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Epidemiology of Diabetes and Diabetes Complications in the Elderly: An Emerging Public Health Burden

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Abstract

Diabetes in the elderly is a growing public health burden. Persons with diabetes are living longer and are vulnerable to the traditional microvascular and macrovascular complications of diabetes but also at increased risk for geriatric syndromes. Peripheral vascular disease, heart disease and stroke all have a high prevalence among older adults with diabetes. Traditional microvascular complications such as retinopathy, nephropathy, and neuropathy also frequently occur. Unique to this older population is the effect of diabetes on functional status. Older adults with diabetes are also more likely to experience geriatric syndromes such as falls, dementia, depression and incontinence. Further studies are needed to better characterize those elderly individuals who may be at the highest risk of adverse complications from diabetes.

Keywords

Elderly; Diabetes; Epidemiology; Complications; Public Health Burden

Introduction

The prevalence of abnormal glucose states among older adults is high. One third of the elderly population has diabetes and three quarters of the elderly population has pre-diabetes or diabetes. However, a large proportion of older adults with type 2 diabetes are undiagnosed. Among the total proportion of patients age 65 years and older with diabetes, 45.6% of the cases are undiagnosed (1). Those with undiagnosed diabetes were more likely to be men and rate their health status more favorably (2). The prevalence of diabetes is more than two times higher among elderly adults compared to middle age or young adults (1). Not only is the prevalence of diabetes high in older populations, but the incidence of new cases continues to grow. National Health Survey data demonstrates the rising incidence of diabetes in this older population over time. The incidence of diabetes for age 65–79 years per 1000 population was 6.0 in 1990, 11.6 in 2000, and 12.4 in 2010 (3). With a high incidence of disease and an aging population, forecasts project the number of cases of

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Compliance with Ethics Guidelines

Conflict of Interest

Mark Corriere, Nira Rooparinesingh, and Rita Rastogi Kalyani declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent

This article does not contain any studies with human or animal subjects performed by any of the authors.

diagnosed diabetes among people aged 65 years and older will grow more than 4-fold from 2005 to 2050 (4).

As the problem of diabetes among older adults grows, so too does the cost of providing diabetes-related care. In 2013, the American Diabetes Association estimated that the total costs of diagnosed diabetes in the U.S. have risen to \$245 billion in 2012 from \$174 billion in 2007. This represents a 41% increase over a five year period. The majority of these costs (62.4%) are via Medicare (which provides coverage to older adults) and Medicaid (5). Also, a large portion of diabetes-related cost involves treating diabetes related complications.

With a greater proportion of diabetes cases present in the older population, it is prudent to consider how this population compares to younger patients with regard to the development of diabetes complications. Older adults encounter many of the same traditional microvascular and macrovascular complications that younger patients experience. In addition, having comorbid diabetes in older age increases the risk of developing geriatric syndromes.

Traditional Diabetic Complications

Vulnerable older adults with diabetes may be at a disproportionately increased risk of microvascular and macrovascular complications due to the potentially longer duration of disease. These elderly patients with abnormal glucose metabolism may have less end organ reserve due to aging and comorbid illnesses. This could result in more abrupt and severe end organ disease than what is seen among younger patients.

Macrovascular

Coronary Heart Disease

Elderly adults with diabetes have a high prevalence of Coronary Heart Disease (CHD). Using a composite definition of CHD (bypass surgery, angiographic evidence of coronary disease, previous percutaneous intervention, documented myocardial infarction (MI), or electrocardiographic features of MI), the prevalence among diabetes patients with a mean age of 80 years at an academic center was 44% (6). The prevalence of cardiovascular disease is higher in persons with diabetes compared to those without diabetes. An Italian cohort of 3,474 patients aged 65–84 years demonstrated the prevalence of MI among patients with diabetes was 11.3%, among patients with impaired fasting glucose was 8.5%, and among patients with normal glycemia was 8%. The comparison from the diabetes group to the normal glycemia group was statistically significant ($P=0.032$). Older men with diabetes had a higher prevalence of MI compared to women with diabetes (15.5% vs. 7.2%, $P=0.001$) (7), however, survival bias may be present. CHD among older patients with diabetes is a leading cause of mortality. The Cardiovascular Health Study included participants aged 65 years and older with and without diabetes. Compared to persons without diabetes, those with treated diabetes had an elevated risk of CHD related mortality (oral-treated diabetes: HR 2.47 95% CI 1.89–3.24 and insulin-treated diabetes: HR 2.75 95% CI 1.95–3.87) (8).

Many older patients with diabetes are unaware they have CHD. An autopsy series included 293 persons with diabetes (mean age 73 years), without clinically known CHD. Nearly 75% had high grade coronary disease and greater than half had multivessel disease (9). Silent ischemia is also a problem among older patients with diabetes. A French study screened asymptomatic patients with diabetes for CHD. Their cohort included 130 patients with type 2 diabetes and a mean age of 60.7 years. With their screening process, 20.9% of asymptomatic men in this group had significant coronary lesions on angiography (10).

Cerebrovascular Disease

Older adults with diabetes are at particularly high risk of morbidity and mortality from cerebrovascular disease (CVA). The prevalence of CVA in the older population with diabetes is higher than those without diabetes. An Italian study investigated the prevalence in a group of adults aged 65 to 84 years that were stratified into groups (diabetes, impaired fasting glucose, and normal glycemia). The prevalence of CVA in patients with a history of diabetes was 10.6%. This was higher than the prevalence in patients without diabetes (7%, $P=0.003$). Looking specifically at the subgroup of patients age 75 to 84, the prevalence among patients with diabetes was 13% compared to 10% in patients without diabetes (7). Elderly patients with diabetes who experience excess worry related to diabetes symptoms, diet restrictions, treatment satisfaction, and medications and have a lower sense of well being may be more likely to have a CVA. A prospective cohort study of 375 geriatric patients with a mean age of 75 years demonstrated that lower scores on the Geriatric Morale scale and Elderly Diabetes Burden scale were predictors for CVA (HR=2.6, 95% CI=1.1–6.5, $P=0.039$) (11). This suggests psychosocial factors may be associated with stroke events among elderly patients with diabetes.

Peripheral Vascular Disease

Peripheral Vascular Disease (PVD) is a common diabetes complication in older adults. Among U.S. adults age 60 years and older, the prevalence of PVD for patients with diabetes was almost twice as high compared to those without diabetes (12). A recent multicenter study estimated the prevalence of PVD to be 60.6% among a cohort of 1,430 diabetes patients aged 70 years and older (mean age 78 years). Predictors of an abnormal ankle brachial index (ABI) included male gender, smoking, dyslipidemia and having other diabetes related complications (13). A recent study in Malta also supports the finding that having other diabetes-related complications increases the risk of PVD. Investigators sought to see what risk factors and complications associated with a low ABI in older patients with type 2 diabetes and proliferative retinopathy. The cohort's average age was 65 years with a mean duration of diabetes of 18.6 years. Their results showed that dyslipidemia and vibration perception thresholds (neuropathy) were associated with low ABI. In addition, older age and declining GFR also were associated risk factors (14). Progressively older age increases the risk of developing PVD. An Indonesian study demonstrated that patients with type 2 diabetes age 70–80 years were 7.4 times more likely to develop PVD compared to patients with type 2 diabetes age 60–69 years (15).

Microvascular

Retinopathy

Retinopathy is a common microvascular complication of diabetes. An analysis of National Health and Nutritional Examination Survey (NHANES) data reports a crude prevalence of diabetic retinopathy at 29.5% among patients age 65 years and older with diabetes. This prevalence is similar to the prevalence of diabetes in patients age 40–64 years (28.0%, $P=0.64$ for comparison). Among the entire cohort of patients with diabetes, men were more likely than women to have diabetic retinopathy (31.6% vs. 25.7%, $P=0.04$). Patients with retinopathy had a longer duration of diabetes (15 years vs. 7.3 years, $P<0.001$), higher HbA1c value (7.9% vs. 7.05, $P<0.001$), and were more likely to be using insulin (44.6% vs. 10.2%, $P<0.01$) (16). Retinopathy is less common among adults diagnosed with diabetes in older-age compared to middle-age (17).

Nephropathy

Chronic kidney disease (CKD) is a common diabetes related complication in older adults. For adults older than 60 years, the most common cause of CKD and end-stage renal disease (ESRD) in the United States is diabetic nephropathy (18). Among adults age 75 years and older, about 1/3 of new cases of ESRD are caused by diabetic nephropathy (19). Comparing older adults with diabetes to those without, the prevalence of CKD is consistently higher among patients with diabetes. This was demonstrated with a recent analysis of the Kidney Early Evaluation Program (KEEP) database (a community-based screening program targeting adults at high risk of kidney disease), NHANES data, and billing codes from a sample of the U.S. Medicare population. In all 3 data sets, the prevalence of CKD was higher in individuals older than 65 years diagnosed with diabetes compared to those without (KEEP 48.2% vs. 40.4%, NHANES 58.3% vs. 41.4%, Medicare 14.2% vs. 4.4%; $P<0.001$) (20).

Over the last 25 years, the proportion of patients with diabetic nephropathy who have stage 5 chronic kidney disease and are initiating dialysis in the U.S. rose from one in six persons to almost one in two persons. This rising rate of diabetes-related ESRD correlates with the increased burden of diabetes. The elderly population with diabetes remains a large proportion of those receiving dialysis for diabetic nephropathy. In Canada, this older diabetes population makes up 37% of all patients receiving dialysis. This older population presents unique challenges in medical management. Most have multiple comorbid conditions, such as heart disease and peripheral vascular disease. In the elderly, ESRD with diabetes is associated with an increased risk of dementia which can further complicate therapy. Additionally, this older population may be more likely to have arteriovenous fistula complications. Among a cohort of patients 65 years and older, 28.6% of patients with diabetes had fistula failure compared to only 10.3% of patients without diabetes ($P=0.04$) (21). All of these comorbid conditions make caring for the elderly patient with diabetes and ESRD challenging (19).

Neuropathy

Distal sensorimotor polyneuropathy is one of the most common long-term complications of diabetes. Patients with diabetic peripheral neuropathy (DPN) are at a high risk for falling. For older patients with diabetes duration greater than 25 years, about half have comorbid DPN and this can be associated with functional impairment and decreased quality of life (22). Factors associated with increased risk of DPN among the elderly with diabetes include female sex, longer duration of diabetes, retinopathy, stroke, hypertension, dyslipidemia, and a history of foot ulcers (23).

As the severity of neuropathy increases, the functional impairment worsens and quality of life can be affected (22). Examples of functional limitations include reduced walking speed, cadence, and step length compared with patients without diabetes. Patients with DPN also display impaired peripheral sensation, reaction time, and balance (24).

Geriatric Specific Complications

Normal aging results in a constellation of health conditions collectively known as “geriatric syndromes”. These geriatric syndromes include impairment of multiple physiological systems and can lead to functional disability, falls, depression, dementia and incontinence. Diabetes is associated with an increased prevalence of geriatric syndromes in the elderly. Table 1 summarizes the epidemiology of geriatric syndromes in older patients with diabetes.

Falls

Falls represent a major source of morbidity and mortality for the elderly. Older patients with diabetes are at increased risk of having a fall. The Longitudinal Ageing Study Amsterdam evaluated 1,145 community dwelling patients aged >65 years prospectively for three years. Recurrent falls were defined as two falls or more in 6 months. 30.6% of individuals with diabetes compared to 19.4% of individuals without diabetes experienced recurrent falls (HR=1.67, 95% CI 1.11–2.51). This increased risk persisted after adjustment for confounders. Potential factors related to the increased frequency of falls in persons with diabetes include polypharmacy, pain, lower physical activity, functional limitations, and cognitive impairments (25). The use of insulin therapy may also be related to the risk of falls in persons with diabetes. The Study of Osteoporotic Fractures included a prospective cohort of 9,249 patients followed for an average of 7.2 years. Recurrent falls were defined as a fall more than once a year. 18% of the cohort experienced recurrent falls. Non-insulin treated patients (OR 1.68, 95% CI 1.37–2.07) and insulin-treated patients (OR 2.78, 95% CI 1.82–4.24) both had an increased risk of recurrent falls compared to patients without diabetes (26). Similar findings in regards to insulin therapy and an increased risk of falls were found in a large Kaiser Permanente Registry. However, no relationship of oral diabetes agents to the risk of falls was found. This study included 46,946 patients with type 2 diabetes with an average age of 61.5 years. The patients were followed for 5 years and assessed for incident fall. Comparing participants that experienced an incident fall to those that did not, 28.6% vs. 22.9% were using insulin ($P<0.01$), 56.8% vs. 58.5% were using a sulfonylurea ($P=0.15$) and 5.09% vs. 5.12% were using metformin ($P=0.96$) (27). The available literature supports that falls are more common among patients with diabetes. This is particularly true of patients treated with insulin. Specific oral agents have not been found to increase risk.

Vision and Hearing Impairment

Loss of vision and hearing can increase the risk of falls in older individuals, leading to functional disability, and potentially result in older patients feeling isolated and being more vulnerable to depression. Older adults with diabetes have a higher prevalence of vision impairment than those without diabetes. Among persons age 60 years and older, the prevalence of self-reported vision impairment was 34.2% for those diagnosed with diabetes compared to 21.4% for those with a diagnosis of diabetes ($P<0.001$) (12). Recent epidemiology studies show an improvement in the trends of self-reported vision impairment among patients in the U.S. with diabetes. Comparing results from the National Health Interview Survey in 1997 to 2010 reveals a decline in self-reported vision impairment. Among patients older than 75 years, 32.4% reported vision impairment in 1997 compared to only 19.5% in 2010 (28). The authors speculated that this may be due to improved control of risk factors or earlier detection and treatment of eye disease. Alternatively, compared to those persons queried in 1997, the 2010 survey respondents have not had diabetes long enough to develop associated eye disease.

Diabetes is also associated with an increased risk of hearing loss. Data from the National Health and Nutrition Examination Survey (NHANES) demonstrates a two-fold increased risk of hearing loss among persons aged 20–69 years with diabetes compared to those without (OR 2.0, 95% CI 1.2–3.2) (29). This relationship has been demonstrated in other studies (30, 31). Focusing on older patients only, an Australian survey assessed age-related hearing loss in a group with a mean age of 70 years. 50% of patients with diabetes had hearing loss compared to 38.2% of patients without diabetes (OR 1.44, 95% CI 1.11–2.17) (31). Similarly, among older U.S. adults, the prevalence of self-reported hearing impairment was 50.5% for those diagnosed with diabetes versus 43.6% for those without diagnosed diabetes ($P=0.01$) (12).

Urinary Incontinence

Urinary incontinence can have a negative influence on a patient's quality-of-life, physical functioning, mental health and general health perception (32). Incontinence is highly prevalent among women with diabetes, in particular. A recent study revealed that women with diabetes reported having at least weekly incontinence significantly more than women without diabetes (35.4% vs. 25.7%, $P<0.001$). Additionally, women with diabetes were less likely to report the incontinence to their physician (33). A Turkish study had similar findings regarding the high prevalence of urinary incontinence among women with diabetes. 41% of women with diabetes and 22.1% of patients without diabetes reported incontinence in this case control designed study ($P<0.001$). In addition to diabetes, older age and increasing BMI are both associated with urinary incontinence (34).

Older men with diabetes also experience more urinary incontinence when compared to counterparts without diabetes. A recent study including 1,369 men aged 65 years and older evaluated the prevalence of incontinence by diabetes status. 21.7% of men with diabetes had incontinence compared to only 13.9% of men without diabetes ($P<0.05$) (35). The pathophysiology of incontinence among patients with diabetes is felt to be multifactorial. Components of neuronal, smooth muscle, and urothelial dysfunction all contribute (36).

Cognitive Impairment and Dementia

The prevalence of cognitive impairment and dementia increase with age. The presence of comorbidities in diabetes contributes to this relationship. A recent cross-sectional study screened 66,813 patients aged 65 years and older for cognitive impairment with the Abbreviated Mental Test. 10.4% of study participants were being treated for diabetes. The patients with diabetes were more likely to have cognitive impairment compared to patients without diabetes (OR 1.28, 95% CI 1.11–1.48) (37). A large database analysis of U.S. Veterans demonstrated a high prevalence of memory problems among older adults with diabetes. The analysis included 497,900 patients aged 65 years and older with diabetes. In this population, the prevalence of combined cognitive impairment and dementia was 13.1% for individuals aged 65 to 74 years and 24.1% for individuals older than 75 (38).

The presence of diabetic retinopathy (a manifestation of microvascular disease) has been associated with worsening memory in older patients with diabetes. In the Edinburgh Type 2 Diabetes Study, patients were examined and categorized by their degree of diabetic retinopathy (none, mild, moderate to severe). After adjustment for age and sex, increasing severity of retinopathy was independently associated with memory loss (39).

Stroke (a manifestation of macrovascular disease) may also contribute to the observed relationship between diabetes and memory loss. This was demonstrated in a 15 year study of 1,702 African American patients. They were screened for dementia six times during the 15 year follow up. 441 of the participants had diabetes and they experienced an accelerated cognitive decline compared to participants without diabetes ($P=0.046$). When a history of incident stroke was added to the adjustment models, interestingly, the relationship of accelerated cognitive decline among patients with diabetes strengthened compared to patients without diabetes ($P=0.007$) (40).

Aside from vascular disease, hypoglycemia has also been strongly linked to memory loss in older patients with diabetes. Feil and colleagues studied U.S. Veterans older than 65 years with diabetes and showed dementia increased the likelihood of hypoglycemia (OR=2.42; 95% CI 2.36–2.48) (38). The Edinburgh Type 2 Diabetes Study demonstrated a similar relationship. 1,066 patients aged 60–75 years with type 2 diabetes were queried about lifetime and recent history of severe hypoglycemia. These patients also underwent

neuropsychological testing to assess cognitive ability. Self-reported hypoglycemia associated with poor late-life cognitive ability. This relationship persisted after adjustment for potential confounders (41).

Depression

Older patients with diabetes are more likely to have depression. The increased incidence of major depression among patient with diabetes was shown in the Health, Aging and Body Composition Study. 2,522 community dwelling participants age 70–79 were followed for a mean of 5.9 years. None had depression symptoms at baseline. The development of depression was defined as use of antidepressants or depression symptoms via a screening tool at follow up visits. Older persons with diabetes had a higher incidence of depressed mood after adjustment for age, sex, race, and site (23.5% vs. 19%, $P=0.02$). Defining recurrent depressed mood as two consecutive visits with a positive screening test, participants with diabetes had a higher rate of recurrent depressed mood (8.8% vs. 4.3%, $P<0.001$) (42). Similar results were seen in a large cross-sectional study performed in Hong Kong. Chau and colleagues found that persons older than 65 years of age with diabetes had an odds ratio of 1.35 (95% CI 1.25–1.46) for the presence of depression compared to counterparts without diabetes (37).

An older individual with co-existing diabetes and depression is at greater risk of having functional disability. 30,022 adults with available data from the National Health Interview Survey were categorized as having no diabetes and no major depression, major depression alone, diabetes alone, or diabetes and comorbid major depression. Prevalence of functional disability was calculated for each category. Functional disability prevalence was 24.5% for the group with no diabetes and no depression, 51.3% for the depression-only group, 58.1% for the diabetes-only group, and 77.8% for the group with both diabetes and depression. Using the no diabetes and no depression group as the reference, the odds of functional disability was 7.15 (95% CI 4.53–11.28) for the group with both diabetes and depression (43). In addition to increasing the risk of functional disability, total annual health care costs in a study of Medicare patients were 4.5 times greater for patients with both diabetes and depression compared to patients with just diabetes (44).

Functional Disability

Functional status includes the ability to perform simple day-to-day tasks required for routine living. This includes activities of daily living (ADL) such as bathing, dressing, eating, and ambulating indoors. Another category includes instrumental activities of daily living (IADL) such as preparing meals, managing money, doing light housework, or managing medications. Of particular interest is the ability to perform tasks of lower extremity mobility. This includes the ability to ambulate outdoors or ambulate up a flight of stairs (45). In general, persons with diabetes report a two-to-three times greater difficulty in performing these tasks of daily living compared to patients without diabetes (46).

The Mexican Health and Aging Study explored disability-free life expectancy in older adults with and without diabetes. Using basic scales of ADL and IADL to define disability, this study showed that patients with diabetes had a shorter disability-free life expectancy. At age 50 years, persons with diabetes had a disability-free life expectancy of 20.8 years (95% CI 19.2–22.3) compared to patients without diabetes whose disability-free life expectancy was 29.9 years (95% CI 28.8–30.9) (47). Similar findings were observed in a descriptive study performed in Hong Kong. 66,813 patients aged 65 years and older were included and approximately 10% reported treatment for diabetes. Using assessments of ADL and IADL, patients with diabetes were 1.7 times more likely to have functional impairment (OR 1.65, 95% CI 1.51–1.80) compared to persons without diabetes (37). A recent Taiwanese study

had comparable findings. A nationwide cohort of 1,873 persons was followed for 7 years. 15.3% had a history of diabetes. All patients were assessed for functional ability with ADL, IADL and general physical function tasks. Based on results of this testing, their level of functional ability was categorized. "High" function meant the patient had no deficits in any domains. 50.5% of the non-diabetes group was in the "high" function category compared to only 32.5% of the diabetes patients ($P<0.001$) (48).

As our ability to treat diabetes improves and patients live longer with diabetes, recent trends suggest that rates of functional impairment are worsening. Data from the Spanish National Health Survey highlighted these trends. Comparing survey data from 2000–2001 to survey data from 2006–2007, patients over the age of 65 years with diabetes had increased rates of functional impairment across all measured modalities. Impairment in ADLs rose from 19.3% to 20.6%, impairment in IADLs rose from 35.3% to 49.2%, and impairment of mobility tasks rose from 29.2% to 38.2% over an average of six years. The prevalence of these impairments was higher across all domains compared to persons older than 65 without diabetes (45). A U.S. study showed similar trends with regard to self-care tasks (ADL), but not mobility. Using repeated cross sectional analysis of over 10,000 participants age 65 and older from the Health and Retirement Study, investigators compared study wave participants from 1998 and 2008. The odds ratio for disability in self-care tasks for persons with versus without diabetes was 1.21 in 1998 compared to 1.52 in 2008 ($P=0.03$). In comparison, mobility-related disability did not have a worsening trend. The odds ratio for mobility problems in persons with versus without diabetes was 1.57 in 1998 compared to 1.47 in the 2008 group ($P=0.92$) (49).

Frailty

Older adults with diabetes are more likely to be frail. The frailty syndrome is a condition of physiological vulnerability to stressors which may be related to adverse outcomes such as disability and mortality (50–53). Components of the frailty syndrome can include three or more of the following: unintentional weight loss, self-reported exhaustion, muscle weakness (poor grip strength), slow walking speed, or low physical activity (53). Using this definition, the prevalence of diabetes is two-fold higher in frail compared to nonfrail older adults (54, 55). Further, abnormal glucose status in older adults may be a risk factor for the eventual development of frailty (56, 57).

Life Expectancy

Diabetes in the older patient is associated with an increased risk of traditional diabetic complications and geriatric syndromes, and may be expected to have a negative impact on life expectancy. The Mexican Health and Aging Study demonstrated that compared to patients without diabetes, patients with diabetes have a reduced total life expectancy of 10 years at age 50 years and 4 years at age 80 years (47). Whether this decreased life expectancy is found in all patients with diabetes is not clear. A Taiwanese study aimed to investigate if mortality differed among older patients with diabetes and varying levels of functional disability. "High" functioning participants had no functional disability. In the high functioning group of patients, a diagnosis of diabetes did not increase mortality compared to similar high functioning older adults without diabetes. Interestingly, "middle" and "low" functioning adults experienced a gradient of increasing mortality when they had a comorbid diagnosis of diabetes compared to similarly disabled participants that did not have diabetes (48).

Although mortality is generally increased in persons with diabetes, recent trends suggest that patients with diabetes are living longer. An analysis of 9,066 deaths in patients with type 2 diabetes followed at a diabetes center in Romania illustrates the improved life expectancy

over time. Deaths were split into three groups based on the time period that the death occurred (1945–1965, 1966–1988, or 1989–2009). The mean duration of diabetes at the time of death was 9.9 ± 7.3 years for 1943–1966, followed by a significant rise to 12.2 ± 8.2 years in 1966–1988, and 14 ± 8.1 years in 1989–2009 ($P < 0.001$) (58). The age at diagnosis of diabetes did not change dramatically during these time periods and, instead, these findings seem more related to increasing ages at death for persons with diabetes. However, this study was limited to one country and its results may not be generalizable to all populations.

Similar improvements in life expectancy have been demonstrated for type 1 diabetes. The same Romanian diabetes center analyzed data on 845 patients with type 1 diabetes. During the three periods of time evaluated (1946–1965, 1966–1985, and 1986–2005) the mean age of onset for type 1 diabetes did not differ but the mean age at death did. Focusing just on those diagnosed after age 18 years, the mean age at death was 42.33 ± 9.77 for those diagnosed in 1945–1965, 54.47 ± 12.02 years for those diagnosed in 1966–1985, and 58.77 ± 12.3 years for those diagnosed in 1986–2005 ($P < 0.001$) (59). The Pittsburgh Epidemiology of Diabetes Complications Study also showed improved life expectancy trends among patients with type 1 diabetes. The life expectancy at birth for those diagnosed in 1965–1980 was ~15 years greater than participants diagnosed in 1950–1964 (68.8 years vs. 53.4 years, $P < 0.0001$) (60). With improving life expectancy among both type 1 and type 2 diabetes, the proportion of individuals with these diseases who are elderly will continue to grow.

Unique Populations

Diabetes among Nursing Home Residents

The prevalence of diabetes in chronic care facilities for older individuals is high. Many of these individuals have long-standing diabetes and diabetes-related complications leading to significant cognitive and functional disabilities. The 2004 National Nursing Home Survey collected cross-sectional data for 11,939 nursing home residents aged 65 years. For their survey, about a quarter of nursing home residents had diabetes as a primary admission and/or current diagnosis. Residents with diabetes were more often admitted from acute care hospitals (42.5% vs. 35.3%; $P < 0.0001$), more likely to have a length of stay over 100 days (22.6% vs. 20.1%; $P < 0.05$), and took more medications (10.3 vs. 8.4; $P < 0.0001$) compared to residents without diabetes (61).

A more recent Spanish study of nursing home residents had similar findings. In this study, the prevalence of diabetes was 26.5% among nursing home residents with a mean age of 79.7 years. These patients had both macrovascular and microvascular complications with CVA (55.2%), MI (14.5%), PVD (29.6%), retinopathy (29.6%), nephropathy (21.3%) and neuropathy (25.6%). Dementia (46.2%) and functional disability (45.6%) were also both commonly present (62).

Conclusion

The burden of diabetes continues to grow. With an aging population and patients with diabetes living longer, the proportion of elderly patients with diabetes will continue to rise. This elderly population with diabetes is susceptible to increased risk of traditional microvascular and macrovascular diabetes-related complications. The prolonged duration of disease and decreased end organ reserve renders older adults with diabetes particularly susceptible to retinopathy, nephropathy, neuropathy, stroke and heart disease. In addition, this vulnerable population is at risk for developing geriatric syndromes. Diabetes increases the risk of falls, urinary incontinence, dementia, depression, and vision and hearing loss. In addition, older persons with diabetes are more likely to have functional limitations and

report disability. Although it is clear that this older population with diabetes is at high risk for traditional and geriatric specific complications, further study is needed to identify sub-populations of the elderly at highest risk. This could facilitate targeted screening and prevention efforts among this vulnerable population.

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Table 1

Epidemiology of geriatric syndromes among older adults with diabetes

	Prevalence or Incidence	Risk Ratio (95% Confidence Interval)*
Falls	Incidence of recurrent falls over 3 years among persons age >65 years: 30.6% diabetes group vs. 19.4% non diabetes group (25).	Incidence: HR 1.67 (1.11–2.51) (25).
Vision Loss	Prevalence of self-reported vision impairment among persons age > 60 years: 34.2% diabetes group vs. 21.4% non diabetes group (12)	
Hearing Loss	Prevalence of hearing loss among cohort with mean age 70 years: 50% diabetes group vs. 38.2% non diabetes group (31).	Prevalence: OR 1.44 (1.11–2.17) (31).
Urinary Incontinence	Prevalence of weekly incontinence among women: 35.4% diabetes group vs. 25.7% non diabetes group (33). Prevalence of incontinence among men with a mean age 76 years: 21.7% diabetes group vs. 13.9% non diabetes group (35).	
Cognitive impairment and Dementia	Prevalence of cognitive impairment in cohort age >65 years: 3.4% diabetes group vs. 2.8% non diabetes group (38). Prevalence combined cognitive impairment and dementia in a cohort age >75 years with diabetes: 24.1% (37). Incidence of cognitive impairment and dementia in a cohort age >60 years with 6.5 years mean follow up: 13.6% treated diabetes group vs. 8% non diabetes group (63).	Prevalence: OR 1.28 (1.11–1.48) (37). Incidence: HR 2.05 (1.41–2.97) (63).
Depression	Incidence of depression among persons age 70–79 years over mean 5.9 years: 23.5% diabetes group vs. 19% non diabetes group (42). Prevalence depression in cohort age > 65 years: 12.2% diabetes group vs. 9.3% non diabetes group (37).	Prevalence: OR 1.35 (1.25–1.46) (37).
Frailty	Prevalence of frailty among women aged 70–79 years: 16.1% for group with A1C 6.5% vs. 9.4% for group with A1C < 6.5% (64)	Incidence: HR 3.63 (1.41–9.33) for developing frailty among women with baseline A1C >8% compared to A1C <5.5% (55). Incidence: HR 1.15 (1.02–1.31) for incident frailty per SD increase in HOMA-IR (56).

HR: Hazard Ratio, OR: Odds Ratio

* Comparison of diabetes group to non diabetes group.