 percent of older adults with dementia rely on three or more unpaid caregivers, whereas 23 percent of older adults without dementia rely on three or more unpaid caregivers.[263] Only a small percentage of older adults with dementia do not receive help from family members or other informal care providers (8 percent). Of these individuals, 40 percent live alone, perhaps making it more difficult to ask for and receive informal care.[263]

Who Are the Caregivers?

Several sources have examined the demographic background of family caregivers of people with Alzheimer's or other dementias in the United States, and found the following:[A15,264-268]

- About one in three caregivers (34 percent) is age 65 or older.[A15]
- Over two-thirds of caregivers are married, living with a partner or in a long-term relationship.[A15,265]
- More than two-thirds of caregivers are non-Hispanic white,[A15,264-265,268] while 10 percent are African-American, 8 percent are Hispanic, and 5 percent are Asian.[A15] These percentages may reflect the prevalence of Alzheimer's disease and related dementias among different racial/ethnic groups.

- Approximately 40 percent of dementia caregivers have a college degree or greater education.[A15,265,268]
- Forty-one percent of caregivers have a household income of $50,000 or less.[A15]
- Among primary caregivers (individuals who indicate having the most responsibility for helping their relatives) of people with dementia, over half take care of their parents.[169,267,269-270]
- Most caregivers (66 percent) live with the care recipient in the community.[263]
- It is estimated that 250,000 children and young adults between ages 8 and 18 provide help to someone with Alzheimer's or another dementia.[271]
- National surveys have found that approximately one quarter of dementia caregivers were "sandwich generation" caregivers — meaning that they care not only for an aging parent, but also for children under age 18.[A15,169,268]

Caregiving and Women

The responsibilities of caring for someone with dementia often fall to women. Approximately two-thirds of caregivers are women.[A15,264-265,269-270] More specifically, over one-third of dementia caregivers are daughters.[259,263] It is more common for wives to provide informal care for a husband than vice versa.[272] On average, female caregivers spend more time caregiving than male caregivers.[263] According to the 2014 Alzheimer's Association Women and Alzheimer's Poll, which surveyed both men and women, of those providing care for 21 to more than 60 hours per week, 67 percent were women.[273] Similarly, the 2015 BRFSS survey found that of all dementia caregivers who spend more than 40 hours per week providing care, 69 percent were women.[169] Two and a half times as many women reported living with the person with dementia full time.[273] Of those providing care to someone with dementia for more than 5 years, 63 percent are women.[169] Similarly, caregivers who are women may experience slightly higher levels of burden, impaired mood, depression and impaired health than men, with evidence suggesting that these differences arise because female caregivers tend to spend more time caregiving, assume more caregiving tasks, and care for someone with more cognitive, functional and/or behavioral problems.[274-275] Women caregivers are also more likely than men to indicate a need for individual counseling (83 percent versus 17 percent), respite care (72 percent versus 29 percent) and support groups (73 percent versus 27 percent).[169]

Caregiving Tasks

The care provided to people with Alzheimer's or other dementias is wide-ranging and in some instances all-encompassing. Table 7 summarizes some of the most common types of dementia care provided.

TABLE 7

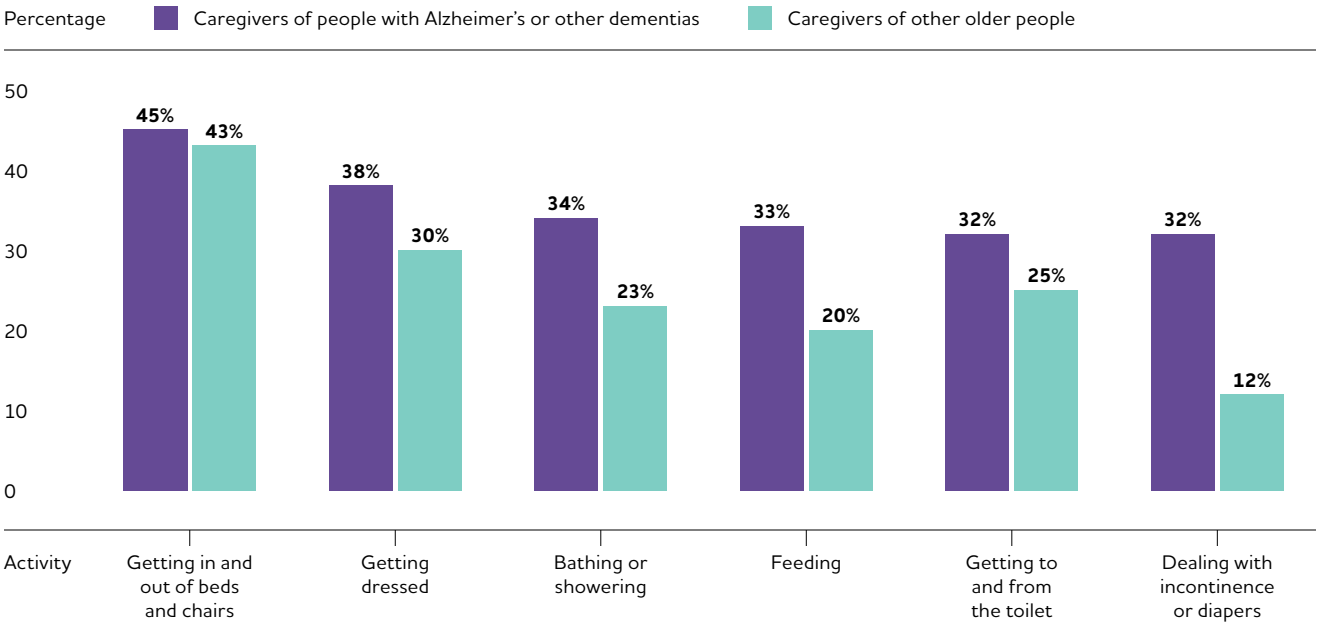
Dementia Caregiving Tasks

Helping with instrumental activities of daily living (IADLs), such as household chores, shopping, preparing meals, providing transportation, arranging for doctor's appointments, managing finances and legal affairs, and answering the telephone.
Helping the person take medications correctly, either via reminders or direct administration of medications.
Helping the person adhere to treatment recommendations for dementia or other medical conditions.
Assisting with personal activities of daily living (ADLs), such as bathing, dressing, grooming and feeding and helping the person walk, transfer from bed to chair, use the toilet and manage incontinence.
Managing behavioral symptoms of the disease such as aggressive behavior, wandering, depressive mood, agitation, anxiety, repetitive activity and nighttime disturbances.
Finding and using support services such as support groups and adult day service programs.
Making arrangements for paid in-home, nursing home or assisted living care.
Hiring and supervising others who provide care.
Assuming additional responsibilities that are not necessarily specific tasks, such as: • Providing overall management of getting through the day. • Addressing family issues related to caring for a relative with Alzheimer's disease, including communication with other family members about care plans, decision-making and arrangements for respite for the main caregiver. • Managing other health conditions (i.e., "comorbidities"), such as arthritis, diabetes or cancer. • Providing emotional support and a sense of security.

Though the care provided by family members of people with Alzheimer's or other dementias is somewhat similar to the help provided by caregivers of people with other conditions, dementia caregivers tend to provide more extensive assistance. Family caregivers of people with dementia are more likely to monitor the health of their care recipients than are caregivers of people without dementia (79 percent versus 66 percent).[276] Data from the 2011 National Health and Aging Trends Study[258,264] indicated that caregivers of people with dementia are more likely than caregivers of people without dementia to provide help

FIGURE 7

Proportion of Caregivers of People with Alzheimer's or Other Dementias Versus Caregivers of Other Older People Who Provide Help with Specific Activities of Daily Living, United States, 2015



Created from data from the National Alliance for Caregiving and AARP.[268]

with self-care and mobility (85 percent versus 71 percent) and health or medical care (63 percent versus 52 percent). Seventy-seven percent of older adults with dementia receive informal assistance with at least one ADL or household activity in contrast to only 20 percent of older adults without dementia; nearly 40 percent of people with dementia receive informal help with three or more ADLs compared with 14 percent of people without dementia.[263] Figure 7 illustrates how family caregivers of people with dementia are more likely than caregivers of other older people to assist with ADLs. Over half of individuals with dementia (53 percent) receive assistance from family members or other informal caregivers for ADLs compared with 11 percent of older adults without dementia.[263]

In addition to assisting with ADLs, more caregivers of people with Alzheimer's or other dementias advocate for their care recipient with community agencies and care providers (65 percent) and manage finances (68 percent) compared with caregivers of people without dementia (46 percent and 50 percent, respectively).[268] More caregivers of people with Alzheimer's or other dementias arrange for outside services (46 percent) and communicate with health care professionals (80 percent) compared with caregivers of people without dementia (27 percent and 59 percent, respectively).[268] Caregivers of people with dementia are more likely to coordinate health care for the care recipient than caregivers of people without dementia (86 percent versus 72 percent).[264] One in five caregivers of people with Alzheimer's or other dementias (22 percent) report problems dealing with a bank or credit union when helping with a care recipient's finances, compared with 9 percent of caregivers of people without dementia.[268] Caring for a person with dementia also means managing symptoms that caregivers of people with other diseases may not face, such as neuropsychiatric symptoms (for example, anxiety, apathy and lack of inhibition) and severe behavioral problems. Family caregivers of people with Alzheimer's or other dementias are more likely than family caregivers of people without dementia to help with emotional or mental health problems (41 percent versus 16 percent) and behavioral issues (15 percent versus 4 percent).[268]

When a person with Alzheimer's or another dementia moves to an assisted living residence or a nursing home, the help provided by his or her family caregiver usually changes from the comprehensive care summarized in Table 7 to providing emotional support, interacting with facility staff and advocating for appropriate care. However, some family caregivers continue to help with bathing, dressing and other ADLs.[277-279]

Duration of Caregiving

Eighty-six percent of dementia caregivers have provided care and assistance for at least the past year, according to the national 2014 Alzheimer's Association Women and Alzheimer's Poll.[A15] According to another study, well over half (57 percent) of family caregivers of people with Alzheimer's or other dementias in the community had provided care for 4 or more years.[263] More than six in 10 (63 percent) Alzheimer's caregivers expect to continue having care responsibilities for the next 5 years compared with less than half of caregivers of people without dementia (49 percent).[268]

Hours of Unpaid Care and Economic Value of Caregiving

In 2017, the 16.1 million family and other unpaid caregivers of people with Alzheimer's or other dementias provided an estimated 18.4 billion hours of unpaid care. This number represents an average of 21.9 hours of care per caregiver per week, or 1,139 hours of care per caregiver per year.[A16] With this care valued at $12.63 per hour,[A17] the estimated economic value of care provided by family and other unpaid caregivers of people with dementia across the United States was $232.1 billion in 2017. Table 8 (see page 36) shows the total hours of unpaid care as well as the value of care provided by family and other unpaid caregivers for the United States and each state. Unpaid caregivers of people with Alzheimer's or other dementias provided care valued at more than $4 billion in each of 21 states. Unpaid caregivers in each of the four most populous states — California, Florida, New York and Texas — provided care valued at more than $14 billion. A longitudinal study of the monetary value of family caregiving for people with dementia found that the overall value of daily family care increased 18 percent with each additional year of providing care, and that the value of this care increased as the care recipient's cognitive abilities declined.[280-281] Additional research is needed to estimate the future value of family care for people with Alzheimer's as the U.S. population continues to age.

Apart from its long duration, the immediate demands of caregiving are also time-intensive. Caregivers of people with dementia report providing 27 hours more care per month on average (92 hours versus 65 hours) than caregivers of people without dementia, with over half providing more than 21 hours of care per week.[264,276] A recent national poll found that 42 percent of caregivers of people with dementia provided an average of 9 hours of care per day.[270] An analysis of national caregiving trends from 1999 to 2015 found that the average hours of care per week increased from 45 hours in 1999 to 48 hours in 2015 for dementia caregivers; over the same time period, weekly hours of care decreased for non-dementia caregivers from 34 hours to 24 hours.[282]

Impact of Alzheimer's Caregiving

Caring for a person with Alzheimer's or another dementia poses special challenges. For example, people in the middle to later stages of Alzheimer's experience losses in judgment, orientation, and the ability to understand and communicate effectively. Family caregivers must often help people with Alzheimer's manage these issues. The personality and behavior of a person with Alzheimer's are affected as well, and these changes are often among the most challenging for family caregivers.[283-285] Individuals with Alzheimer's also require increasing levels of supervision and personal care as the disease progresses. As symptoms worsen, the care required of family members can result in increased emotional stress and depression; new or exacerbated health problems; and depleted income and finances due in part to disruptions in employment and paying for health care or other services for themselves and their care recipients.[A15,286-294]

Caregiver Emotional and Social Well-Being

The intimacy, shared experiences and memories that are often part of the relationship between a caregiver and care recipient may also be threatened due to the memory loss, functional impairment and psychiatric/behavioral disturbances that can accompany the progression of Alzheimer's. However, in a recent national poll, 45 percent of respondents indicated that caring for someone with dementia was very rewarding.[270] Although caregivers report positive feelings about caregiving, such as family togetherness and the satisfaction of helping others,[A15,295-299] they also frequently report higher levels of stress.

Stress

- More dementia caregivers were classified as having a high level of burden than caregivers of people without dementia (46 percent versus 38 percent) based on the 2015 NAC/AARP survey's Burden of Care Index, which combined the number of hours of care and the number of ADL tasks performed by the caregiver into a single numerical score.[268]
- Compared with caregivers of people without dementia, twice as many caregivers of those with dementia indicate substantial emotional, financial and physical difficulties.[264]
- Fifty-nine percent of family caregivers of people with Alzheimer's or other dementias rated the emotional stress of caregiving as high or very high (Figure 8).[A15] Nearly half of dementia caregivers indicate that providing help is highly stressful (49 percent) compared with 35 percent of caregivers of people without dementia.[268]

Depression and Mental Health

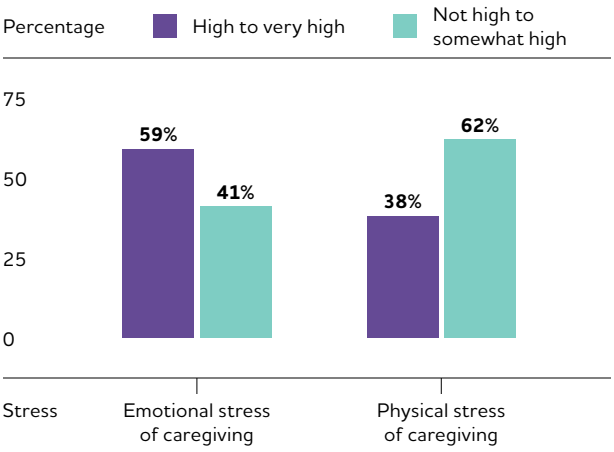
- Approximately 30 to 40 percent of family caregivers of people with dementia suffer from depression, compared with 5 to 17 percent of non-caregivers of similar ages.[300-305] A recent meta-analysis reported that caregivers of people with dementia were significantly more likely to experience depression and anxiety than non-caregivers.[275]
- The prevalence of depression (see above) is higher among dementia caregivers than other caregivers, such as those who provide help to individuals with schizophrenia (20 percent) or stroke (19 percent).[304-306]
- Depression risk increases as cognitive impairment worsens in the person with dementia.[307]
- In a meta-analysis, kin relationship was the strongest predictor of caregiver depression; caregivers of spouses had two and a half times higher odds of having depression than caregivers of people who were not spouses.[304]
- The prevalence of anxiety among dementia caregivers is 44 percent, which is higher than among caregivers of people with stroke (31 percent), for example.[304-305]
- Caregivers of individuals with Alzheimer's report more subjective cognitive problems (for example, problems with memory) and experience greater declines in cognition over time than non-caregivers matched on age and other characteristics.[308-309]

Strain

- Caregivers of people with Alzheimer's or other dementias were twice as likely as caregivers of individuals without dementia (22 percent compared with 11 percent) to report that completing medical/nursing-related tasks (for example, injections, tube feedings and catheter/colostomy care) was difficult.[276]
- Half of caregivers (51 percent) of people with Alzheimer's or another dementia indicate having no experience performing medical/nursing-related tasks,[276] and they often lack the information or resources necessary to manage complex medication regimens.[310-311]
- According to the 2014 Alzheimer's Association poll of caregivers, respondents often believed they had no choice in taking on the role of caregiver.[A15]
- The poll also found that women with children under age 18 felt that caregiving for someone with Alzheimer's was more challenging than caring for children (53 percent).[A15]
- Many caregivers of people with Alzheimer's or other dementias provide help alone. Forty-one percent of dementia caregivers in the 2014 Alzheimer's Association poll reported that no one else provided unpaid assistance.[A15]

FIGURE 8

Proportion of Caregivers of People with Alzheimer's or Other Dementias Who Report High to Very High Emotional and Physical Stress Due to Caregiving



Created from data from the Alzheimer's Association.[A15]

Stress of Care Transitions

- Admitting a relative to a residential care facility has mixed effects on the emotional and psychological well-being of family caregivers. Some studies suggest that distress remains unchanged or even increases after a relative is admitted to a residential care facility, but other studies have found that distress declines following admission.[279,312-313]
- The demands of caregiving may intensify as people with dementia approach the end of life.[314] In the year before a care recipient's death, 59 percent of caregivers felt they were "on duty" 24 hours a day, and many felt that caregiving during this time was extremely stressful.[315] The same study found that 72 percent of family caregivers experienced relief when the person with Alzheimer's or another dementia died.[315]

Caregiver Physical Health

For some caregivers, the demands of caregiving may cause declines in their own health. Evidence suggests that the stress of providing dementia care increases caregivers' susceptibility to disease and health complications.[316] As shown in Figure 8, 38 percent of Alzheimer's and dementia caregivers indicate that the physical stress of caregiving is high to very high.[A15] Building on this, a recent analysis found that 29 percent of caregivers of people with Alzheimer's or other dementias report that providing care results in high physical strain compared with 17 percent of caregivers of people without dementia.[268] The distress associated with caring for a relative with Alzheimer's or another dementia has also been shown to negatively influence the quality of family caregivers' sleep.[317-318]

TABLE 8

Number of Caregivers of People with Alzheimer's or Other Dementias, Hours of Unpaid Care, Economic Value of Unpaid Care and Higher Health Care Costs of Caregivers by State, 2017*

State	Number of Caregivers (in thousands)	Hours of Unpaid Care (in millions)	Value of Unpaid Care (in millions of dollars)	Higher Health Care Costs of Caregivers (in millions of dollars)†
Alabama	304	346	$4,367	$193
Alaska	33	38	479	32
Arizona	330	376	4,751	187
Arkansas	177	201	2,545	114
California	1,616	1,841	23,250	1,073
Colorado	247	282	3,559	148
Connecticut	178	203	2,563	154
Delaware	54	62	779	49
District of Columbia	29	33	411	30
Florida	1,121	1,277	16,129	793
Georgia	527	600	7,577	304
Hawaii	66	75	944	42
Idaho	83	94	1,190	50
Illinois	590	672	8,482	428
Indiana	338	385	4,857	245
Iowa	136	154	1,950	98
Kansas	151	172	2,173	101
Kentucky	272	310	3,915	190
Louisiana	232	265	3,343	159
Maine	69	79	992	58
Maryland	294	334	4,222	221
Massachusetts	337	384	4,845	312
Michigan	514	586	7,395	363
Minnesota	254	289	3,647	197
Mississippi	206	235	2,963	137
Missouri	316	360	4,546	224

TABLE 8 (cont.)

Number of Caregivers of People with Alzheimer's or Other Dementias, Hours of Unpaid Care, Economic Value of Unpaid Care and Higher Health Care Costs of Caregivers by State, 2017*

State	Number of Caregivers (in thousands)	Hours of Unpaid Care (in millions)	Value of Unpaid Care (in millions of dollars)	Higher Health Care Costs of Caregivers (in millions of dollars)†
Montana	50	56	$713	$36
Nebraska	82	94	1,183	61
Nevada	149	169	2,136	87
New Hampshire	67	76	961	56
New Jersey	453	516	6,517	352
New Mexico	107	122	1,538	68
New York	1,028	1,171	14,791	881
North Carolina	466	531	6,707	297
North Dakota	30	34	436	26
Ohio	600	684	8,633	458
Oklahoma	223	254	3,212	149
Oregon	184	209	2,641	130
Pennsylvania	675	769	9,708	547
Rhode Island	53	61	768	45
South Carolina	309	352	4,441	197
South Dakota	38	43	544	30
Tennessee	435	495	6,252	279
Texas	1,405	1,600	20,202	861
Utah	152	173	2,180	79
Vermont	30	34	430	27
Virginia	462	526	6,640	305
Washington	341	389	4,911	237
West Virginia	106	121	1,530	88
Wisconsin	194	220	2,785	149
Wyoming	28	31	396	20
U.S. Total	**16,139**	**18,379**	**$232,129**	**$11,367**

*State totals may not add to the U.S. total due to rounding.

†Higher health care costs are the dollar amount difference between the weighted per capita personal health care spending of caregivers and non-caregivers in each state.[A18]

Created from data from the 2009 BRFSS, U.S. Census Bureau, Centers for Medicare & Medicaid Services, National Alliance for Caregiving, AARP and U.S. Department of Labor.[A14,A16,A17,A18]

General Health

Seventy-four percent of caregivers of people with Alzheimer's or other dementias reported that they were "somewhat concerned" to "very concerned" about maintaining their own health since becoming a caregiver.[A15] Forty-two percent of caregivers of people with Alzheimer's or another dementia report that their health is excellent or very good, which is lower than caregivers of people without dementia (50 percent).[268] In addition, 35 percent of caregivers of people with Alzheimer's or another dementia report that their health has gotten worse due to care responsibilities compared with 19 percent of caregivers of people without dementia.[268] A recent poll reported that 27 percent of dementia caregivers delayed or did not do things they should for their own health.[270] Dementia caregivers indicated lower health-related quality of life than non-caregivers and are more likely than non-caregivers or other caregivers to report that their health is fair or poor.[288,292,319-321] Data from the Health and Retirement Study showed that dementia caregivers who provided care to spouses were much more likely (41 percent increased odds) than other spousal caregivers of similar age to become increasingly frail during the time between becoming a caregiver and their spouse's death.[322] Other studies, however, suggest that caregiving tasks have the positive effect of keeping older caregivers more physically active than non-caregivers.[323]

Physiological Changes

The chronic stress of caregiving is associated with physiological changes that could increase the risk of developing chronic conditions. For example, several studies found that under certain circumstances some Alzheimer's caregivers were more likely to have elevated biomarkers of cardiovascular disease risk and impaired kidney function risk than those who were not caregivers.[324-329]

Caregivers of a spouse with Alzheimer's or another dementia are more likely than married non-caregivers to have physiological changes that may reflect declining physical health, including high levels of stress hormones,[330] impaired immune function,[286,331] slow wound healing,[332] coronary heart disease,[333] impaired function of the endothelium (the inner lining of blood vessels) and increased incidence of hypertension.[334] Some of these changes may be associated with an increased risk of cardiovascular disease.[335] Studies also indicate abnormal hypothalamic-pituitary-adrenal axis function among dementia caregivers.[336]

Health Care

The physical and emotional impact of dementia caregiving is estimated to have resulted in $11.4 billion in health care costs in the United States in 2017.[A18] Table 8 shows the estimated higher health care costs for caregivers of people with Alzheimer's or other dementias in each state. In separate studies, hospitalization and emergency department visits were more likely for dementia caregivers who helped care for recipients who were depressed, had low functional status or had behavioral disturbances.[337-338] Increased depressive symptoms among caregivers over time are also linked to more frequent doctor visits, a higher number of outpatient tests and procedures, and greater use of over-the-counter and prescription medications.[338]

Mortality

The health of a person with dementia may also affect the caregiver's risk of dying, although studies have reported mixed findings.[339] In one study, caregivers of spouses who were hospitalized and had dementia in their medical records were more likely to die in the following year than caregivers whose spouses were hospitalized but did not have dementia, after accounting for differences in caregiver age.[340] One study found that caregivers who perceive higher strain due to care responsibilities are at higher risk for death than caregivers who perceive little or no strain.[341]

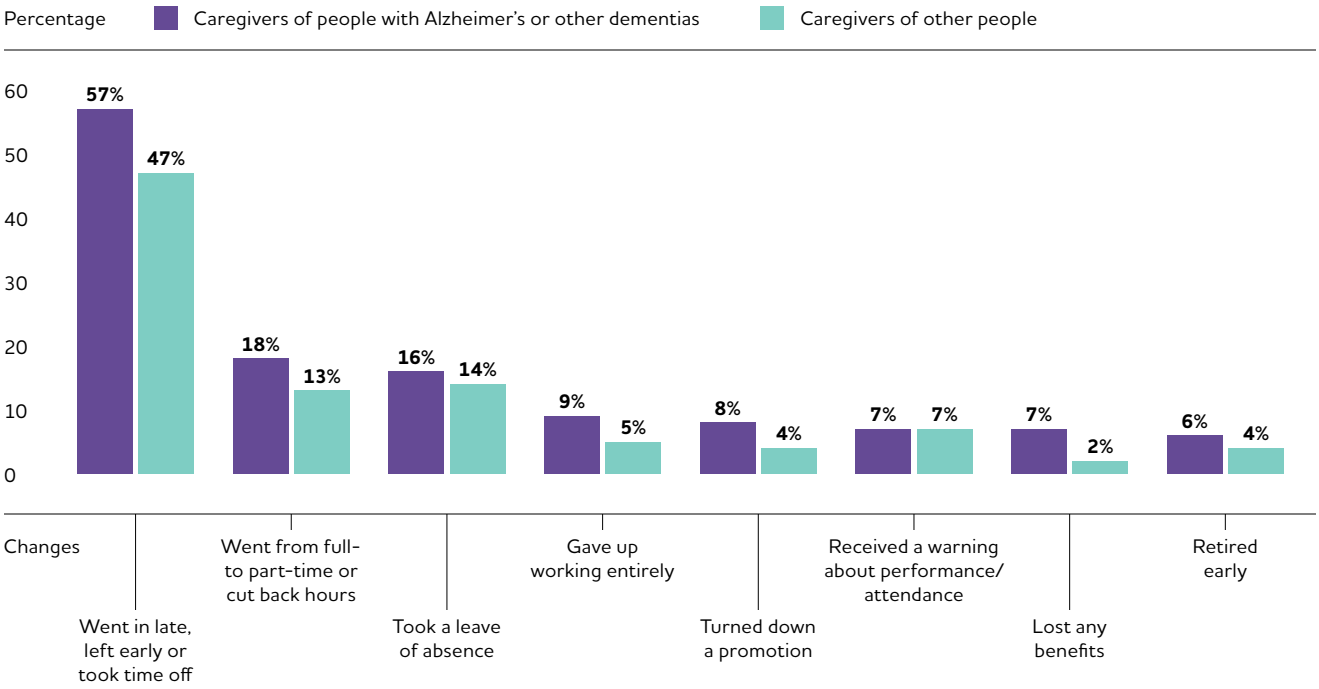
Caregiver Employment and Finances

Six in 10 caregivers of people with Alzheimer's or another dementia were employed in the past year while providing help.[268] These individuals worked an average of 35 hours per week while caregiving.[268] Among people who were employed in the past year while providing care to someone with Alzheimer's or another dementia, 57 percent reported sometimes needing to go in late or leave early compared with 47 percent of non-dementia caregivers. Compared with 13 percent of non-dementia caregivers, 18 percent of dementia caregivers reduced their work hours due to care responsibilities. Nine percent of dementia caregivers gave up working entirely, compared with 5 percent of non-dementia caregivers. Other work-related changes among dementia and non-dementia caregivers who had been employed in the past year are summarized in Figure 9.[268]

In 2016, dementia caregivers reported nearly twice the average out-of-pocket costs ($10,697) of non-dementia caregivers ($5,785).[342] Data from the 2016 Alzheimer's Association Family Impact of Alzheimer's Survey reported in *2016 Alzheimer's Disease Facts and Figures* indicated that among care contributors (a friend or relative who paid for dementia expenses and/or provided care for someone with dementia at least once a month in the prior year), 48 percent cut back on spending and 43 percent cut back on saving due to the out-of-pocket cost of providing help to someone with dementia.[293] Due to care responsibilities in the year prior to the survey, close to four in 10 care contributors indicated that the "food they bought just didn't last, and they didn't have money to get more," and three in 10 ate less because of care-related costs.[293]

FIGURE 9

Work-Related Changes Among Caregivers of People with Alzheimer's or Other Dementias Who Had Been Employed at Any Time Since They Began Caregiving



Created from data from the National Alliance for Caregiving and AARP.[268]

Interventions Designed to Assist Caregivers

For more than 30 years, strategies to support family caregivers of people with Alzheimer's have been developed and evaluated. The types and focus of these strategies (often called "interventions") are summarized in Table 9 (see page 40).[290,343]

In general, the goal of interventions is to improve the health and well-being of dementia caregivers by relieving the negative aspects of caregiving. Some also aim to delay nursing home admission of the person with dementia by providing caregivers with skills and resources (emotional, social and psychological) to continue helping their relatives or friends at home. Specific approaches used in various interventions include providing education to caregivers, helping caregivers manage dementia-related symptoms, improving social support for caregivers and providing caregivers with respite from caregiving duties.

According to a publication on dementia caregiver interventions that reviewed seven meta-analyses and 17 systematic reviews of randomized controlled trials, the following characteristics distinguish interventions that are effective: family caregivers are actively involved in the intervention, in contrast to passively receiving information; the intervention is tailored and flexible to meet the changing needs of family caregivers during the course of a relative's dementia; and the intervention meets the needs not only of caregivers, but of care recipients as well.[344] A 2012 report identified 44 interventions in the United States that have benefits for individuals with Alzheimer's or other dementias as well as their family caregivers, based on randomized, controlled studies, and more such evaluations are emerging each year.[345-346]

Interventions for dementia caregivers that have demonstrated efficacy in scientific evaluations have been gradually implemented in the community.[347-358] These implementation efforts are generally successful at improving how caregiver services are delivered, and they have the potential to reach a large number of families while also helping caregivers cope with their responsibilities.[359] Similar efforts have attempted to broaden the reach and accessibility of interventions for dementia caregivers through the use of technologies (for instance, video-phone delivery and online training) and have shown some success.[360-363]

Because caregivers and the settings in which they provide care are diverse, more studies are required to define which interventions are most effective for specific situations and how these programs are successful.[364-367] Improved tools

TABLE 9

Type and Focus of Caregiver Interventions

Type	Focus
Case management	Provides assessment, information, planning, referral, care coordination and/or advocacy for family caregivers.
Psychoeducational approaches	Include a structured program that provides information about the disease, resources and services, and about how to expand skills to effectively respond to symptoms of the disease (that is, cognitive impairment, behavioral symptoms and care-related needs). Include lectures, discussions and written materials and are led by professionals with specialized training.
Counseling	Aims to resolve pre-existing personal problems that complicate caregiving to reduce conflicts between caregivers and care recipients and/or improve family functioning.
Support groups	Are less structured than psychoeducational or psychotherapeutic interventions. Support groups provide caregivers the opportunity to share personal feelings and concerns to overcome feelings of social isolation.
Respite	Provides planned, temporary relief for the caregiver through the provision of substitute care; examples include adult day services and in-home or institutional respite for a certain number of weekly hours.
Psychotherapeutic approaches	Involve the establishment of a therapeutic relationship between the caregiver and a professional therapist (for example, cognitive-behavioral therapy for caregivers to focus on identifying and modifying beliefs related to emotional distress, developing new behaviors to deal with caregiving demands, and fostering activities that can promote caregiver well-being).
Multicomponent approaches	Are characterized by intensive support strategies that combine multiple forms of interventions, such as education, support and respite into a single, long-term service (often provided for 12 months or more).

Created from data from Pinquart et al. and Gaugler et al.[290,343]

to personalize services for caregivers to maximize their benefits represent an emerging area of research.[368-371] More studies are also needed to explore the effectiveness of interventions in different racial, ethnic and socioeconomic groups and in various geographic settings.[372-381]

Paid Caregivers

Direct-Care Workers for People with Alzheimer's or Other Dementias

Direct-care workers, such as nurse aides, home health aides, and personal and home care aides provide most of the paid long-term care to older adults living at home or in residential settings.[382-383] In nursing homes, nursing assistants make up the majority of staff who work with cognitively impaired residents.[384-386] Nursing assistants help with bathing, dressing, housekeeping, food preparation and other activities. Most nursing assistants are women, and they come from increasingly diverse ethnic, racial and geographic backgrounds.

Direct-care workers have difficult jobs, and they may not receive the training necessary to provide dementia care.[385,387-389] Turnover rates are high among direct-care workers, and recruitment and retention are persistent challenges.[388,390] Inadequate education and challenging work environments have also contributed to higher turnover rates among nursing staff across care environments.[391] Studies have shown that staff training programs to improve the quality of dementia care in nursing homes and hospitals have modest benefits.[387,392-396] The National Academies of Sciences, Engineering, and Medicine have recommended that federal requirements for direct care worker training be increased from 75 hours to 120 hours, and that instruction content focus more on knowledge and skills related to caring for individuals with Alzheimer's and other dementias.[388-389]

Shortage of Geriatric Health Care Professionals in the United States

Professionals who may receive special training in caring for older adults include physicians, nurse practitioners, registered nurses, social workers, pharmacists, physician assistants and case workers.[388] It is estimated that the United States has approximately half the number of certified geriatricians that it currently needs.[397] As of 2016, there were 7,293 certified geriatricians in the United States, or one geriatrician for every 1,924 Americans age 65 or older in need of care.[398]

The American Geriatrics Society estimates that, due to the increase in vulnerable older Americans who require geriatric care, an additional 23,750 geriatricians should be trained between now and 2030 to meet the needs of an aging U.S. population.[399] There were 234,000 nurse practitioners in the United States in 2016. Nine percent of nurse practitioners had special expertise in gerontological care, and 4 percent of nurse practitioners had expertise in gerontological care with a primary care focus.[400] Less than 1 percent of registered nurses, physician assistants and pharmacists identify themselves as specializing in geriatrics.[388] Although 73 percent of social workers serve clients age 55 and older, only 4 percent have formal certification in geriatric social work.[388] Furthermore, the overall aging of the long-term care workforce may affect the number of paid caregivers.[391]

A recent analysis examined the capacity of the U.S. health care system to care for people with Alzheimer's disease or related dementias in the upcoming decades.[401] Persons with dementia would have to wait an average of 19 months in 2020 to receive treatment if historical trends in the number of specialty care providers and other services continue. Approximately 2.1 million individuals with MCI would develop Alzheimer's dementia between 2020 and 2040 while on waiting lists for treatment.

Enhancing Health Care for Family Caregivers

There is a growing consensus that professionals caring for people with Alzheimer's and other dementias should acknowledge the role family caregivers play in facilitating the treatment of dementia, and that professionals should assess the well-being of family caregivers to improve overall disease management of the person with dementia.[402-405] Recognizing that the complex care challenges of people with dementia also require interprofessional collaboration and education,[406-407] ongoing efforts have attempted to integrate innovative care management practices with traditional primary care for people with dementia.[408-411] One example involves a skilled professional who serves as the care manager of the person with dementia. The care manager collaborates with primary care physicians and nurse practitioners to develop personalized care plans. These plans can provide support to family caregivers, help people with dementia manage care transitions (for example, a change in care provider or site of care), and ensure the person with dementia has access to appropriate community-based services. Other models include addressing the needs of family caregivers simultaneously with comprehensive disease management of the care recipient to improve the quality of life of both family caregivers and people with dementia in the community.[412] Several evaluations have suggested that such approaches have considerable potential for improving outcomes for people with dementia and their family caregivers (for example, delayed nursing home admission and reduction in caregiver distress).[413-420] Current research is attempting to determine the feasibility of these models beyond the specialty settings in which they currently operate.[421-422]

In 2016, the National Academies of Sciences, Engineering, and Medicine released *Families Caring for an Aging America*, a seminal report that includes a number of recommendations to refocus national health care reform efforts from models of care that center on the patient (person-centered care) to models of care that also explicitly engage and support the patient's family (person- and family-centered care).[423] These service models recognize the important role family members play in providing care and incorporate family caregivers during the delivery of health care to their relatives with dementia. Furthermore, these models encourage health care providers to deliver evidence-based services and support to both caregivers and care recipients.[423-424]

In January 2017, Medicare began reimbursing physicians, physician assistants, nurse practitioners and clinical nurse specialists for health care visits that result in a comprehensive dementia care plan. Comprehensive care planning is a core element of effective dementia care management and can result in the delivery of services that potentially enhance quality of life for people with dementia and their caregivers. Effective care planning for people living with dementia should include family caregivers. The Alzheimer's Association has developed a care planning kit (alz.org/careplanning/) to help guide providers to deliver effective care planning for people with dementia and their family caregivers.

Trends in Dementia Caregiving

There is some indication that families are better managing the care they provide to relatives with dementia than in the recent past. From 1999 to 2015, dementia caregivers were significantly less likely to report physical (30 percent in 1999 to 17 percent in 2015) and financial (22 percent in 1999 to 9 percent in 2015) difficulties related to care provision. In addition, use of respite care by dementia caregivers increased substantially (from 13 percent in 1999 to 27 percent in 2015).[282] However, more work is needed to ensure that interventions for dementia caregivers are available and accessible to those who need them. A 2016 study of the Older Americans Act's National Family Caregiver Support Program found that over half (52 percent) of Area Agencies on Aging did not offer evidence-based family caregiver interventions.[425]

USE AND COSTS OF HEALTH CARE, LONG-TERM CARE AND HOSPICE

$341,840

is the estimated lifetime cost of care for an individual living with dementia.

The costs of health care and long-term care for individuals with Alzheimer's or other dementias are substantial, and dementia is one of the costliest conditions to society.[426] Total payments in 2018 (in 2018 dollars) for all individuals with Alzheimer's or other dementias are estimated at $277 billion (Figure 10). Medicare and Medicaid are expected to cover $186 billion, or 67 percent, of the total health care and long-term care payments for people with Alzheimer's or other dementias. Out-of-pocket spending is expected to be $60 billion, or 22 percent of total payments.[A19] Throughout the rest of this section, all costs are reported in 2017 dollars unless otherwise indicated.[A20]

Total Cost of Health Care and Long-Term Care

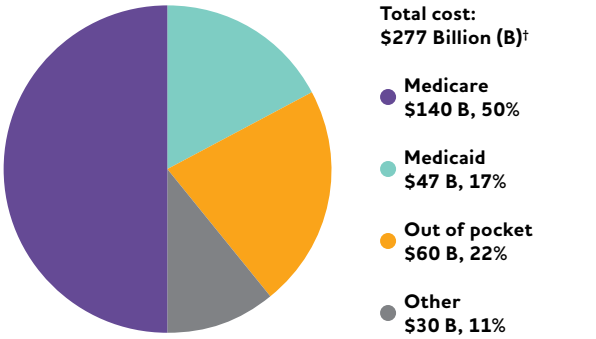
Table 10 reports the average annual per-person payments for health care and long-term care services for Medicare beneficiaries age 65 and older with and without Alzheimer's or other dementias. Total per-person health care and long-term care payments from all sources for Medicare beneficiaries with Alzheimer's or other dementias were over three times as great as payments for other Medicare beneficiaries in the same age group ($48,028 per person for those with dementia compared with $13,705 per person for those without dementia).[A21,427]

Twenty-seven percent of older individuals with Alzheimer's or other dementias who have Medicare also have Medicaid coverage, compared with 11 percent of individuals without dementia.[427] Medicaid pays for nursing home and other long-term care services for some people with very low income and low assets, and the high use of these services by people with dementia translates into high costs for the Medicaid program. Average annual Medicaid payments per person for Medicare beneficiaries with Alzheimer's or other dementias ($8,399) were 23 times as great as average Medicaid payments for Medicare beneficiaries without Alzheimer's or other dementias ($358) (Table 10).[427]

Despite these and other sources of financial assistance, individuals with Alzheimer's or other dementias still incur

FIGURE 10

Distribution of Aggregate Costs of Care by Payment Source for Americans Age 65 and Older with Alzheimer's or Other Dementias, 2018*



*Data are in 2018 dollars.

†Before rounding, Medicare and Medicaid payments combined total $186 billion, and out-of-pocket and other expenses combined total $91 billion.

Created from data from the Lewin Model.[A19] "Other" payment sources include private insurance, health maintenance organizations, other managed care organizations and uncompensated care.

TABLE 10

Average Annual Per-Person Payments for Health Care and Long-Term Care Services, Medicare Beneficiaries Age 65 and Older, with and without Alzheimer's or Other Dementias, in 2017 Dollars

Payment Source	Beneficiaries with Alzheimer's or Other Dementias	Beneficiaries without Alzheimer's or Other Dementias
Medicare	$24,122	$7,415
Medicaid	8,399	358
Uncompensated	374	375
Health maintenance organization	1,237	1,514
Private insurance	2,209	1,394
Other payer	919	237
Out of pocket	10,589	2,291
Total*	**48,028**	**13,705**

*Payments from sources do not equal total payments exactly due to the effect of population weighting. Payments for all beneficiaries with Alzheimer's and other dementias include payments for community-dwelling and facility-dwelling beneficiaries.

Created from unpublished data from the Medicare Current Beneficiary Survey for 2011.[427]

high out-of-pocket costs. These costs are for Medicare and other health insurance premiums and for deductibles, copayments and services not covered by Medicare, Medicaid or additional sources of support. On average, Medicare beneficiaries age 65 and older with Alzheimer's or other dementias paid $10,589 out of pocket annually for health care and long-term care services not covered by other sources (Table 10).[427]

Researchers have evaluated the additional or "incremental" health care, residential long-term care and family caregiving costs of dementia (that is, the costs specifically attributed to dementia when comparing people with and without dementia who have the same coexisting medical conditions and demographic characteristics).[262,426,428-429] One group of researchers found that the incremental health care and nursing home costs for those with dementia were $28,501 per person per year in 2010 dollars ($34,825 in 2017 dollars).[A20,A22,426] Another group of researchers found that the incremental lifetime cost of Alzheimer's dementia was substantially higher for women than men, due to a greater lifetime risk of developing Alzheimer's dementia.[430] Additionally, because women are more likely to be widowed and living in poverty, the incremental Medicaid costs associated with Alzheimer's dementia were 70 percent higher for women than men. A third group of researchers found that the lifetime cost of care, including out-of-pocket, Medicare and Medicaid expenditures, and the value of informal caregiving, was $321,780 per person with dementia in 2015 dollars ($341,840 in 2017 dollars).[262] Compared with an individual without dementia, the incremental lifetime cost of dementia was $184,500 ($196,002 in 2017 dollars), with informal caregiving representing 72 percent and out-of-pocket costs representing 14 percent of the excess costs due to the disease.

Other researchers compared end-of-life costs for individuals with and without dementia and found that the total cost in the last 5 years of life was $287,038 per person for individuals with dementia in 2010 dollars and $183,001 per person for individuals without dementia but with other conditions ($350,725 and $223,605 respectively, in 2017 dollars), a difference of 57 percent.[431] Additionally, out-of-pocket costs represented a substantially larger proportion of total wealth for those with dementia than for people without dementia (32 percent versus 11 percent).

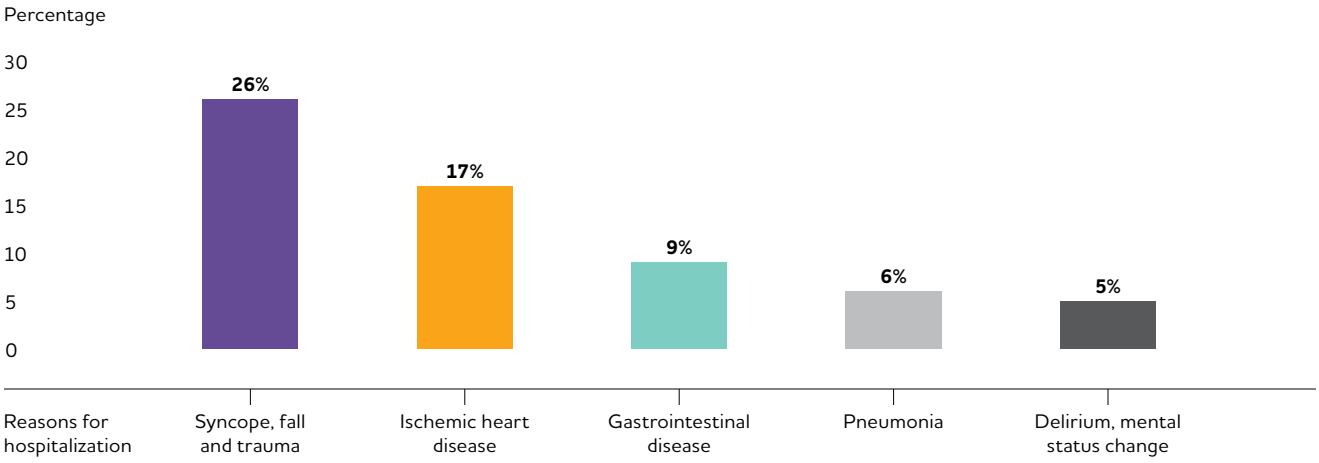
Use and Costs of Health Care Services

Use of Health Care Services

People with Alzheimer's or other dementias have twice as many hospital stays per year as other older people.[208] Moreover, the use of health care services by people with other serious medical conditions is strongly affected

FIGURE 11

Reasons for Hospitalization of Individuals with Alzheimer's Dementia: Percentage of Hospitalized Individuals by Admitting Diagnosis*



*All hospitalizations for individuals with a clinical diagnosis of probable or possible Alzheimer's were used to calculate percentages. The remaining 37 percent of hospitalizations were due to other reasons.

Created from data from Rudolph et al.[433]

by the presence or absence of dementia. In particular, people with coronary artery disease, diabetes, chronic kidney disease, chronic obstructive pulmonary disease (COPD), stroke or cancer who also have Alzheimer's or other dementias have higher use and costs of health care services than people with these medical conditions but no coexisting dementia.

In addition to having more hospital stays, older people with Alzheimer's or other dementias have more skilled nursing facility stays and home health care visits per year than other older people.

- Hospital. There are 538 hospital stays per 1,000 Medicare beneficiaries age 65 and older with Alzheimer's or other dementias compared with 266 hospital stays per 1,000 Medicare beneficiaries age 65 and older without these conditions.[208] A person with dementia in 2012 had, on average, 23 inpatient days — defined as days in a hospital or skilled nursing facility — compared with 5 days for the Medicare population as a whole.[432] The most common reasons for hospitalization of people with Alzheimer's dementia are syncope (fainting), fall and trauma (26 percent); ischemic heart disease (17 percent); and gastrointestinal disease (9 percent) (Figure 11).[433] In a study of inpatient hospitalizations of adults age 60 and older, those with Alzheimer's were at 7 percent greater risk of dying during the hospital stay and stayed nearly a day longer than individuals without Alzheimer's dementia.[434] Among Medicare beneficiaries with Alzheimer's or other dementias, 21 percent of hospital stays are followed by a readmission within 30 days.[435] (While not directly comparable, one study of a portion of Medicare beneficiaries found an overall readmission rate of 18 percent.[436])
- Emergency department. There are 1,471 emergency department visits per 1,000 Medicare beneficiaries with Alzheimer's or other dementias per year.[435] (While not directly comparable, there were 640 emergency department visits per 1,000 Medicare beneficiaries per year in a review of utilization patterns of a subset of Medicare beneficiaries.[436])
- Skilled nursing facility. Skilled nursing facilities provide direct medical care that is performed or supervised by registered nurses, such as giving intravenous fluids, changing dressings and administering tube feedings.[437] There are 283 skilled nursing facility stays per 1,000 beneficiaries with Alzheimer's or other dementias compared with 73 stays per 1,000 beneficiaries without these conditions — a rate nearly four times as great.[208]
- Home health care. Twenty-five percent of Medicare beneficiaries age 65 and older with Alzheimer's or other dementias have at least one home health care visit during the year, compared with 10 percent of Medicare beneficiaries age 65 and older without Alzheimer's or other dementias.[208]

TABLE 11

Average Annual Per-Person Payments for Health Care and Long-Term Care Services Provided to Medicare Beneficiaries Age 65 and Older, with and without Alzheimer's or Other Dementias, in 2017 Dollars

Service	Beneficiaries with Alzheimer's or Other Dementias	Beneficiaries without Alzheimer's or Other Dementias
Inpatient hospital	$10,862	$3,509
Medical provider*	5,729	3,569
Skilled nursing facility	6,750	462
Nursing home	15,462	749
Hospice	2,017	153
Home health care	2,525	367
Prescription medications†	3,436	2,947

*"Medical provider" includes physician, other medical provider and laboratory services, and medical equipment and supplies.

†Information on payments for prescription medications is only available for people who were living in the community, that is, not in a nursing home or an assisted living facility.

Created from unpublished data from the Medicare Current Beneficiary Survey for 2011.[427]

Costs of Health Care Services

Average per-person payments for health care services (hospital, physician and other medical provider, nursing home, skilled nursing facility, hospice and home health care) and prescription medications were higher for Medicare beneficiaries with Alzheimer's or other dementias than for other Medicare beneficiaries in the same age group (Table 11).

Use and Costs of Health Care Services by State

Substantial geographic variation in health care utilization and Medicare payments by individuals with Alzheimer's or other dementias exists (Table 12). Emergency department visits range from 1,030 per 1,000 beneficiaries in South Dakota to 1,758 per 1,000 beneficiaries in West Virginia, and hospital readmissions within 30 days range from 14.7 percent in Utah to 25.2 percent in the District of Columbia. Medicare spending per capita ranges from $15,106 in North Dakota to $31,387 in Nevada (in 2017 dollars).[435]

Use and Costs of Health Care Services Across the Spectrum of Cognitive Impairment

Health care costs increase with the presence of dementia. In a population-based study of adults ages 70 to 89, annual health care costs were significantly higher for individuals with dementia than for those with either mild cognitive impairment or normal cognition.[438] Annual health care costs for individuals with mild cognitive impairment were not significantly different, however, from costs for individuals with normal cognition.

Several groups of researchers have found that both health care and prescription drug spending are significantly higher in the year prior to diagnosis[439-441] and 2 years prior to diagnosis[442] compared with otherwise similar individuals not diagnosed with Alzheimer's or another dementia, although there are differences in the sources of increased spending. In one study, the largest differences were in inpatient and post-acute care,[440] while in another study the differences in spending were primarily due to outpatient care, home care and medical day services.[441] In a third study, the differences were due to home health care, skilled nursing care and durable medical equipment.[442] Two groups of researchers have found that spending in the year after diagnosis continued to be higher than that for individuals not diagnosed with the disease, by amounts ranging from $9,333 in additional costs in 2011 dollars based on individuals enrolled in a Medicare Advantage Prescription Drug plan ($11,067 in 2017 dollars)[439] to $17,852 in additional costs in 2014 dollars based on individuals with Medicare fee-for-service coverage ($19,464 in 2017 dollars).[440]

One group of researchers found no difference in health care spending in the 2 years after diagnosis.[442] Researchers have found that time to Alzheimer's dementia diagnosis after the earliest diagnosis of cognitive decline was shorter for individuals whose cognitive impairment was diagnosed by a specialist (that is, neurologist, psychiatrist or geriatrician) than those diagnosed by a non-specialist. Additionally, individuals diagnosed with cognitive impairment by a specialist had lower Medicare costs in the year after receiving a diagnosis of Alzheimer's dementia than those diagnosed by a non-specialist.[443] While more research is needed to understand the underlying causes of increased use of health care services immediately prior to and after receiving a diagnosis of Alzheimer's dementia, possible causes include care for disability and injuries, such as falls, that might result from the early stage of the disease[444]; treatments related to cognitive impairment or coexisting medical conditions; the disease stage at diagnosis (annual costs being higher when an individual receives a diagnosis in a later disease stage); and costs of diagnostic procedures.

TABLE 12

Emergency Department (ED) Visits, Hospital Stays and Per Capita Medicare Payments in 2017 Dollars by Medicare Beneficiaries with Alzheimer's or Other Dementias by State, 2015

State	Number of ED Visits per 1,000 Beneficiaries	Percentage of Hospital Stays Followed by Readmission within 30 Days	Per Capita Medicare Payments
Alabama	1,366	20.7	$21,647
Alaska	1,398	18.2	21,635
Arizona	1,441	19.1	23,885
Arkansas	1,510	21.2	21,361
California	1,428	21.7	30,072
Colorado	1,383	16.9	21,417
Connecticut	1,483	21.2	26,761
Delaware	1,576	20.7	27,970
District of Columbia	1,737	25.2	29,705
Florida	1,482	23.1	28,082
Georgia	1,528	21.1	23,240
Hawaii	1,074	16.1	17,617
Idaho	1,305	14.7	19,101
Illinois	1,528	21.9	26,667
Indiana	1,419	19.6	24,486
Iowa	1,243	16.8	16,931
Kansas	1,308	18.0	20,980
Kentucky	1,635	22.2	23,244
Louisiana	1,703	21.2	28,375
Maine	1,574	17.9	19,443
Maryland	1,509	22.1	28,450
Massachusetts	1,504	22.5	28,435
Michigan	1,598	23.4	26,717
Minnesota	1,279	18.7	20,035
Mississippi	1,685	22.2	26,240
Missouri	1,458	21.7	21,990
Montana	1,230	16.3	$17,118
Nebraska	1,092	16.8	19,859
Nevada	1,592	23.0	31,387
New Hampshire	1,366	19.2	22,185
New Jersey	1,423	22.4	29,473
New Mexico	1,421	18.9	21,495
New York	1,384	23.2	28,816
North Carolina	1,615	20.2	21,477
North Dakota	1,059	16.1	15,106
Ohio	1,519	21.5	24,616
Oklahoma	1,625	20.7	24,688
Oregon	1,482	18.0	19,143
Pennsylvania	1,409	20.8	25,225
Rhode Island	1,608	22.2	25,848
South Carolina	1,506	20.5	23,215
South Dakota	1,030	15.9	17,387
Tennessee	1,565	21.2	23,237
Texas	1,451	20.5	29,319
Utah	1,129	14.7	20,643
Vermont	1,455	18.8	20,664
Virginia	1,567	21.7	22,155
Washington	1,415	17.7	20,274
West Virginia	1,758	22.4	23,211
Wisconsin	1,382	18.5	19,695
Wyoming	1,344	16.0	18,772
U.S. Total	**1,471**	**21.3**	**$25,435***

*The U.S. total differs slightly from the figure in Table 10 due to different underlying sources of data.

Created from data from the U.S. Centers for Medicare & Medicaid Services.[435]

TABLE 13

Percentage of Medicare Beneficiaries Age 65 and Older with Alzheimer's or Other Dementias Who Have Specified Coexisting Conditions

Coexisting Condition	Percentage
Coronary artery disease	38
Diabetes	37
Chronic kidney disease	29
Congestive heart failure	28
Chronic obstructive pulmonary disease	25
Stroke	22
Cancer	13

Created from unpublished data from the National 5% Sample Medicare Fee-for-Service Beneficiaries for 2013.[208]

Impact of Alzheimer's and Other Dementias on the Use and Costs of Health Care in People with Coexisting Medical Conditions

Medicare beneficiaries with Alzheimer's or other dementias are more likely than those without dementia to have other chronic conditions.[208] While 26 percent of Medicare beneficiaries age 65 and older with Alzheimer's or other dementias have five or more chronic conditions (including Alzheimer's or other dementias), only 4 percent of Medicare beneficiaries without Alzheimer's or other dementias have five or more chronic conditions.[208] Table 13 reports the proportion of people with Alzheimer's or other dementias who have certain coexisting medical conditions. In 2013, the latest year for which information is available, 38 percent of Medicare beneficiaries age 65 and older with dementia also had coronary artery disease, 37 percent had diabetes, 29 percent had chronic kidney disease, 28 percent had congestive heart failure and 25 percent had chronic obstructive pulmonary disease.[208]

Medicare beneficiaries who have Alzheimer's or other dementias and a coexisting medical condition have higher average per-person payments for most health care services than Medicare beneficiaries with the same medical condition but without dementia. Table 14 shows the average per-person Medicare payments for seven specific medical conditions among beneficiaries who have Alzheimer's or other dementias and beneficiaries who do not have Alzheimer's or another dementia.[208] Medicare beneficiaries with Alzheimer's or other dementias had higher average per-person payments in all categories except hospital care payments for individuals with congestive heart failure.

Use and Costs of Long-Term Care Services

An estimated 70 percent of older adults with Alzheimer's or other dementias live in the community, compared with 98 percent of older adults without Alzheimer's or other dementias.[427] Of those with dementia who live in the community, 74 percent live with someone and the remaining 26 percent live alone.[427] As their disease progresses, people with Alzheimer's or other dementias generally receive more care from family members and other unpaid caregivers. Many people with dementia also receive paid services at home; in adult day centers, assisted living facilities or nursing homes; or in more than one of these settings at different times during the often long course of the disease. The average costs of these services are high (assisted living: $45,000 per year[445] and nursing home care: $85,775 to $97,455 per year [445]), and Medicaid is the only public program that covers the long nursing home stays that most people with dementia require in the late stages of their illnesses.

Use of Long-Term Care Services by Setting

Most people with Alzheimer's or other dementias who live at home receive unpaid help from family members and friends, but some also receive paid home- and community-based services, such as personal care and adult day care. People with Alzheimer's or other dementias make up a large proportion of all elderly people who receive adult day services and nursing home care.

- Adult day services. Thirty percent of individuals using adult day services have Alzheimer's or other dementias.[446] Overall, 69 percent of adult day service programs offer specific programs for individuals with Alzheimer's or other dementias, and 14 percent of adult day service centers primarily serve individuals with Alzheimer's or other dementias.[447]
- Assisted living. Forty percent of residents in residential care facilities (that is, housing that includes services to assist with everyday activities, such as medication management and meals), including assisted living facilities, have Alzheimer's or other dementias.[448] Small residential care facilities (four to 25 beds) have a larger proportion of residents with Alzheimer's or other dementias than larger facilities (47 percent in facilities with four to 25 beds compared with 42 percent in facilities with 26 to 50 beds and 37 percent in facilities with more than 50 beds).[448] Fifty-eight percent of residential care facilities offer programs for residents with Alzheimer's or other dementias.[449]

TABLE 14

Average Annual Per-Person Payments by Type of Service and Coexisting Medical Condition for Medicare Beneficiaries Age 65 and Older, with and without Alzheimer's or Other Dementias, in 2017 Dollars*

	Average Per-Person Medicare Payment					
Medical Condition by Alzheimer's/Dementia (A/D) Status	**Total Medicare Payments**	Hospital Care	Physician Care	Skilled Nursing Facility Care	Home Health Care	Hospice Care
Coronary artery disease						
With A/D	**$27,562**	$8,659	$2,253	$4,652	$2,461	$3,020
Without A/D	**17,202**	6,237	1,603	1,495	1,020	393
Diabetes						
With A/D	**26,682**	8,239	2,206	4,499	2,381	2,720
Without A/D	**14,730**	5,162	1,413	1,299	886	267
Congestive heart failure						
With A/D	**30,243**	9,731	2,366	5,085	2,578	3,625
Without A/D	**25,659**	9,880	2,125	2,753	1,830	847
Chronic kidney disease						
With A/D	**29,433**	9,325	2,310	4,949	2,435	3,230
Without A/D	**21,103**	7,707	1,822	1,997	1,262	497
Chronic obstructive pulmonary disease						
With A/D	**29,217**	9,352	2,339	4,904	2,519	3,349
Without A/D	**19,931**	7,490	1,767	1,855	1,261	632
Stroke						
With A/D	**27,967**	8,546	2,230	4,841	2,367	3,360
Without A/D	**20,148**	6,953	1,796	2,433	1,528	635
Cancer						
With A/D	**26,495**	8,107	2,160	4,173	2,178	3,006
Without A/D	**16,804**	5,329	1,482	1,114	727	508

*This table does not include payments for all kinds of Medicare services, and as a result the average per-person payments for specific Medicare services do not sum to the total per-person Medicare payments.

Created from unpublished data from the National 5% Sample Medicare Fee-for-Service Beneficiaries for 2014.[208]

- Nursing home care. Fifty percent of nursing home residents in 2014 had Alzheimer's or other dementias,[450] and 61 percent had moderate or severe cognitive impairment.[451] Nursing home admission by age 80 is expected for 75 percent of people with Alzheimer's dementia compared with only 4 percent of the general population.[242]
- Alzheimer's special care units. An Alzheimer's special care unit is a dedicated unit in a nursing home that has tailored services for individuals with Alzheimer's or other dementias. Nursing homes had a total of 73,742 beds in Alzheimer's special care units in 2014, a decrease of 3 percent from the previous year.[452-453] These Alzheimer's special care unit beds accounted for just 4 percent of all nursing home beds, despite 61 percent of nursing home residents having moderate or severe cognitive impairment.

Long-Term Care Services Provided at Home and in the Community

Nationally, state Medicaid programs are shifting long-term care services from institutional care to home- and community-based services as a means to both reduce unnecessary costs and meet the growing demand for these services by older adults. The federal and state governments share the management and funding of the program, and states differ greatly in the services covered by their Medicaid programs. In 2014, home- and community-based services represented the majority (53 percent) of Medicaid spending on long-term services and supports, with institutional care representing the remaining 47 percent.[454] Additionally, total spending on home care for Medicare beneficiaries with Alzheimer's or other dementias nearly doubled between 2004 and 2011, although increases in spending may be due to a variety of factors, including more people being diagnosed with Alzheimer's dementia, more people using home care, an increase in the number of coexisting medical conditions, more intensive use of home care services and an increase in Medicaid coverage by older adults.[427,455]

Transitions Between Care Settings

A research study demonstrated that individuals with dementia often move between a nursing facility, hospital and home, rather than remaining solely in a nursing facility.[456] In this longitudinal study of primary care patients with dementia, researchers found that those discharged from a nursing facility were nearly equally as likely to be discharged home (39 percent) as discharged to a hospital (44 percent). Individuals with dementia may also transition between a nursing facility and hospital or between a nursing facility, home and hospital, creating challenges for caregivers and providers to ensure that care is coordinated across settings. Other research has shown that nursing home residents frequently have burdensome transitions at the end of life, including admission to an intensive care unit in the last month of life and late enrollment in hospice.[457] The number of care transitions for nursing home residents with advanced cognitive impairment varies substantially across geographic regions of the United States.[458]

Costs of Long-Term Care Services

Long-term care services include home- and community-based services, assisted living and nursing home care. The following estimates are for all users of these services.

- Home care. The median cost for a paid non-medical home health aide is $22 per hour and $135 per day.[459-460] Home care costs increased by 6.2 percent between 2016 and 2017 and 2.5 percent annually over the past 5 years.[459]
- Adult day centers. The median cost of adult day services is $70 per day.[459] The cost of adult day services has increased 2.8 percent annually over the past 5 years.
- Assisted living facilities. The median cost for care in an assisted living facility is $3,750 per month, or $45,000 per year.[445,459] The cost of assisted living has increased 2.6 percent annually over the past 5 years.[459]
- Nursing homes. The average cost for a private room in a nursing home is $267 per day, or $97,455 per year, and the average cost of a semi-private room in a nursing home is $235 per day, or $85,775 per year.[445,459] The cost of nursing home care has increased 3.8 percent and 3.3 percent annually over the past 5 years for a private and semi-private room, respectively.[459]

Affordability of Long-Term Care Services

Few individuals with Alzheimer's or other dementias have sufficient long-term care insurance or can afford to pay out of pocket for long-term care services for as long as the services are needed.

- Income and asset data are not available for people with Alzheimer's or other dementias specifically, but 50 percent of Medicare beneficiaries have incomes of $26,200 or less in 2016 dollars ($26,704 in 2017 dollars) and 25 percent have incomes of $15,250 or less in 2016 dollars ($15,543 in 2017 dollars).[461]
- Fifty percent of Medicare beneficiaries had total savings of $74,450 or less in 2016 dollars ($75,882 in 2017 dollars), 25 percent had savings of $14,550 or less in 2016 dollars ($14,830 in 2017 dollars), and 8 percent had no savings or were in debt. Median savings were substantially lower for African-American and Hispanic beneficiaries than for white Medicare beneficiaries.[461]

Long-Term Care Insurance

Long-term care insurance covers costs of long-term care services and supports in the home, in the community and in residential facilities. Long-term care insurance typically covers care provided in a nursing home, assisted living facility and Alzheimer's special care facility, as well as community-based services such as adult day care and services provided in the home, including nursing care and help with personal care.[462] The 2016 Alzheimer's Association Family Impact of Alzheimer's Survey reported in *2016 Alzheimer's Disease Facts and Figures* that among the more than 3,500 respondents, 28 percent believed that Medicare covered the cost of nursing home care for people with Alzheimer's and 37 percent did not know whether it covered the cost of nursing home care.[293] While Medicare covers care in a long-term care hospital, skilled nursing care in a skilled nursing facility and hospice care, it does not cover long-term care in a nursing home.[463]

Industry reports estimate that approximately 7.2 million Americans had long-term care insurance in 2014.[464] The median income for individuals purchasing long-term care insurance was $87,500 in 2010, in 2010 dollars, with 77 percent having an annual income greater than $50,000 and 82 percent having assets greater than $75,000.[464] Private health care and long-term care insurance policies funded only about 8 percent of total long-term care spending in 2013, representing $24.8 billion of the $310 billion total in 2013 dollars.[465] The private long-term care insurance market is highly concentrated and has consolidated since 2000. In 2000, 41 percent of individuals with a long-term care policy were insured by one of the five largest insurers; in 2014, 56 percent were insured by one of the five largest insurers.[464]

Medicaid Costs

Medicaid covers nursing home care and long-term care services in the community for individuals who meet program requirements for level of care, income and assets. To receive coverage, beneficiaries must have low incomes. Most nursing home residents who qualify for Medicaid must spend all of their Social Security income and any other monthly income, except for a very small personal needs allowance, to pay for nursing home care. Medicaid only makes up the difference if the nursing home resident cannot pay the full cost of care or has a financially dependent spouse. While Medicaid covers the cost of nursing home care, its coverage of many long-term care and support services, such as assisted living care, home-based skilled nursing care and help with personal care, varies by state.

Total Medicaid spending for people with Alzheimer's or other dementias is projected to be $47 billion in 2018 (in 2018 dollars).[A19] Estimated state-by-state Medicaid spending on people with Alzheimer's or other dementias in 2018 (in 2018 dollars) is included in Table 15. Total per-person Medicaid payments for Medicare beneficiaries age 65 and older with Alzheimer's or other dementias were 23 times as great as Medicaid payments for other Medicare beneficiaries.[427] Much of the difference in payments for beneficiaries with Alzheimer's or other dementias and other beneficiaries is due to the costs associated with long-term care (nursing homes and other residential care facilities, such as assisted living facilities) and the greater percentage of people with dementia who are eligible for Medicaid.

Use and Costs of Care at the End of Life

Hospice care provides medical care, pain management, and emotional and spiritual support for people who are dying, including people with Alzheimer's or other dementias. Hospice care also provides emotional and spiritual support and bereavement services for families of people who are dying. The main purpose of hospice is to allow individuals to die with dignity and without pain and other distressing symptoms that often accompany terminal illness. Individuals can receive hospice care in their homes, assisted living residences or nursing homes. Medicare is the primary source of payment for hospice care, but private insurance, Medicaid and other sources also pay for hospice care.

More than twice as many individuals with dementia were receiving hospice care at the time of death in 2009 than in 2000 (48 percent in 2009 versus 20 percent in 2000). Expansion of hospice care is associated with fewer individuals with dementia having more than two hospitalizations for any reason or more than one hospitalization for pneumonia, urinary tract infection, dehydration or sepsis in the last 90 days of life.[466] In 2015, 18 percent of Medicare beneficiaries admitted to hospice had a primary diagnosis of dementia, including Alzheimer's dementia (Table 16),[467] compared with 17 percent in 2009.[468] Dementia was the second most common primary diagnosis for Medicare beneficiaries admitted to hospice overall, with cancer being the most common primary diagnosis. Forty-five percent of hospice users in 2014 had a primary or secondary diagnosis of Alzheimer's or other dementias, suggesting that a large proportion of hospice users have Alzheimer's as a comorbid condition.[450]

For Medicare beneficiaries with advanced dementia who receive skilled nursing facility care in the last 90 days of life, those who are enrolled in hospice are less likely to die in the hospital.[469] Additionally, those enrolled in hospice care are less likely to be hospitalized in the last 30 days of life[470] and more likely to receive regular treatment for pain.[471-472] Nearly half of individuals with dementia die while receiving hospice care.[473] Additionally, 19 percent of individuals with dementia receive hospice care in a given year, a higher percentage than for other chronic conditions.[208] Satisfaction with

TABLE 15

Total Medicaid Costs for Americans Age 65 and Older Living with Alzheimer's or Other Dementias by State*

State	2018 (in millions of dollars)	2025 (in millions of dollars)	Percentage Increase	State	2018 (in millions of dollars)	2025 (in millions of dollars)	Percentage Increase
Alabama	$839	$1,107	31.9	Montana	$150	$199	33.4
Alaska	66	109	63.9	Nebraska	347	404	16.3
Arizona	364	537	47.6	Nevada	178	272	53.5
Arkansas	353	446	26.3	New Hampshire	236	329	39.2
California	3,776	5,150	36.4	New Jersey	2,011	2,568	27.7
Colorado	573	775	35.3	New Mexico	199	274	37.7
Connecticut	926	1,166	25.9	New York	4,834	6,206	28.4
Delaware	226	307	35.8	North Carolina	1,188	1,600	34.7
District of Columbia	121	132	9.6	North Dakota	175	211	21.0
Florida	2,502	3,392	35.6	Ohio	2,360	2,888	22.4
Georgia	1,114	1,565	40.4	Oklahoma	481	600	24.8
Hawaii	207	280	35.4	Oregon	235	311	32.7
Idaho	139	193	39.0	Pennsylvania	3,404	3,958	16.3
Illinois	1,649	2,162	31.1	Rhode Island	438	555	26.6
Indiana	981	1,211	23.4	South Carolina	573	804	40.2
Iowa	630	778	23.7	South Dakota	167	208	24.3
Kansas	424	533	25.8	Tennessee	989	1,353	36.8
Kentucky	721	932	29.3	Texas	2,805	3,882	38.4
Louisiana	712	917	28.8	Utah	160	231	44.9
Maine	197	269	36.9	Vermont	106	144	36.1
Maryland	1,096	1,508	37.5	Virginia	900	1,244	38.2
Massachusetts	1,633	1,996	22.2	Washington	497	678	36.4
Michigan	1,368	1,707	24.8	West Virginia	414	512	23.6
Minnesota	824	1,069	29.7	Wisconsin	723	909	25.7
Mississippi	564	716	26.9	Wyoming	76	109	42.7
Missouri	888	1,117	25.8	**U.S. Total**	**$46,535**	**$60,523**	**30.1**

*All cost figures are reported in 2018 dollars. State totals may not add to the U.S. total due to rounding.

Created from data from the Lewin Model.[A19]

TABLE 16

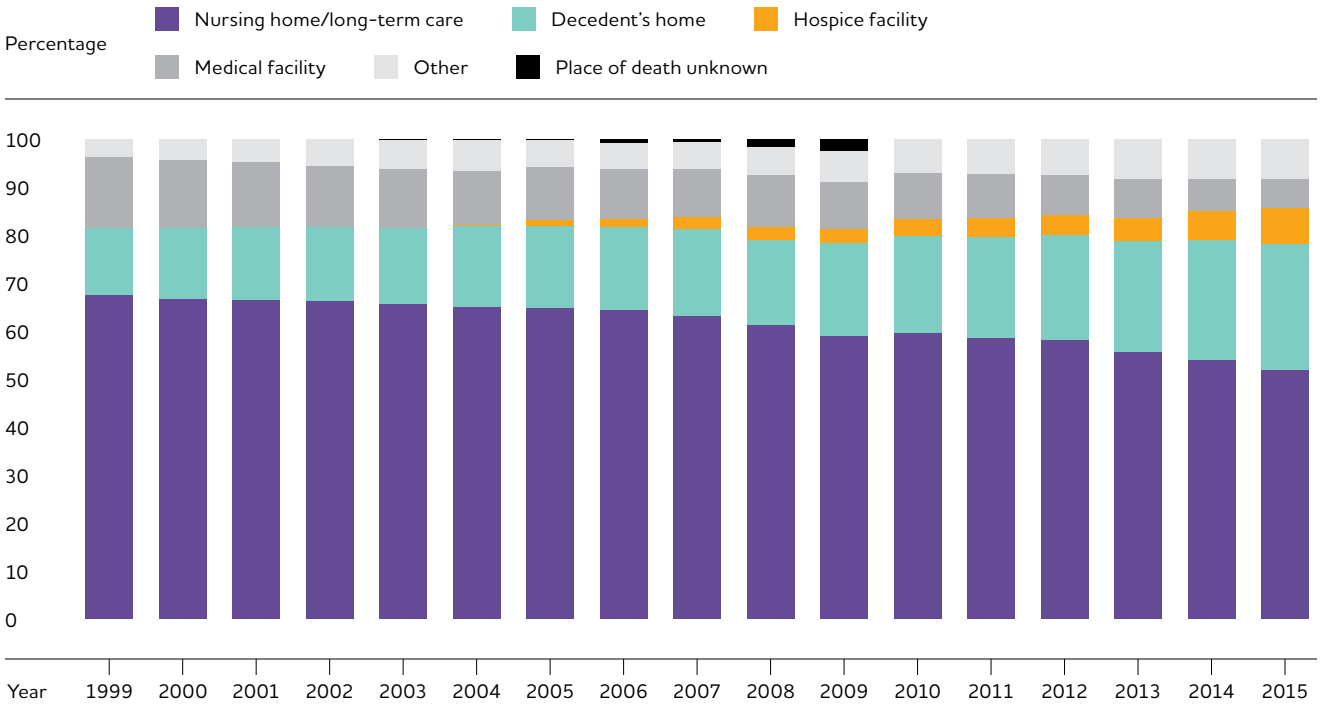
Number of Medicare Beneficiaries Admitted to Hospice and Percentage with Dementia by State, 2015

State	Number of Beneficiaries	Percentage with a Primary Diagnosis of Dementia	State	Number of Beneficiaries	Percentage with a Primary Diagnosis of Dementia
Alabama	29,114	20	Montana	4,282	13
Alaska	689	16	Nebraska	8,544	20
Arizona	35,400	18	Nevada	10,611	17
Arkansas	15,567	18	New Hampshire	5,364	17
California	128,635	21	New Jersey	32,997	21
Colorado	19,313	15	New Mexico	8,904	15
Connecticut	14,061	17	New York	47,120	16
Delaware	5,214	11	North Carolina	45,666	18
District of Columbia	1,276	17	North Dakota	2,320	19
Florida	120,517	15	Ohio	67,298	17
Georgia	44,444	22	Oklahoma	20,297	18
Hawaii	5,273	19	Oregon	19,594	18
Idaho	8,087	18	Pennsylvania	68,255	17
Illinois	49,647	18	Rhode Island	6,035	26
Indiana	31,005	17	South Carolina	27,695	23
Iowa	17,886	14	South Dakota	2,905	13
Kansas	14,185	17	Tennessee	29,551	18
Kentucky	16,941	15	Texas	106,601	23
Louisiana	22,270	20	Utah	11,521	18
Maine	7,049	18	Vermont	2,482	14
Maryland	20,551	17	Virginia	29,574	17
Massachusetts	27,728	24	Washington	24,759	21
Michigan	51,542	16	West Virginia	9,545	16
Minnesota	23,023	20	Wisconsin	28,965	17
Mississippi	15,346	20	Wyoming	1,073	7
Missouri	31,875	16	**U.S. Total**	**1,378,596**	**18**

Created from data from the U.S. Centers for Medicare & Medicaid Services.[467]

FIGURE 12

Place of Death Due to Alzheimer's Disease, 1999 to 2015



Created from data from the Centers for Disease Control and Prevention.[477]

patient care is higher for families of individuals with dementia who are enrolled in hospice care than for families of individuals not enrolled in hospice care.[474]

For all Medicare beneficiaries admitted to hospice, the average length of stay was 69 days in 2014, with 27 percent having a stay of 7 or fewer days. While average length of stay for hospice beneficiaries by primary diagnosis was not publicly reported for 2014, in 2009 the average length of stay was 106 days for hospice beneficiaries with a primary diagnosis of Alzheimer's dementia and 92 days for hospice beneficiaries with non-Alzheimer's dementia.[468] The average per-person hospice payment for individuals with Alzheimer's dementia was $2,017 (this average includes persons who did not use hospice) compared with $153 for all other Medicare beneficiaries.[427]

Feeding Tube Use at the End of Life

Individuals with frequent transitions between health care settings are more likely to have feeding tubes at the end of life, even though feeding tube placement has little or no benefit.[432] The odds of having a feeding tube inserted at the end of life vary across the country and are not explained by severity of illness, restrictions on the use of artificial hydration and nutrition, ethnicity or gender. Researchers found that feeding tube use was highest for people with dementia whose care was managed by a subspecialist physician or both a subspecialist and a general practitioner. By contrast, feeding tube use was lower among people with dementia whose care was managed by a general practitioner.[475-476] With the expansion of Medicare-supported hospice care, the use of feeding tubes in the last 90 days of life has decreased for individuals with Alzheimer's or other dementias.[466] Finally, with the increased focus on the lack of evidence supporting feeding tube use for people with advanced dementia, the proportion of nursing home residents receiving a feeding tube in the 12 months prior to death decreased from nearly 12 percent in 2000 to less than 6 percent in 2014.[476]

Place of Death for Individuals with Alzheimer's or Other Dementias

The proportion of individuals with Alzheimer's who died in a nursing home or medical facility decreased 26 percent between 1999 and 2014.[245] Between 1999 and 2015, the proportion of individuals with Alzheimer's who died in a nursing home decreased from 68 percent to 52 percent, and the proportion who died in a medical facility decreased from 15 percent to 6 percent.[477] During the same period, the proportion of individuals who died at home increased from 14 percent to 26 percent (Figure 12).

TABLE 17

Average Annual Per-Person Payments by Type of Service and Race/Ethnicity for Medicare Beneficiaries Age 65 and Older, with Alzheimer's or Other Dementias, 2014, in 2017 Dollars

	Total Medicare Payments Per Person	Hospital Care	Physician Care	Skilled Nursing Facility Care	Home Health Care	Hospice Care
White	$20,199	$5,364	$1,622	$3,462	$1,734	$3,200
African-American	27,315	9,028	2,199	4,291	2,119	2,369
Hispanic	21,649	7,258	1,912	3,299	1,828	1,764
Other	26,280	8,164	2,151	3,456	3,755	2,607

Created from unpublished data from the National 5% Sample Medicare Fee-for-Service Beneficiaries for 2014.[208]

Use and Costs of Health Care and Long-Term Care Services by Race/Ethnicity

Among Medicare beneficiaries with Alzheimer's or other dementias, African-Americans had the highest Medicare payments per person, while whites had the lowest payments ($27,315 versus $20,199, respectively) (Table 17). The largest difference in payments was for hospital care, with Medicare paying 1.7 times as much for African-Americans as for whites ($9,028 versus $5,364).[208]

In a study of Medicaid beneficiaries with a diagnosis of Alzheimer's dementia that included both Medicaid and Medicare claims data, researchers found significant differences in the costs of care by race/ethnicity.[478] These results demonstrated that African-Americans had significantly higher costs of care than whites or Hispanics, primarily due to more inpatient care and more comorbidities. These differences may be attributable to later-stage diagnosis, which may lead to higher levels of disability while receiving care; delays in accessing timely primary care; lack of care coordination; and duplication of services across providers. However, more research is needed to understand the reasons for this health care disparity.

Avoidable Use of Health Care and Long-Term Care Services

Preventable Hospitalizations

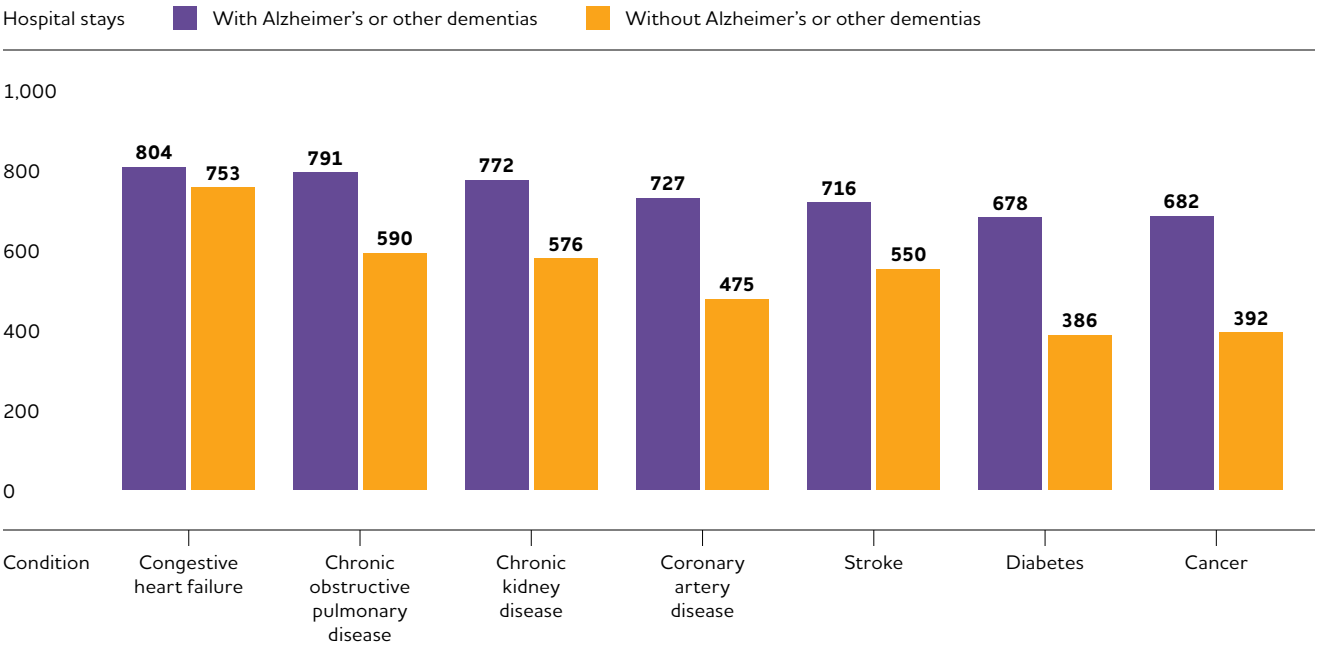
Preventable hospitalizations are one common measure of health care quality. Preventable hospitalizations are hospitalizations for conditions that could have been avoided with better access to or quality of preventive and primary care. In addition, unplanned hospital readmissions within 30 days are another type of hospitalization that potentially could have been avoided with appropriate post-discharge care. In 2013, 21 percent of hospitalizations for fee-for-service Medicare enrollees with Alzheimer's or other dementias were either unplanned readmissions within 30 days or for an ambulatory care sensitive condition, that is, a condition that was potentially avoidable with timely and effective ambulatory care. The total cost to Medicare of these potentially preventable hospitalizations was $4.7 billion.[479] Of people with dementia who had at least one hospitalization, 18 percent were readmitted within 30 days. Of those who were readmitted within 30 days, 27 percent were readmitted two or more times. Ten percent of Medicare enrollees had at least one hospitalization for an ambulatory care sensitive condition, and 14 percent of the total hospitalizations for Medicare enrollees with Alzheimer's or other dementias were for ambulatory care sensitive conditions.

Based on data from the 2006 to 2008 Health and Retirement Study and from Medicare, preventable hospitalizations represented 25 percent of the total hospitalizations for individuals with Alzheimer's or other dementias.[157] The proportion was substantially higher, however, for African-Americans, Hispanics and individuals with low incomes. Hispanic older adults had the highest proportion of preventable hospitalizations (34 percent).

Based on data from the 1998 to 2008 Health and Retirement Study and from Medicare, after controlling for demographic, clinical, and health risk factors, individuals with dementia had a 30 percent greater risk of having a preventable hospitalization than those without a neuropsychiatric disorder (that is, dementia, depression or cognitive impairment without dementia). Moreover, individuals with both dementia and depression had a 70 percent greater risk of preventable hospitalization than those without a neuropsychiatric

FIGURE 13

Hospital Stays Per 1,000 Medicare Beneficiaries Age 65 and Older with Specified Coexisting Medical Conditions, with and without Alzheimer's or Other Dementias, 2014



Created from unpublished data from the National 5% Sample Medicare Fee-for-Service Beneficiaries for 2014.[208]

disorder.[480] Healthy People 2020, the U.S. Department of Health and Human Services' initiative to achieve 10-year goals for health promotion and disease prevention, has set a target to reduce preventable hospitalizations for people with Alzheimer's or other dementias by 10 percent by 2020.[157]

Medicare beneficiaries who have Alzheimer's or other dementias and a serious coexisting medical condition (for example, congestive heart failure) are more likely to be hospitalized than people with the same coexisting medical condition but without dementia (Figure 13).[208] One research team found that individuals hospitalized with heart failure are more likely to be readmitted or die after hospital discharge if they also have cognitive impairment.[481] Another research team found that Medicare beneficiaries with Alzheimer's or other dementias have more potentially avoidable hospitalizations for diabetes complications and hypertension, meaning that the hospitalizations could possibly be prevented through proactive care management in the outpatient setting.[482]

Differences in health care use between individuals with and without dementia are most prominent for those residing in the community. Based on data from the Health and Retirement Study, community-residing individuals with dementia were more likely to have a potentially preventable hospitalization, an emergency department visit that was potentially avoidable, and/or an emergency department visit that resulted in a hospitalization.[483] For individuals residing in a nursing home, there were no differences in the likelihood of being hospitalized or having an emergency department visit.

Initiatives to Reduce Avoidable Health Care and Nursing Home Use

Recent research has demonstrated that two types of programs have potential for reducing avoidable health care and nursing home use, with one type of program focusing on the caregiver and the other focusing on the care delivery team. The Caregiving section (see page 30) describes a number of caregiver support programs, and some of these also hold promise for reducing transitions to residential care for individuals with Alzheimer's or other dementias. Additionally, collaborative care models — models that include not only geriatricians, but also social workers, nurses and medical assistants — can improve care coordination, thereby reducing health care costs associated with hospitalizations, emergency department visits and other outpatient visits.[415] For example, an

interprofessional memory care clinic was shown to reduce per-person health care costs by $3,474 in 2012 dollars ($3,974 in 2017 dollars) over a year for individuals with memory problems compared with others whose care was overseen by a primary care provider only.[415] More than half of the cost savings was attributed to lower inpatient hospital costs. The program was relatively low cost per person, with an average annual cost of $618 ($707 in 2017 dollars) — a nearly 6-to-1 return on investment.

Another group of researchers found that individuals with dementia whose care was concentrated within a smaller number of clinicians had fewer hospitalizations and emergency department visits and lower health care spending overall compared with individuals whose care was dispersed across a larger number of clinicians.[484] More research is needed to understand whether continuity of care is a strategy for decreasing unnecessary health care use for people with Alzheimer's or other dementias.

Projections for the Future

Total annual payments for health care, long-term care and hospice care for people with Alzheimer's or other dementias are projected to increase from $277 billion in 2018 to more than $1.1 trillion in 2050 (in 2018 dollars). This dramatic rise includes more than four-fold increases both in government spending under Medicare and Medicaid and in out-of-pocket spending.[A19]

Potential Impact of Changing the Trajectory of Alzheimer's Disease

While there are currently no treatments that prevent or cure Alzheimer's disease, several groups of researchers have estimated the cost savings of future interventions that reduce the symptoms, reduce the prevalence or slow the onset of dementia. One group of researchers estimated that a treatment that slows the rate of functional decline in people with dementia would reduce average per-person lifetime costs by $3,880 in 2015 dollars ($4,122 in 2017 dollars), while a treatment that reduces the number of behavioral and psychological symptoms by 10 percent would reduce average per-person lifetime costs by $680 ($722 in 2017 dollars).[262] Another group of researchers estimated that a treatment introduced in 2025 that delays the onset of Alzheimer's by 5 years would reduce total health care payments 33 percent and out-of-pocket payments 44 percent in 2050.[485] A third group of researchers estimated the cost savings of delaying the onset of Alzheimer's disease by 1 year. For individuals age 70 and older, they projected a 1-year delay would reduce total health care payments 14 percent in 2050, a 3-year delay would reduce total health care payments 27 percent and a 5-year delay would reduce health care payments 39 percent.[486] They also projected that a delay in onset may increase per capita health care payments through the end of life due to longer life, although the additional health care costs may be offset by lower informal care costs. These projections suggest that a treatment that prevents, cures or slows the progression of the disease could result in substantial savings to the U.S. health care system.

SPECIAL REPORT

Alzheimer's Disease: Financial and Personal Benefits of Early Diagnosis

$7.9 trillion

is the potential cost savings for the current U.S. population from early diagnosis of Alzheimer's.

An Evolving Understanding of Alzheimer's Disease

The search for biological markers, or biomarkers, of Alzheimer's disease is a major area of research that is transforming the way that scientists and physicians understand the disease. What was once a disease based on symptoms is becoming a disease based on changes in the brain. Due in large part to the discovery of Alzheimer's biomarkers and the development of biomarker tests, today the diagnosis of Alzheimer's is occurring earlier in the disease process. Individuals are no longer being diagnosed only in later stages of the disease. Individuals can be identified using biomarkers during the mild cognitive impairment due to Alzheimer's disease (MCI due to AD) stage (for more information about MCI, see page 10). In the future, if biomarker changes are detected and validated in preclinical populations, individuals who are not yet showing symptoms may also be identified as being on the Alzheimer's disease continuum.

This Special Report examines the potential effects of a future with widespread biomarker-based diagnosis of Alzheimer's during the MCI due to AD stage.

Changing Diagnostic Criteria

Alzheimer's disease was historically defined as beginning once dementia symptoms appear, and diagnosis was only confirmed on autopsy by elevated levels of beta-amyloid and tau in the brain. However, due to the development of biomarkers, proposed revised diagnostic guidelines were published in 2011 by the National Institute on Aging (NIA) and the Alzheimer's Association.[20-23] These guidelines incorporated biomarker tests in addition to clinical symptoms and gave researchers tools for diagnosing

The Alzheimer's Disease Continuum

The Alzheimer's disease continuum encompasses the full course of the disease. It begins with a period during which an individual experiences brain changes due to Alzheimer's, but symptoms have not yet appeared. It continues through a period of changes in cognitive, functional and physical abilities that happen because of these brain changes. Alzheimer's disease is fatal, so the continuum ends only with an individual's death due to or with Alzheimer's. Between the beginning of Alzheimer's disease and the emergence of overt symptoms, the Alzheimer's continuum represents a decades-long window of hope. It is during this window of time that researchers believe treatments to prevent symptoms or slow or cure the disease will be most effective.

Alzheimer's disease earlier in the Alzheimer's continuum. This move from a symptom-based definition to a biology-based definition of Alzheimer's disease is leading to a better understanding of the underlying mechanisms of the disease and aiding in the development of new interventions to delay or prevent disease progression.

The 2011 guidelines proposed three stages of Alzheimer's disease that exist on a continuum: preclinical Alzheimer's disease, a stage after brain changes have begun but before symptoms are present; MCI due to AD, a stage characterized by both brain changes and mild cognitive symptoms that do not significantly affect everyday living; and dementia due to Alzheimer's disease, a stage with brain changes and significant memory, thinking and behavioral problems that interfere with an individual's daily life.[20-23]

2018 NIA-Alzheimer's Association Research Framework

A working group convened by the NIA and the Alzheimer's Association is currently reviewing the latest available research evidence to determine whether the 2011 diagnostic guidelines should be refined, and this work is expected to be published in 2018.[487] However, the 2018 NIA-Alzheimer's Association framework will be intended for research purposes only; it will need to be validated and possibly further updated before being used in clinical practice. The new research framework will define Alzheimer's disease as a continuum starting with underlying brain processes, which can be observed using biomarkers in living people and by postmortem findings, and continuing through the later stages of MCI due to AD and dementia due to Alzheimer's.[487]

One way to conceptualize Alzheimer's biomarkers is to divide them into three categories (the A/T/N system) based on the underlying brain changes measured.[488] Beta-amyloid deposits in the brain can be measured by amyloid positron emission tomography (PET) imaging and by cerebrospinal fluid (CSF) tests of specific forms of the amyloid protein (collectively known as the A biomarkers). Neurofibrillary tangles can be approximated by CSF levels of phosphorylated tau and cortical tau PET imaging (the T biomarkers). Nonspecific biomarkers of neurodegeneration or neuronal injury, which may be due to Alzheimer's or other pathologies, are elevated levels of CSF total tau, decreased glucose metabolism shown on fluorodeoxyglucose (FDG) PET imaging, and brain atrophy shown with structural magnetic resonance imaging (MRI) (the N biomarkers).[489]

Like the 2011 guidelines, the new research framework will propose a classification system using Alzheimer's disease biomarkers.[487] An individual with evidence of one or more amyloid biomarkers, with or without symptoms, but no evidence of a tau biomarker, would be defined as having an "Alzheimer's pathologic change." An individual with both amyloid and tau biomarkers, with or without symptoms, would be considered to have "Alzheimer's disease." Applying normal/abnormal cut points to each of the biomarker categories yields four Alzheimer's biomarker profiles:

a) A+/T-/N-
b) A+/T-/N+
c) A+/T+/N-
d) A+/T+/N+

TABLE 18

Research Framework Utilizing Biomarker Profiles and Cognitive Stages

	Cognitive Stage		
Biomarker Profile	**Cognitively Unimpaired**	**Mild Cognitive Impairment (MCI)**	**Dementia**
A-/T-/N-	Normal Alzheimer's biomarkers, cognitively unimpaired	Normal Alzheimer's biomarkers with MCI	Normal Alzheimer's biomarkers with dementia
A+/T-/N-	Preclinical Alzheimer's pathologic change	Alzheimer's pathologic change with MCI	Alzheimer's pathologic change with dementia
A+/T-/N+	Alzheimer's and concomitant suspected non-Alzheimer's pathologic change, cognitively unimpaired	Alzheimer's and concomitant suspected non-Alzheimer's pathologic change with MCI	Alzheimer's and concomitant suspected non-Alzheimer's pathologic change with dementia
A+/T+/N- **A+/T+/N+**	Preclinical Alzheimer's disease	Alzheimer's disease with MCI (prodromal Alzheimer's)	Alzheimer's disease with dementia

Table from a draft of the 2018 NIA-Alzheimer's Association research framework.[487]

A combination of ATN that does not include A+ (for example, A-/T+/N-) indicates that a person is not on the Alzheimer's continuum.

The 2018 research framework also will include a cognitive staging dimension that is independent of the biomarker profile. The cognitive staging dimension is divided into three traditional categories: cognitively unimpaired, MCI and dementia. Dementia is further subdivided into mild, moderate and severe stages. Under the 2018 framework, individuals would be characterized by both a biomarker profile and a cognitive stage. The biomarker profile and cognitive stage are combined to assess an individual's subsequent risk of short-term cognitive decline (Table 18).[487]

Biomarkers of Alzheimer's Disease

The use of biomarkers in all stages of Alzheimer's disease will facilitate the development of treatments that target the underlying brain changes at each stage. Depending on the stage, such treatments might prevent or delay the onset or progression of clinical symptoms.

Neuroimaging Biomarkers

A number of studies comparing imaging data with autopsy findings have demonstrated that beta-amyloid PET imaging accurately reflects levels of amyloid deposits (called neuritic plaques) in the brain.[490-497] Three amyloid PET radiotracers are currently approved by the U.S. Food and Drug Administration (FDA) — florbetapir, flutemetamol and florbetaben (approved in 2012, 2013 and 2014, respectively) — to aid in the diagnosis of Alzheimer's disease. While elevated levels of beta-amyloid detected via PET cannot be used in clinical practice to conclusively diagnose the disease, they give clinicians reason to conduct additional Alzheimer's testing. In addition, in a person with persistent MCI with an unknown cause, the presence of beta-amyloid detected by PET greatly increases the likelihood of that person having MCI due to AD and thus being in the early stages of Alzheimer's. Likewise, non-elevated levels of beta-amyloid indicate a reduced likelihood that cognitive impairment is due to Alzheimer's and may be reason for clinicians to explore other diagnoses.[498]

To aid clinicians in determining when to use amyloid PET imaging, the Amyloid Imaging Taskforce of the Alzheimer's Association and the Society of Nuclear Medicine and Molecular Imaging published appropriate use criteria (AUC) that detail the types of patients and clinical circumstances under which amyloid PET imaging should be used to increase the certainty of an Alzheimer's diagnosis.[499-500] It is important to know that amyloid PET imaging is not right for everyone and that it is not currently covered by Medicare or most insurance companies.

What Are Biomarkers?

A biomarker, or biological marker, is a measurable indicator of a biological state or condition in the human body. Clinicians use biomarkers to determine the presence or absence of disease, assess the risk of developing a disease and understand how an individual has responded to a treatment. For example, a high blood glucose (blood sugar) level may be diagnostic of diabetes and lowering that level can indicate the success of a prescribed diet or medication.

Researchers are investigating several promising biomarkers for Alzheimer's disease. These include, but are not limited to, the amount of accumulation of the proteins beta-amyloid and tau in the brain. These proteins can be measured using brain imaging or the levels in cerebrospinal fluid or blood. Other biomarkers are changes in brain size and activity.

Identifying and then validating biomarkers for Alzheimer's disease is critical for several reasons. One is that biomarkers facilitate early diagnosis and treatment. Many researchers believe that early intervention — either at the mild cognitive impairment (MCI) stage or even in the proposed preclinical stage before symptoms appear — offers the best chance of slowing or stopping the progression of Alzheimer's and therefore the best chance of preserving brain function.

Biomarkers also have an important role in the discovery of treatments. Biomarkers enable researchers to enroll in clinical trials only those individuals with the biomarker changes targeted by a treatment. For example, if a treatment targets beta-amyloid accumulation, researchers would want to enroll only those individuals with high levels of beta-amyloid accumulation as shown on biomarker tests. In addition, biomarkers make it possible for researchers to monitor the effects of treatments. Researchers can compare results of biomarker tests conducted during clinical trials with results of biomarker tests conducted before clinical trials to find out if a treatment has slowed or stopped the brain changes targeted. It's important to note that the most effective biomarker test or combination of tests may differ depending on the stage of the disease and other factors.

Research on new strategies for earlier diagnosis, including ongoing efforts to identify and validate biomarkers for Alzheimer's disease, is among the most active areas in Alzheimer's science.

The Imaging Dementia — Evidence for Amyloid Scanning (IDEAS) Study, led by the Alzheimer's Association, is currently assessing the impact of amyloid PET imaging on patient management and health outcomes in people with MCI or dementia of uncertain origin. Preliminary results indicate that amyloid PET imaging does have a substantial impact on how clinicians diagnose the cause of cognitive impairment and select the most appropriate course of follow-up. In both the MCI and dementia groups, changes in patient management were observed in more than 60 percent of individuals who underwent amyloid PET imaging.[501]

Three other Alzheimer's neuroimaging biomarkers are currently used for research and in some cases are used to aid in clinical diagnosis. Elevated cortical tau shown with PET imaging[502-504] is a biomarker for neurofibrillary tangles; decreased glucose metabolism shown by FDG-PET imaging and atrophy shown by structural MRI are biomarkers for neurodegeneration or neuronal injury.[505]

CSF and Blood Biomarkers

Additional types of biomarkers currently being studied in Alzheimer's disease and used mainly for research purposes are found in CSF and blood. CSF biomarkers reflect the rates of both protein production and clearance at one point in time rather than the cumulative damage assessed by neuroimaging biomarkers, but nevertheless may provide insight into the pathological changes of Alzheimer's.[487] A lower CSF level of a specific form of the amyloid protein, known as $A\beta_{42}$, is a biomarker for beta-amyloid deposition in the brain.[506-508] Elevated CSF levels of phosphorylated tau[507,509] and total tau[510] are biomarkers of neurofibrillary tangles and neurodegeneration, respectively. Candidate blood biomarkers, currently in the early stages of development, include neurofilament light protein as a proxy for neurodegeneration[511] and specific forms of the amyloid protein as a screening tool for the accumulation of beta-amyloid in the brain.[512-514]

It is important to note that while much research has been conducted on biomarker levels in white populations, less is known about these markers in diverse populations.[487,515] Therefore, a better understanding of how biomarkers behave and correlate with underlying disease and clinical symptoms in African-Americans, Asian-Americans, Hispanic-Americans and other groups underrepresented in clinical studies is a high priority for researchers.

Benefits of Early Detection and Diagnosis for People Living with Alzheimer's and Caregivers

An early and accurate diagnosis has many benefits.[516-517] One benefit is accurate determination of what may be causing an individual's cognitive decline.

As clinically approved biomarkers become more widespread, more individuals who receive a diagnosis of MCI may be able to undergo biomarker testing to see if their cognitive changes are indeed due to Alzheimer's disease. Currently, biomarker testing is not reimbursed as part of normal clinical care by the Centers for Medicare & Medicaid Services (CMS) or most insurance plans. The only ways to obtain amyloid PET imaging, for example, are through a coverage with evidence development study (such as the IDEAS Study), participation in another research study or through private pay. Until biomarker testing is used routinely, individuals who receive a diagnosis of MCI can be followed closely by their medical teams to ensure that any subsequent cognitive changes indicative of an underlying progression of Alzheimer's disease are detected promptly.

In cases where cognitive impairment is detected but Alzheimer's biomarker results are within the normal range, additional tests can be performed to identify the cause of the cognitive problems when it is something other than Alzheimer's. When further testing shows reversible or treatable causes (for example, depression, obstructive sleep apnea or vitamin B_{12} deficiency) rather than Alzheimer's disease, early diagnosis can lead to treatment and improvement of cognition and quality of life.

Medical Benefits

There are medical benefits to being diagnosed with MCI due to Alzheimer's early in the disease process.[516] When individuals receive a diagnosis of MCI due to AD, they can begin health measures to preserve their existing cognitive function for as long as possible. For example, prevention of stroke and minimization of vascular risk factors through control of blood pressure and diabetes, as well as smoking cessation, may reduce the risk of progression from MCI to dementia.[518] Aerobic exercise, mental activity and social engagement may also help to delay further cognitive decline in MCI.[518]

If a diagnosis of Alzheimer's is confirmed, the earlier that a diagnosis is obtained, the earlier that treatment of symptoms with medications or other interventions can start, enabling individuals to better manage their symptoms and optimize their ability to function. (It is important to note, however, that the current medications for the cognitive symptoms of Alzheimer's have not been shown by clinical trials to provide benefit in the MCI due to AD stage.) While current therapies do not prevent, halt or reverse Alzheimer's disease, they can temporarily improve and prolong cognitive function in many individuals with Alzheimer's dementia.[519-520] An early diagnosis of Alzheimer's also maximizes the chances of participation in a clinical trial, which may also provide medical benefits, as discussed in the Clinical Trial Participation section (see page 63).

In addition, receiving an Alzheimer's diagnosis early in the disease process gives the individual time to assemble medical and caregiving teams to provide support and help prevent or treat medical concerns, such as dental problems, incontinence and pneumonia, that can occur with Alzheimer's. This proactive approach includes discussions about the treatment and management of coexisting medical conditions, which represent a significant and expensive problem in individuals with undiagnosed Alzheimer's. An early diagnosis also enables potential safety issues, such as problems with driving or wandering, to be addressed ahead of time. For example, increased caregiver awareness of higher fall risk for individuals living with dementia may lead to fewer falls and other accidents.

Emotional and Social Benefits

Early diagnosis offers a number of emotional and social benefits.[517] Once a diagnosis of MCI due to AD or Alzheimer's dementia has been made, individuals and family members can learn what to expect for the future and plan accordingly. In addition, early diagnosis allows individuals to maximize time spent engaging in activities that are meaningful to them and interacting with the most important people in their lives. It can also open doors to the many training, education and support programs available to individuals and family members and facilitate relationships with others living with Alzheimer's.

For affected individuals and family members, a diagnosis can also reduce anxiety and provide a sense of relief and closure as worrisome symptoms are finally given a name.[521] In fact, in a survey of public perceptions and awareness about Alzheimer's, nearly 90 percent of Americans said they would want to know if the cause of their symptoms was Alzheimer's.[522] Among those age 60 and older, it was even higher: 95 percent of participants said they would want to know. Similarly, the survey showed that 97 percent of Americans would want to know if a family member had Alzheimer's.

Planning for the Future

Early diagnosis gives individuals more time to plan for the future while they are cognitively able to make decisions and understand available choices.[516,522] It also empowers individuals and their families to make the best choices for the future, such as moving closer to members of one's support team. Additional types of planning include legal, financial and end-of-life, as well as the assembly of a care team.

Legal planning includes taking inventory of existing legal documents and reviewing and updating them as necessary. It also includes making plans for finances and property, and for identifying an individual's future health care and long-term care preferences. Finally, legal planning includes designating another person to make decisions on behalf of the individual when he or she is no longer able to do so.

Financial planning includes preparing for the costs associated with the care of an individual with Alzheimer's. An individual may also want to review government benefits, including veterans benefits, as well as any long-term care insurance policies. Financial planning also includes deciding who will help the individual with routine financial responsibilities such as paying bills, handling benefits claims, making investment decisions, managing bank accounts and preparing tax returns when an individual is no longer able to complete these tasks.

For an individual diagnosed early in the disease when he or she may still be working, additional financial plans, including a reassessment of the family budget, may be needed to prepare for the loss of future income. Alternative plans for financing children's education and a spouse or partner's retirement may be necessary. In addition, it is important for employed individuals to investigate the benefits they may be able to access through their employer before they stop working. It may also be possible to tap into financial resources from retirement plans prior to retirement age without penalty, or receive pension payments prior to retirement age, if the worker is defined as disabled under the plan's guidelines. An elder law attorney or a financial adviser may help individuals to understand their options.

End-of-life planning, although often difficult and emotional, is another important aspect of preparation that early diagnosis affords. When an individual with MCI due to AD or Alzheimer's dementia expresses his or her wishes while still able to make decisions, it helps family members ensure that these requests will be followed when the time comes. Legal documents called advance directives, which include a living will and a health care power of attorney, allow an individual to document his or her preferences regarding treatment, end-of-life care, comfort care and funeral arrangements.

To learn more about planning for a future with Alzheimer's disease, visit alz.org/i-have-alz/plan-for-your-future.asp.

Clinical Trial Participation

An early diagnosis of MCI due to AD or Alzheimer's dementia maximizes the chances that an individual can enroll in a clinical trial or participate in other forms of scientific research. Participation in research helps to accelerate progress and provides valuable insights into potential treatments that may halt or slow the progression of the disease.

The novel therapy tested in a clinical trial may provide benefits to the individual who is participating whether or not it is proven effective. Regardless of effectiveness, the knowledge that one is contributing to important research and helping future generations with the disease has its own psychological benefits. Additional benefits of clinical

trial participation include receipt of high-quality care at leading institutions, often at no cost; close monitoring and management of symptoms; and opportunities for education about Alzheimer's through regular contact with trial staff.[516]

To learn more about participating in clinical trials and to find studies that might be right for you, visit alz.org/TrialMatch.

Financial Benefits of Early Diagnosis

Currently, most people who are diagnosed with Alzheimer's have received a clinical diagnosis without the support of biomarker confirmation. This means that many people who are diagnosed with Alzheimer's may in reality have MCI or dementia due to other causes. Regardless of underlying cause, however, diagnosis of individuals earlier in the symptomatic stages — MCI and dementia —could result in a reduction in health care costs at both the individual and national levels. A number of analyses have examined the potential economic benefits of early diagnosis of Alzheimer's, and there is general agreement that early diagnosis will save costs.[517,523-525] For example, a cost-benefit analysis based on long-term care cost data from Wisconsin suggests that early diagnosis and treatment of Alzheimer's has financial benefits at both the state and federal levels, and that benefits are highest when individuals are identified at the earliest stages.[524] Early diagnosis could also maximize the economic benefits that are projected to result from the availability of potential disease-modifying treatments, when available.[262,485-486]

Model of Reduction in Health Care Costs Resulting from Early Diagnosis

To learn more about the potential cost savings associated with earlier diagnosis, the Alzheimer's Association commissioned Precision Health Economics to study the effect on medical expenditures (including medical, pharmaceutical and institutional long-term care costs) of the introduction of early detection measures that would lead to the diagnosis of individuals with Alzheimer's at the MCI stage rather than the dementia stage or not at all.

The study used The Health Economics Medical Innovation Simulation (THEMIS), which utilizes data from the Health and Retirement Study (HRS), a nationally representative sample of adults age 50 and older, to estimate health care spending. Individuals were tracked from age 50 through death, and the probability of an individual being diagnosed with Alzheimer's was determined through a regression model based on an individual's cognitive performance, functional limitations, other health conditions and demographics. The model included the entire U.S. population alive in 2018, and early detection measures were assumed to begin in 2020.

The model did not assume that biomarkers were used in the diagnostic process; indeed, timely diagnosis is possible now, even without widespread use of biomarkers. For this reason, the language used to describe Alzheimer's in this section differs from the rest of this Special Report. Most notably, the term "MCI due to AD" is not used because it is closely tied to biomarker confirmation of diagnosis. In addition, "Alzheimer's dementia" refers to Alzheimer's in the dementia stage, regardless of whether the diagnosis has been confirmed with biomarker testing. Unless otherwise stated, "Alzheimer's" refers to the symptomatic stages of the disease — MCI or dementia— regardless of whether the diagnosis has been confirmed with biomarker testing.

The model included three scenarios: 1) the current status quo, in which many people never receive a diagnosis or tend to receive it later in the disease process, typically in the dementia stage and too often when dementia is quite advanced; 2) a partial early diagnosis scenario, in which individuals with Alzheimer's have a higher likelihood of receiving a diagnosis and receiving it during the MCI stage rather than the dementia stage; and 3) a full early diagnosis scenario, in which all individuals with Alzheimer's receive a diagnosis in the MCI stage. Based on existing medical literature, differences in expected costs come from two primary sources: 1) there is a "spike" in costs during the period immediately before and after diagnosis, and this spike is smaller when diagnosis is made during the MCI stage, and 2) medical and long-term care costs are lower in people with diagnosed and managed MCI and dementia than in people with unmanaged MCI and dementia.

For a full description of the model, see page 67.

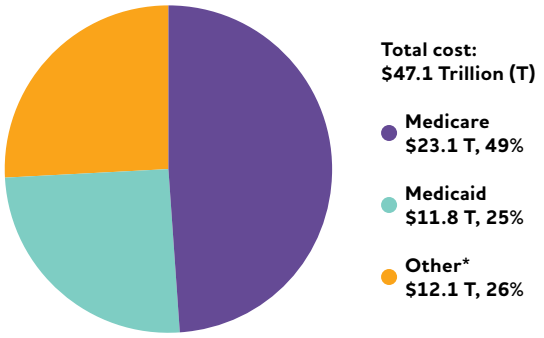
Results

Under the current status quo, the cumulative total cost of medical and long-term care expenditures for all individuals alive in the United States in 2018 who will develop Alzheimer's is projected to be $47.1 trillion. This projection is the present value of future costs[A23] and includes medical and long-term care costs calculated from the year prior to the development of MCI and continuing until death. This does not include the costs of everyone who actually has Alzheimer's disease because it does not include 1) people who are alive now and already in the dementia stage or 2) people who have brain changes on the Alzheimer's continuum but have not yet entered the MCI stage of the disease. Under the assumptions of the model, this total cost represents $23.1 trillion in Medicare costs, $11.8 trillion in Medicaid costs and $12.1 trillion in other costs (for example, out-of-pocket expenses)[A24] (Figure 14).

Under the partial early diagnosis scenario, in which individuals with Alzheimer's have a 70 percent chance of being diagnosed every 2 years, starting in the MCI stage (yielding a total diagnosis rate of 88 percent),

FIGURE 14

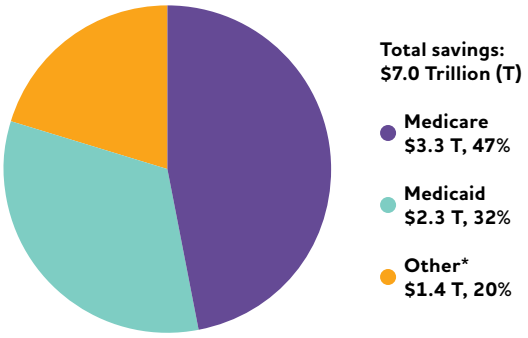
Projected Total Medical Costs (in Trillions of 2017 Dollars, Present Value of Future Savings[A23]) Under the Current Status Quo, by Category of Expenditures[A24]



*The "Other" category includes all costs outside of Medicare and Medicaid, such as out-of-pocket expenses and private insurance.

FIGURE 15

Projected Total Medical Savings (in Trillions of 2017 Dollars, Present Value of Future Savings[A23]) Under the Partial Early Diagnosis Scenario Compared with the Current Status Quo, by Category of Expenditures[A24]

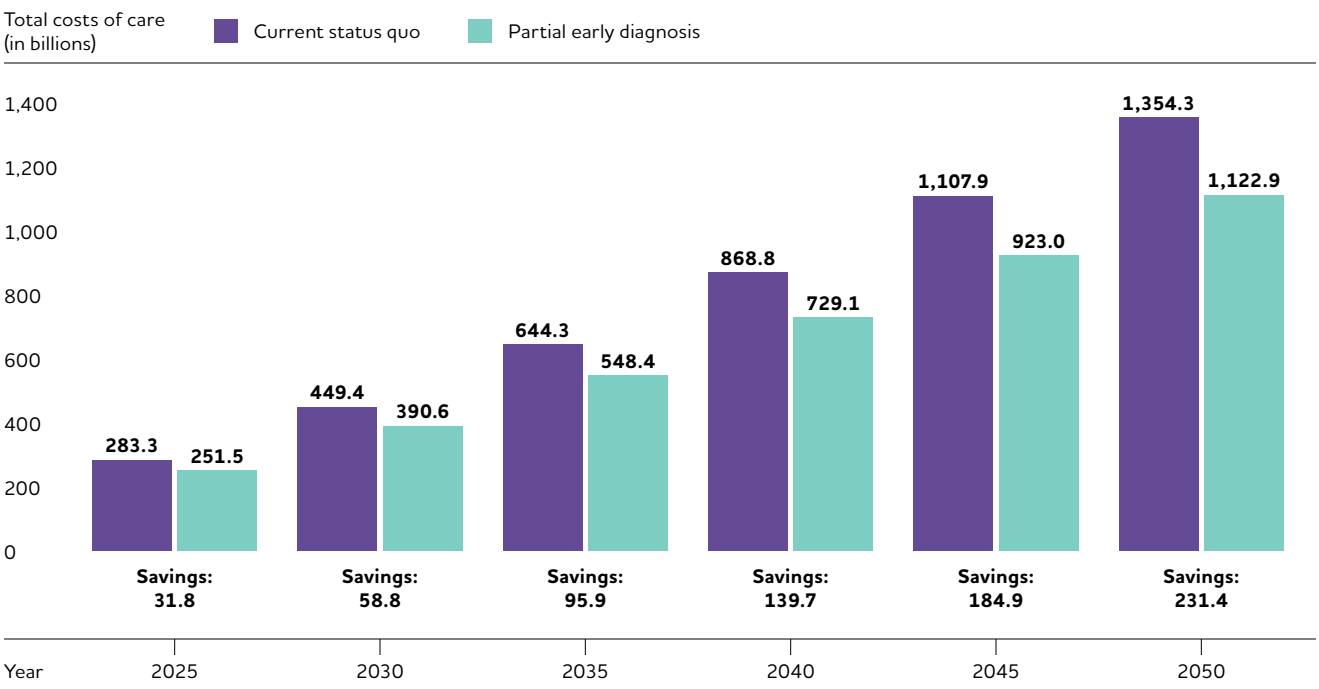


*The "Other" category includes all savings outside of Medicare and Medicaid, such as out-of-pocket expenses and private insurance.

Percentages do not total 100 due to rounding.

FIGURE 16

Projected Total Medical and Long-Term Care Costs and Cost Savings (in Billions of 2017 Dollars) by Diagnosis Scenario and Year



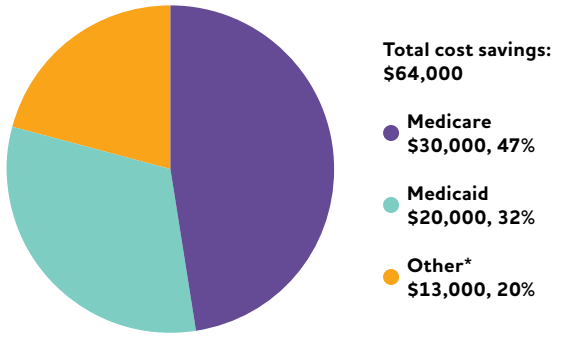
the cumulative total cost of medical and long-term care expenditures is projected to be $40.1 trillion. Thus, increasing early detection and diagnosis of Alzheimer's, even partially, results in significant cost savings. Compared with the current status quo, it yields a total cumulative savings of $7.0 trillion. Under the assumptions used in the model, these savings include $3.3 trillion in Medicare savings, $2.3 trillion in Medicaid savings and $1.4 trillion in other savings (for example, out-of-pocket expenses and private insurance[A24]) (Figure 15).

Under the full early diagnosis scenario, in which 100 percent of individuals with Alzheimer's receive a diagnosis during the MCI stage, the cumulative cost is projected to be $39.2 trillion, yielding a total cumulative savings of $7.9 trillion. Thus, nearly all of the potential savings of early diagnosis can be realized under the partial early diagnosis scenario.

The model also projected total costs of Alzheimer's in specific years (Figure 16). Under the partial early diagnosis scenario, total savings are projected to be $31.8 billion in 2025 and $231.4 billion in 2050. Greater cost savings are realized as an increasing number of individuals with Alzheimer's are diagnosed during the MCI stage rather than the dementia stage.

FIGURE 17

Projected Total Medical Savings per Diagnosed Individual (in 2017 Dollars, Present Value of Future Savings[A23]) from One Year Before Diagnosis to End of Life Under the Partial Early Diagnosis Scenario Compared with the Current Status Quo, by Category of Expenditures[A24]



*The "Other" category includes all costs outside of Medicare and Medicaid, such as out-of-pocket expenses and private insurance.

Percentages do not total 100 due to rounding.

The model also projected how the average per-person medical and long-term care costs of individuals with Alzheimer's would be affected by early diagnosis. Under the current status quo, an individual with Alzheimer's has total projected health and long-term care costs of $424,000 (present value of future costs[A23]) from the year before MCI until death. Under the partial early diagnosis scenario, the average per-person cost for an individual with Alzheimer's is projected to be $360,000, saving $64,000 per individual. Under the assumptions of the model, this represents $30,000 in Medicare savings, $20,000 in Medicaid savings and $13,000 in other savings (for example, out-of-pocket expenses and private insurance)[A24] (Figure 17).

The results of this model underscore the economic benefits — to the government, to individuals, and to the medical and long-term care systems overall — of an early and accurate diagnosis of Alzheimer's. Furthermore, they suggest that diagnosing all individuals who have Alzheimer's is not necessary to achieve large cost savings, and that savings can be achieved with a realistic diagnosis rate goal.

Conclusions

The development of biomarkers for Alzheimer's disease is making it possible to detect the disease and provide an accurate diagnosis earlier than at any other time in history. Early diagnosis of Alzheimer's provides a number of important benefits to diagnosed individuals, their caregivers and loved ones, as well as society as a whole. In addition to providing significant medical, emotional and social benefits and facilitating participation in important clinical trials, early diagnosis enables individuals to prepare legal, financial and end-of-life plans while they are still cognitively able to make decisions and share their wishes. Based on the economic projections presented here, early diagnosis, even without biomarker confirmation, will also yield significant cost savings in medical and long-term care for both the U.S. government and diagnosed individuals. Given the numerous benefits, continued biomarker development and validation rightly remains a top priority of Alzheimer's disease research.

The Precision Health Economics study used The Health Economics Medical Innovation Simulation (THEMIS), a peer-reviewed model,[526-533] to provide projections of the effect of early diagnosis of Alzheimer's disease on future medical and long-term care costs. THEMIS is a microsimulation that uses population data from the Health and Retirement Study (HRS), a nationally representative sample of people 50 years of age and older, and tracks individuals from enrollment at age 50 until death to estimate disease and comorbidity burdens, life expectancy and functional status, and health care spending. People age in the model under a Monte Carlo simulation in which individuals' health states depend on current health states and on a set of random health shocks that vary with individuals' own risk factors (for example, their age, health behaviors and current disease conditions).[A25]

Diagnosis Rates and Probability of Diagnosis

For this study, the impact of early diagnosis on medical expenditures was estimated by modeling an environment where Alzheimer's diagnosis is more likely to occur in the MCI stage, rather than in the dementia stage or not at all. The model included the entire U.S. population born in or prior to 2018, and early detection measures were assumed to begin in 2020. (Because THEMIS includes only those age 50 and older, to be diagnosed with Alzheimer's in the model, an individual would need to be at least 50 years old by 2068.) Two hypothetical scenarios were simulated: 1) a partial early diagnosis scenario and 2) a full early diagnosis scenario.

The probability of an individual being diagnosed with MCI or Alzheimer's dementia was determined through a probit regression model based on an individual's cognitive performance, functional limitations, other health conditions and demographics.[A26] HRS respondents were stratified into age groups. Within each age group, the proportion of individuals with the highest probability of being diagnosed with Alzheimer's was identified, using a randomized process, such that the proportion was consistent with the prevalence of amnestic MCI for that age group in the Mayo Clinic Study of Aging.[515]

Under the partial early diagnosis scenario, these identified individuals had a 70 percent probability of being diagnosed with Alzheimer's every 2 years, beginning in the MCI stage. Because this is a probability model in which individuals who are undiagnosed remain eligible to be diagnosed in later years until they die, the model yields a total diagnosis rate of 88 percent under this scenario.

Under the full early diagnosis scenario, all individuals identified in the probit regression model as having Alzheimer's were considered to have been diagnosed in the MCI stage. While a 100 percent diagnosis rate is an unrealistic expectation, it was simulated to provide an estimate of the true extent of the problem and the upper bound of potential cost savings.

Effect on Costs

The underlying THEMIS model includes estimations of health and long-term care spending that were based on data from the Medical Expenditure Panel Study (MEPS) and the Medicare Current Beneficiary Survey (MCBS). The current study required looking at what would happen to those costs if individuals were diagnosed earlier in the disease process. Studies show that costs of MCI and dementia peak around the time of diagnosis.[439-442,534-536] Accordingly, the model assumed that if an individual with Alzheimer's was diagnosed during the MCI stage rather than the dementia stage, the peak costs would occur surrounding the MCI diagnosis. Thus, for diagnosed individuals, costs from the year they were diagnosed under the hypothetical scenarios until the year they would have been diagnosed under the status quo were adjusted from the underlying THEMIS model to be consistent with the pre- and post-diagnosis costs of dementia reported in a recent Medicare expenditure study.[440,A27] Costs after the point at which individuals would have been diagnosed under the status quo remained the same as determined by the underlying THEMIS model.

The simulated population included everyone alive in 2018. Cognition was assessed beginning at age 50, and diagnosis was possible anytime from that point until death. Costs were assessed for all people who will develop Alzheimer's (diagnosed and undiagnosed) starting the year before early diagnosis (or, for those who are undiagnosed, the year before they would have been diagnosed under the full early diagnosis scenario) and ending in the year of the patient's death.

End Notes

A1. Number of Americans age 65 and older with Alzheimer's dementia for 2018 (prevalence of Alzheimer's in 2018): The number 5.5 million is from published prevalence estimates based on incidence data from the Chicago Health and Aging Project (CHAP) and population estimates from the 2010 U.S. Census.[30]

A2. Proportion of Americans age 65 and older with Alzheimer's dementia: The 10 percent for the age 65 and older population is calculated by dividing the estimated number of people age 65 and older with Alzheimer's dementia (5.5 million) by the U.S. population age 65 and older in 2018, as projected by the U.S. Census Bureau (52.8 million) = approximately 10 percent.[145] Please note that the proportion of Americans age 65 and older with Alzheimer's dementia has gone down slightly in recent years despite the number of Americans with Alzheimer's dementia in this age range going up; this is because of the large number of baby boomers who have started to enter this age range and increased the overall number of seniors, but at the early low risk years in this range.[229]

A3. Percentage of total Alzheimer's dementia cases by age groups: Percentages for each age group are based on the estimated 200,000 people under 65,[30] plus the estimated numbers for people ages 65 to 74 (0.9 million), 75 to 84 (2.5 million), and 85+ (2.1 million) based on prevalence estimates for each age group and incidence data from the CHAP study.

A4. Differences between CHAP and ADAMS estimates for Alzheimer's dementia prevalence: ADAMS estimated the prevalence of Alzheimer's dementia to be lower than CHAP, at 2.3 million Americans age 71 and older in 2002,[148] while the CHAP estimate for 2000 was 4.5 million.[537] At a 2009 conference convened by the National Institute on Aging and the Alzheimer's Association, researchers determined that this discrepancy was mainly due to two differences in diagnostic criteria: (1) a diagnosis of dementia in ADAMS required impairments in daily functioning and (2) people determined to have vascular dementia in ADAMS were not also counted as having Alzheimer's, even if they exhibited clinical symptoms of Alzheimer's.[149] Because the more stringent threshold for dementia in ADAMS may miss people with mild Alzheimer's dementia and because clinical-pathologic studies have shown that mixed dementia due to both Alzheimer's and vascular pathology in the brain is very common,[6] the Association believes that the larger CHAP estimates may be a more relevant estimate of the burden of Alzheimer's dementia in the United States.

A5. Number of women and men age 65 and older with Alzheimer's dementia in the United States: The estimates for the number of U.S. women (3.4 million) and men (2.0 million) age 65 and older with Alzheimer's in 2013 is from unpublished data from CHAP. For analytic methods, see Hebert et al.[30] The numbers for men and women do not add to 5.5 million due to rounding.

A6. Prevalence of Alzheimer's and other dementias in older whites, African-Americans and Hispanics: The statement that African-Americans are twice as likely and Hispanics one and one-half times as likely as whites to have Alzheimer's or other dementias is the conclusion of an expert review of a number of multiracial and multiethnic data sources, as reported in detail in the Special Report of the Alzheimer's Association's *2010 Alzheimer's Disease Facts and Figures*.

A7. State-by-state prevalence of Alzheimer's dementia: These state-by-state prevalence numbers are based on an analysis of incidence data from CHAP, projected to each state's population, with adjustments for state-specific age, gender, years of education, race and mortality.[209] Specific prevalence numbers for 2018 were derived from this analysis and provided to the Alzheimer's Association by a team led by Liesi Hebert, Sc.D., from Rush University Institute on Healthy Aging.

A8. Number of new cases of Alzheimer's dementia this year (incidence of Alzheimer's in 2018): The East Boston Established Populations for Epidemiologic Study of the Elderly (EPESE) estimated that there would be 454,000 new cases in 2010 and 491,000 new cases in 2020 (see Hebert et al[210]). The Alzheimer's Association calculated the incidence of new cases in 2018 by multiplying the 10-year change from 454,000 to 491,000 (37,000) by 0.8 (for the number of years from 2010 to 2018 divided by the number of years from 2010 to 2020), adding that result (29,600) to the Hebert et al. estimate for 2010 (454,000) = 483,600.[210] Rounded to the nearest thousand, this is 484,000 new cases of Alzheimer's dementia in 2018. The same technique for linear interpolation from 2010 to 2020 projections was used to calculate the number of new cases in 2018 for ages 65-74, 75-84 and 85 and older. The age group-specific Alzheimer's dementia incident rate is the number of new people with Alzheimer's per population at risk (the total number of people in the age group in question). These incidence rates are expressed as number of new cases per 1,000 people using the total number of people per age group (e.g., 65-74, 75-84, 85+) for 2018 from population projections from the 2000 U.S. Census as the denominator.[538]

A9. Number of seconds for the development of a new case of Alzheimer's dementia: Although Alzheimer's does not present suddenly like stroke or heart attack, the rate at which new cases develop can be computed in a similar way. The 65 seconds number is calculated by dividing the number of seconds in a year (31,536,000) by the number of new cases in a year (483,600)[A8] = 65.2 seconds, rounded to 65 seconds. Using the same method of calculation for 2050, 31,536,000 divided by 959,000 (from Hebert et al.[210]) = 32.8 seconds, rounded to 33 seconds.

A10. Criteria for identifying people with Alzheimer's or other dementias in the Framingham Study: From 1975 to 2009, 7,901 people from the Framingham Study who had survived free of dementia to at least age 45, and 5,937 who had survived free of dementia until at least age 65 were followed for incidence of dementia.[173] Diagnosis of dementia was made according to Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV) criteria and required that the participant survive for at least 6 months after onset of symptoms. Standard diagnostic criteria (the NINCDS-ADRDA criteria from 1984) were used to diagnose Alzheimer's dementia. The definition of Alzheimer's and other dementias used in the Framingham Study was very strict; if a definition that included milder disease and disease of less than six months' duration were used, lifetime risks of Alzheimer's and other dementias would be higher than those estimated by this study.

A11. Projected number of people with Alzheimer's dementia: This figure comes from the CHAP study.[30] Other projections are somewhat lower (see, for example, Brookmeyer et al.[539]) because they relied on more conservative methods for counting people who currently have Alzheimer's dementia.[A4] Nonetheless, these estimates are statistically consistent with each other, and all projections suggest substantial growth in the number of people with Alzheimer's dementia over the coming decades.

A12. Projected number of people age 65 and older with Alzheimer's dementia in 2025: The number 7.1 million is based on a linear extrapolation from the projections of prevalence of Alzheimer's for the years 2020 (5.8 million) and 2030 (8.4 million) from CHAP.[30]

A13. Annual mortality rate due to Alzheimer's disease by state: Unadjusted death rates are presented rather than age-adjusted death rates in order to provide a clearer depiction of the true burden of mortality for each state. States such as Florida with larger populations of older people will have a larger burden of mortality due to Alzheimer's — a burden that appears smaller relative to other states when the rates are adjusted for age.

A14. Number of family and other unpaid caregivers of people with Alzheimer's or other dementias: To calculate this number, the Alzheimer's Association started with data from the BRFSS survey. In 2009, the BRFSS survey asked respondents age 18 and over whether they had provided any regular care or assistance during the past month to a family member or friend who had a health problem, long-term illness or disability. To determine the number of family and other unpaid caregivers nationally and by state, we applied the proportion of caregivers nationally and for each state from the 2009 BRFSS (as provided by the CDC, Healthy Aging Program, unpublished data) to the number of people age 18 and older nationally and in each state from the U.S. Census Bureau report for July 2017. Available at: https://www.census.gov/data/tables/2017/demo/popest/state-detail.html. Accessed on Dec. 26, 2017. To calculate the proportion of family and other unpaid caregivers who provide care for a person with Alzheimer's or another dementia, the Alzheimer's Association used data from the results of a national telephone survey also conducted in 2009 for the National Alliance for Caregiving (NAC)/AARP.[540] The NAC/AARP survey asked respondents age 18 and over whether they were providing unpaid care for a relative or friend age 18 or older or had provided such care during the past 12 months. Respondents who answered affirmatively were then asked about the health problems of the person for whom they provided care. In response, 26 percent of caregivers said that: (1) Alzheimer's or another dementia was the main problem of the person for whom they provided care, or (2) the person had Alzheimer's or other mental confusion in addition to his or her main problem. The 26 percent figure was applied to the total number of caregivers nationally and in each state, resulting in a total of 16.139 million Alzheimer's and dementia caregivers.

A15. The 2014 Alzheimer's Association Women and Alzheimer's Poll: This poll questioned a nationally-representative sample of 3,102 American adults about their attitudes, knowledge and experiences related to Alzheimer's and dementia from Jan. 9, 2014, to Jan. 29, 2014. An additional 512 respondents who provided unpaid help to a relative or friend with Alzheimer's or a related dementia were asked questions about their care provision. Random selections of telephone numbers from landline and cell phone exchanges throughout the United States were conducted. One individual per household was selected from the landline sample, and cell phone respondents were selected if they were 18 years old or older. Interviews were administered in English and Spanish. The poll "oversampled" Hispanics, selected from U.S. Census tracts with higher than an 8 percent concentration of this group. A list sample of Asian-Americans was also utilized to oversample this group. A general population weight was used to adjust for number of adults in the household and telephone usage; the second stage of this weight balanced the sample to estimated U.S. population characteristics. A weight for the caregiver sample accounted for the increased likelihood of female and white respondents in the caregiver sample. Sampling weights were also created to account for the use of two supplemental list samples. The resulting interviews comprise a probability-based, nationally representative sample of U.S. adults. A caregiver was defined as an adult over age 18 who, in the past 12 months, provided unpaid care to a relative or friend age 50 or older with Alzheimer's or another dementia. Questionnaire design and interviewing were conducted by Abt SRBI of New York.

A16. Number of hours of unpaid care: To calculate this number, the Alzheimer's Association used data from a follow-up analysis of results from the 2009 NAC/AARP national telephone survey (data provided under contract by Matthew Greenwald and Associates, Nov. 11, 2009). These data show that caregivers of people with Alzheimer's or other dementias provided an average of 21.9 hours a week of care, or 1,139 hours per year. The number of family and other unpaid caregivers (16.139 million)[A14] was multiplied by the average hours of care per year, which totals 18.379 billion hours of care. This is slightly lower than the total resulting from multiplying 1,139 by 16.139 million because of rounding.

A17. Value of unpaid caregiving: To calculate this number, the Alzheimer's Association used the method of Amo et al.[541] This method uses the average of the federal minimum hourly wage ($7.25 in 2017) and the mean hourly wage of home health aides ($18.00 in July 2017).[542] The average is $12.63, which was multiplied by the number of hours of unpaid care (18.379 billion) to derive the total value of unpaid care ($232.129 billion; this is slightly higher than the total resulting from multiplying $12.63 by 18.379 billion because 18.379 is a rounded number for the hours of unpaid care).

A18. Higher health care costs of Alzheimer's caregivers: This figure is based on a methodology originally developed by Brent Fulton, Ph.D., for The Shriver Report: A Woman's Nation Takes on Alzheimer's. A survey of 17,000 employees of a multinational firm based in the United States estimated that caregivers' health care costs were 8 percent higher than non-caregivers'.[543] To determine the dollar amount represented by that 8 percent figure nationally and in each state, the 8 percent figure and the proportion of caregivers from the 2009 BRFSS[A14] were used to weight each state's caregiver and non-caregiver per capita personal health care spending in 2014,[544] inflated to 2017 dollars. The dollar amount difference between the weighted per capita personal health care spending of caregivers and non-caregivers in each state (reflecting the 8 percent higher costs for caregivers) produced the average additional health care costs for caregivers in each state. Nationally, this translated into an average of $705. The amount of the additional cost in each state, which varied by state from a low of $523 in Utah to a high of $1,051 in the District of Columbia, was multiplied by the total number of unpaid Alzheimer's and dementia caregivers in that state[A14] to arrive at that state's total additional health care costs of Alzheimer's and other dementia caregivers as a result of being a caregiver. The combined total for all states was $11.367 billion. Fulton concluded that this is "likely to be a conservative estimate because caregiving for people with Alzheimer's is more stressful than caregiving for most people who don't have the disease."[545]

A19. Lewin Model on Alzheimer's and dementia costs: These numbers come from a model created for the Alzheimer's Association by the Lewin Group. The model estimates total payments for health care, long-term care and hospice — as well as state-by-state Medicaid spending — for people with Alzheimer's and other dementias. The model was updated by the Lewin Group in January 2015 (updating previous model) and June 2015 (addition of state-by-state Medicaid estimates). Detailed information on the model, its long-term projections and its methodology are available at alz.org/trajectory. For the purposes of the data presented in this report, the following parameters of the model were changed relative to the methodology outlined at alz.org/trajectory: (1) cost data from the 2011 Medicare Current Beneficiary Survey (MCBS) were used rather than data from the 2008 MCBS; (2) prevalence among older adults was assumed to equal the prevalence levels from Hebert et al[30] and included in this report (5.5 million in 2018),[A2] rather than the prevalence estimates derived by the model itself; (3) estimates of inflation and excess cost growth reflect the most recent relevant estimates from the cited sources (the Centers for Medicare and Medicaid Services [CMS] actuaries and the Congressional Budget Office); and (4) the most recent (2014) state-by-state data from CMS on the number of nursing home residents and percentage with moderate and severe cognitive impairment were used in lieu of 2012 data.

A20. All cost estimates were inflated to year 2017 dollars using the Consumer Price Index (CPI): All cost estimates were inflated using the seasonally adjusted average prices for medical care services from all urban consumers. The relevant item within medical care services was used for each cost element. For example, the medical care item within the CPI was used to

inflate total health care payments; the hospital services item within the CPI was used to inflate hospital payments; and the nursing home and adult day services item within the CPI was used to inflate nursing home payments.

A21. Medicare Current Beneficiary Survey Report: These data come from an analysis of findings from the 2011 Medicare Current Beneficiary Survey (MCBS). The analysis was conducted for the Alzheimer's Association by Avalere Health.[427] The MCBS, a continuous survey of a nationally representative sample of about 15,000 Medicare beneficiaries, is linked to Medicare claims. The survey is supported by the U.S. Centers for Medicare & Medicaid Services (CMS). For community-dwelling survey participants, MCBS interviews are conducted in person three times a year with the Medicare beneficiary or a proxy respondent if the beneficiary is not able to respond. For survey participants who are living in a nursing home or another residential care facility, such as an assisted living residence, retirement home or a long-term care unit in a hospital or mental health facility, MCBS interviews are conducted with a staff member designated by the facility administrator as the most appropriate to answer the questions. Data from the MCBS analysis that are included in *2018 Alzheimer's Disease Facts and Figures* pertain only to Medicare beneficiaries age 65 and older. For this MCBS analysis, people with dementia are defined as:

- Community-dwelling survey participants who answered yes to the MCBS question, "Has a doctor ever told you that you had Alzheimer's disease or dementia?" Proxy responses to this question were accepted.
- Survey participants who were living in a nursing home or other residential care facility and had a diagnosis of Alzheimer's disease or dementia in their medical record.
- Survey participants who had at least one Medicare claim with a diagnostic code for Alzheimer's or other dementias in 2008. The claim could be for any Medicare service, including hospital, skilled nursing facility, outpatient medical care, home health care, hospice or physician, or other health care provider visit. The diagnostic codes used to identify survey participants with Alzheimer's or other dementias are 331.0, 331.1, 331.11, 331.19, 331.2, 331.7, 331.82, 290.0, 290.1, 290.10, 290.11, 290.12, 290.13, 290.20, 290.21, 290.3, 290.40, 290.41, 290.42, 290.43, 291.2, 294.0, 294.1, 294.10 and 294.11.

Costs from the MCBS analysis are based on responses from 2011 and reported in 2017 dollars.

A22. Differences in estimated costs reported by Hurd and colleagues: Hurd et al.[426] estimated per-person costs using data from participants in ADAMS, a cohort in which all individuals underwent diagnostic assessments for dementia. *2018 Alzheimer's Disease Facts and Figures* estimated per-person costs using data from the Medicare Current Beneficiary Survey (MCBS). One reason that the per-person costs estimated by Hurd et al. are lower than those reported in *Facts and Figures* is that ADAMS, with its diagnostic evaluations of everyone in the study, is more likely than MCBS to have identified individuals with less severe or undiagnosed Alzheimer's. By contrast, the individuals with Alzheimer's registered by MCBS are likely to be those with more severe, and therefore more costly, illness. A second reason is that Hurd et al.'s estimated costs reflect an effort to isolate the incremental costs associated with Alzheimer's and other dementias (those costs attributed only to dementia), while the per-person costs in *2018 Alzheimer's Disease Facts and Figures* incorporate all costs of caring for people with the disease (regardless of whether the expenditure was related to dementia or a coexisting condition).

A23. Present value of future costs: Present value is a calculation to determine the current value of a future amount of money. In this study, present value was used when presenting cumulative costs over time. Cumulative costs are in 2017 dollars and calculated using (a) an annual 3 percent discount rate to account for the anticipated value of the money over time and (b) a medical growth rate — the anticipated real growth rate of medical expenditures above and beyond inflation — of 3.1 percent.

A24. Breakdown of total medical savings: Where the literature only calculated reductions in Medicare costs, rather than total costs, the total and Medicaid costs were assumed to change by the same proportions. For example, if Medicare savings were 20 percent, it was assumed that total medical and Medicaid expenses also decreased 20 percent.

A25. THEMIS Monte Carlo simulation: One hundred Monte Carlo repetitions were used for each scenario, where each repetition consisted of an entire run of the simulation with a different random seed. In a given year (for example, 2024), sample individuals may have diseases and functional status limitations that put them at risk of developing new diseases and disabilities, or even dying. THEMIS uses a health transition model to simulate how population health will evolve given existing health conditions and assumptions about treatment and diagnosis for individuals. In addition, while mortality reduces the population over the course of the time step, the sample is "refreshed" by introducing those who turn 50 in 2024 and who now age into the target population. This forms the set of sample individuals for the next time step and the process is repeated for subsequent years.

A26. Variables used to determine individuals' probability of being diagnosed with Alzheimer's: Cognitive performance was assessed in the HRS using the Telephone Interview for Cognitive Status (TICS). Normal cognitive performance was defined as a TICS score of 12 or above; MCI was defined by a TICS score between 7 and 11; and dementia was defined as a TICS score below 7.[546] The functional limitations that contributed to an individual's probability of being diagnosed with Alzheimer's were difficulty (a) taking medications, (b) using the telephone and (c) handling money. Other health conditions included in determining the risk for developing Alzheimer's were diabetes, hypertension and stroke. The following demographic variables were also used: sex, age, race/ethnicity and education level.

A27. Cost adjustments: Adjusting the model's underlying cost estimates for those receiving an early diagnosis had two parts. The first part was a once-per-lifetime reduction in the two-year period centered on the time of diagnosis of $8,140 (2014 dollars), which is the difference between the costs of being diagnosed during the dementia stage and the MCI stage.[440] The second part of the cost adjustment is the cost per patient-year following a diagnosis in the MCI stage, calculated at $14,286 (2014 dollars). To illustrate the second part of the cost adjustment, assume an individual is diagnosed at age 75 under the status quo and diagnosed at age 65 in the early diagnosis scenarios. Under this example, the costs between age 66 and age 75 will be $14,286 times the medical cost growth factor. The medical cost growth — the real growth in medical expenditures above and beyond inflation — was assumed to be 3.1 percent per year, so as an example, the medical cost growth factor 10 years in the future would be 1.031 E+10.

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The Alzheimer's Association is the leading voluntary health organization in Alzheimer's care, support and research. Our mission is to eliminate Alzheimer's disease through the advancement of research; to provide and enhance care and support for all affected; and to reduce the risk of dementia through the promotion of brain health.

Our vision is a world without Alzheimer's disease.®

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