

Diabetes Overview

National Diabetes Information Clearinghouse



U.S. Department
of Health and
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NATIONAL
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NIDDK
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DIABETES AND DIGESTIVE
AND KIDNEY DISEASES

Almost everyone knows someone who has diabetes. An estimated 23.6 million people in the United States—7.8 percent of the population—have diabetes, a serious, lifelong condition. Of those, 17.9 million have been diagnosed, and 5.7 million have not yet been diagnosed. In 2007, about 1.6 million people ages 20 or older were diagnosed with diabetes. For additional statistics, see the *National Diabetes Statistics, 2007* fact sheet online at www.diabetes.niddk.nih.gov/dm/pubs/statistics or call the National Diabetes Information Clearinghouse (NDIC) at 1-800-860-8747 to request a copy.

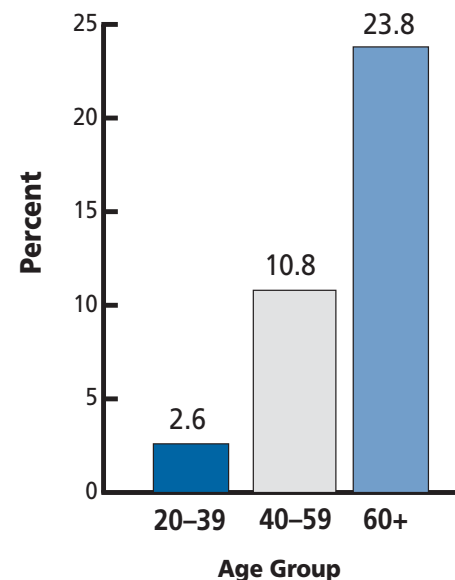
What is diabetes?

Diabetes is a disorder of metabolism—the way the body uses digested food for growth and energy. Most of the food people eat is broken down into glucose, the form of sugar in the blood. Glucose is the main source of fuel for the body.

After digestion, glucose passes into the bloodstream, where it is used by cells for growth and energy. For glucose to get into cells, insulin must be present. Insulin is a hormone produced by the pancreas, a large gland behind the stomach.

When people eat, the pancreas automatically produces the right amount of insulin to move glucose from blood into the cells. In people with diabetes, however, the pancreas either produces little or no insulin, or the cells do not respond appropriately to the insulin that

Estimated prevalence of diagnosed and undiagnosed diabetes in people ages 20 years or older, by age group, United States, 2007



Source: 2003–2006 National Health and Nutrition Examination Survey estimates of total prevalence—both diagnosed and undiagnosed—were projected to year 2007.

is produced. Glucose builds up in the blood, overflows into the urine, and passes out of the body in the urine. Thus, the body loses its main source of fuel even though the blood contains large amounts of glucose.

What are the types of diabetes?

The three main types of diabetes are

- type 1 diabetes
- type 2 diabetes
- gestational diabetes

Type 1 Diabetes

Type 1 diabetes is an autoimmune disease. An autoimmune disease results when the body's system for fighting infection—the immune system—turns against a part of the body. In diabetes, the immune system attacks and destroys the insulin-producing beta cells in the pancreas. The pancreas then produces little or no insulin. A person who has type 1 diabetes must take insulin daily to live.

At present, scientists do not know exactly what causes the body's immune system to attack the beta cells, but they believe that autoimmune, genetic, and environmental factors, possibly viruses, are involved. Type 1 diabetes accounts for about 5 to 10 percent of diagnosed diabetes in the United States. It develops most often in children and young adults but can appear at any age.

Symptoms of type 1 diabetes usually develop over a short period, although beta cell destruction can begin years earlier. Symptoms may include increased thirst and urination, constant hunger, weight loss, blurred vision, and extreme fatigue. If not diagnosed and treated with insulin, a person with type 1 diabetes can lapse into a life-threatening diabetic coma, also known as diabetic ketoacidosis.

Type 2 Diabetes

The most common form of diabetes is type 2 diabetes. About 90 to 95 percent of people with diabetes have type 2. This form of diabetes is most often associated with older age, obesity, family history of diabetes, previous history of gestational diabetes, physical inactivity, and certain ethnicities. About 80 percent of people with type 2 diabetes are overweight or obese.

Type 2 diabetes is increasingly being diagnosed in children and adolescents, especially among African American, Mexican American, and Pacific Islander youth.

When type 2 diabetes is diagnosed, the pancreas is usually producing enough insulin, but for unknown reasons the body cannot use the insulin effectively, a condition called insulin resistance. After several years, insulin production decreases. The result is the same as for type 1 diabetes—glucose builds up in the blood and the body cannot make efficient use of its main source of fuel.

The symptoms of type 2 diabetes develop gradually. Their onset is not as sudden as in type 1 diabetes. Symptoms may include fatigue, frequent urination, increased thirst and hunger, weight loss, blurred vision, and slow healing of wounds or sores. Some people have no symptoms.

Gestational Diabetes

Some women develop gestational diabetes late in pregnancy. Although this form of diabetes usually disappears after the birth of the baby, women who have had gestational diabetes have a 40 to 60 percent chance of developing type 2 diabetes within 5 to 10 years. Maintaining a reasonable body weight and being physically active may help prevent development of type 2 diabetes.

About 3 to 8 percent of pregnant women in the United States develop gestational diabetes. As with type 2 diabetes, gestational diabetes occurs more often in some ethnic groups and among women with a family history of diabetes. Gestational diabetes is caused by the hormones of pregnancy or a shortage of insulin. Women with gestational diabetes may not experience any symptoms.

Diabetes in Youth

The SEARCH for Diabetes in Youth multicenter study, funded by the Centers for Disease Control and Prevention (CDC) and the National Institutes of Health (NIH), has determined that

- based on data from 2002 to 2003, a total of 15,000 youth in the United States were newly diagnosed with type 1 diabetes each year. In addition, about 3,700 youth were newly diagnosed with type 2 diabetes each year.
- non-Hispanic white youth had the highest rate of new cases of type 1 diabetes.
- type 2 diabetes was rarely diagnosed among youth younger than 10 years of age.

Additional information about specific rates of new cases of type 1 and type 2 diabetes among youth younger than age 20 can be found in the fact sheet *National Diabetes Statistics, 2011*, available online at www.diabetes.niddk.nih.gov/dm/pubs/statistics.

Other Types of Diabetes

A number of other types of diabetes exist. A person may exhibit characteristics of more than one type. For example, in latent autoimmune diabetes in adults (LADA), also called type 1.5 diabetes or double diabetes, people show signs of both type 1 and type 2 diabetes.

Other types of diabetes include those caused by

- genetic defects of the beta cell—the part of the pancreas that makes insulin—such as maturity-onset diabetes of the young (MODY) or neonatal diabetes mellitus (NDM)
- genetic defects in insulin action, resulting in the body's inability to control blood glucose levels, as seen in leprechaunism and the Rabson-Mendenhall syndrome
- diseases of the pancreas or conditions that damage the pancreas, such as pancreatitis and cystic fibrosis
- excess amounts of certain hormones resulting from some medical conditions—such as cortisol in Cushing's syndrome—that work against the action of insulin
- medications that reduce insulin action, such as glucocorticoids, or chemicals that destroy beta cells
- infections, such as congenital rubella and cytomegalovirus

- rare immune-mediated disorders, such as stiff-man syndrome, an autoimmune disease of the central nervous system
- genetic syndromes associated with diabetes, such as Down syndrome and Prader-Willi syndrome

Latent Autoimmune Diabetes in Adults (LADA)

People who have LADA show signs of both type 1 and type 2 diabetes. Diagnosis usually occurs after age 30. Researchers estimate that as many as 10 percent of people diagnosed with type 2 diabetes have LADA. Some experts believe that LADA is a slowly developing kind of type 1 diabetes because patients have antibodies against the insulin-producing beta cells of the pancreas.

Most people with LADA still produce their own insulin when first diagnosed, like those with type 2 diabetes. In the early stages of the disease, people with LADA do not require insulin injections. Instead, they control their blood glucose levels with meal planning, physical activity, and oral diabetes medications. However, several years after diagnosis, people with LADA must take insulin to control blood glucose levels. As LADA progresses, the beta cells of the pancreas may no longer make insulin because the body's immune system has attacked and destroyed them, as in type 1 diabetes.

Diabetes Caused by Genetic Defects of the Beta Cell

Genetic defects of the beta cell cause several forms of diabetes. For example, monogenic forms of diabetes result from mutations, or changes, in a single gene. In most cases of monogenic diabetes, the gene mutation is inherited. In the remaining cases, the gene mutation develops spontaneously. Most mutations in monogenic diabetes reduce the body's ability to produce insulin. Genetic testing can diagnose most forms of monogenic diabetes.

NDM and MODY are the two main forms of monogenic diabetes. NDM is a form of diabetes that occurs in the first 6 months of life. Infants with NDM do not produce enough insulin, leading to an increase in blood glucose. NDM can be mistaken for the much more common type 1 diabetes, but type 1 diabetes usually occurs after the first 6 months of life. More information about the two types of NDM, permanent neonatal diabetes and transient neonatal diabetes mellitus, is provided in the fact sheet *Monogenic Forms of Diabetes*, available online from the NDIC at www.diabetes.niddk.nih.gov/dm/pubs/mody. For printed copies of the fact sheet, call the NDIC at 1-800-860-8747.

MODY usually first occurs during adolescence or early adulthood. However, MODY sometimes remains undiagnosed until later in life. A number of different gene mutations have been shown to cause MODY, all of which limit the pancreas' ability to produce insulin. This process leads to the high blood glucose levels characteristic of diabetes. More information about specific types of MODY is provided in the fact sheet *Monogenic Forms of Diabetes*.

Diabetes Caused by Genetic Defects in Insulin Action

A number of types of diabetes result from genetic defects in insulin action. Changes to the insulin receptor may cause mild hyperglycemia—high blood glucose—or severe diabetes. Symptoms may include acanthosis nigricans, a skin condition characterized by darkened skin patches, and, in women, enlarged and cystic ovaries plus virilization and the development of masculine characteristics such as excess facial hair. Two syndromes in children, leprechaunism and the Rabson-Mendenhall syndrome, cause extreme insulin resistance.

Diabetes Caused by Diseases of the Pancreas

Injuries to the pancreas from trauma or disease can cause diabetes. This category includes pancreatitis, infection, and cancer of the pancreas. Cystic fibrosis and hemochromatosis can also damage the pancreas enough to cause diabetes.

Diabetes Caused by Endocrinopathies

Excess amounts of certain hormones that work against the action of insulin can cause diabetes. These hormones and their related conditions include growth hormone in acromegaly, cortisol in Cushing's syndrome, glucagon in glucagonoma, and epinephrine in pheochromocytoma.

Diabetes Caused by Medications or Chemicals

A number of medications and chemicals can interfere with insulin secretion, leading to diabetes in people with insulin resistance. These medications and chemicals include pentamidine, nicotinic acid, glucocorticoids, thyroid hormone, phenytoin (Dilantin), and Vacor, a rat poison.

Diabetes Caused by Infections

Several infections are associated with the occurrence of diabetes, including congenital rubella, coxsackievirus B, cytomegalovirus, adenovirus, and mumps.

Rare Immune-mediated Types of Diabetes

Some immune-mediated disorders are associated with diabetes. About one-third of people with stiff-man syndrome develop diabetes. In other autoimmune diseases, such as systemic lupus erythematosus, patients may have anti-insulin receptor antibodies that cause diabetes by interfering with the binding of insulin to body tissues.

Other Genetic Syndromes Sometimes Associated with Diabetes

Many genetic syndromes are associated with diabetes. These conditions include Down syndrome, Klinefelter's syndrome, Huntington's chorea, porphyria, Prader-Willi syndrome, and diabetes insipidus.

How is diabetes diagnosed?

The fasting blood glucose test is the preferred test for diagnosing diabetes in children and nonpregnant adults. The test is most reliable when done in the morning. However, a diagnosis of diabetes can be made based on any of the following test results, confirmed by retesting on a different day:

- A blood glucose level of 126 milligrams per deciliter (mg/dL) or higher after an 8-hour fast. This test is called the fasting blood glucose test.
- A blood glucose level of 200 mg/dL or higher 2 hours after drinking a beverage containing 75 grams of glucose dissolved in water. This test is called the oral glucose tolerance test (OGTT).
- A random—taken at any time of day—blood glucose level of 200 mg/dL or higher, along with the presence of diabetes symptoms.

Gestational diabetes is diagnosed based on blood glucose levels measured during the OGTT. Glucose levels are normally lower during pregnancy, so the cutoff levels for diagnosis of diabetes in pregnancy are lower. Blood glucose levels are measured before a woman drinks a beverage containing glucose. Then levels are checked 1, 2, and 3 hours afterward. If a woman has two blood glucose levels meeting or exceeding any of the following numbers, she has gestational diabetes: a fasting blood glucose level of 95 mg/dL, a 1-hour level of 180 mg/dL, a 2-hour level of 155 mg/dL, or a 3-hour level of 140 mg/dL.

What is prediabetes?

People with prediabetes have blood glucose levels that are higher than normal but not high enough for a diagnosis of diabetes. This condition raises the risk of developing type 2 diabetes, heart disease, and stroke.

Prediabetes is also called impaired fasting glucose (IFG) or impaired glucose tolerance (IGT), depending on the test used to diagnose it. Some people have both IFG and IGT.

- IFG is a condition in which the blood glucose level is high—100 to 125 mg/dL—after an overnight fast, but is not high enough to be classified as diabetes. The former definition of IFG was 110 mg/dL to 125 mg/dL.
- IGT is a condition in which the blood glucose level is high—140 to 199 mg/dL—after a 2-hour OGTT, but is not high enough to be classified as diabetes.

Prediabetes is becoming more common in the United States. The U.S. Department of Health and Human Services estimates that at least 57 million U.S. adults ages 20 or older had prediabetes in 2007. Those with prediabetes are likely to develop type 2 diabetes within 10 years, unless they take steps to prevent or delay diabetes.

The good news is that people with prediabetes can do a lot to prevent or delay diabetes. Studies have clearly shown that people can lower their risk of developing diabetes by losing 5 to 7 percent of their body weight through diet and increased physical activity.

A major study of more than 3,000 people with IGT found that diet and exercise resulting in a 5 to 7 percent weight loss—about 10 to 14 pounds in a person who weighs 200 pounds—lowered the incidence of type 2 diabetes by nearly 60 percent. Study participants lost weight by cutting fat and calories in their diet and by exercising—most chose walking—at least 30 minutes a day, 5 days a week.

What are the scope and impact of diabetes?

Diabetes is widely recognized as one of the leading causes of death and disability in the United States. In 2006, it was the seventh leading cause of death. However, diabetes is likely to be underreported as the underlying cause of death on death certificates. In 2004, among people ages 65 years or older, heart disease was noted on 68 percent of diabetes-related death certificates; stroke was noted on 16 percent of diabetes-related death certificates for the same age group.

Diabetes is associated with long-term complications that affect almost every part of the body. The disease often leads to blindness, heart and blood vessel disease, stroke, kidney failure, amputations, and nerve damage. Uncontrolled diabetes can complicate pregnancy, and birth defects are more common in babies born to women with diabetes.

In 2007, diabetes cost the United States \$174 billion. Indirect costs, including disability payments, time lost from work, and reduced productivity, totaled \$58 billion. Direct medical costs for diabetes care, including hospitalizations, medical care, and treatment supplies, totaled \$116 billion.

Who gets diabetes?

Diabetes is not contagious. People cannot “catch” it from each other. However, certain factors can increase the risk of developing diabetes.

Type 1 diabetes occurs equally among males and females but is more common in whites than in nonwhites. Data from the World Health Organization’s Multinational Project for Childhood Diabetes indicate that type 1 diabetes is rare in most African, American Indian, and Asian populations. However, some northern European countries, including Finland and Sweden, have high rates of type 1 diabetes. The reasons for these differences are unknown. Type 1 diabetes develops most often in children but can occur at any age.

Type 2 diabetes is more common in older people, especially in people who are overweight, and occurs more often in African Americans, American Indians, some Asian Americans, Native Hawaiians and other Pacific Islander Americans, and Hispanics/Latinos. National survey data in 2007 indicate a range in the prevalence of diagnosed and undiagnosed diabetes in various populations ages 20 years or older:

- **Age 20 years or older:** 23.5 million, or 10.7 percent, of all people in this age group have diabetes.
- **Age 60 years or older:** 12.2 million, or 23.1 percent, of all people in this age group have diabetes.
- **Men:** 12.0 million, or 11.2 percent, of all men ages 20 years or older have diabetes.
- **Women:** 11.5 million, or 10.2 percent, of all women ages 20 years or older have diabetes.

- **Non-Hispanic whites:** 14.9 million, or 9.8 percent, of all non-Hispanic whites ages 20 years or older have diabetes.
- **Non-Hispanic blacks:** 3.7 million, or 14.7 percent, of all non-Hispanic blacks ages 20 years or older have diabetes.

Diabetes prevalence in the United States is likely to increase for several reasons. First, a large segment of the population is aging. Also, Hispanics/Latinos and other minority groups at increased risk make up the fastest-growing segment of the U.S. population. Finally, Americans are increasingly overweight and sedentary. According to recent estimates from the CDC, diabetes will affect one in three people born in 2000 in the United States. The CDC also projects that the prevalence of diagnosed diabetes in the United States will increase 165 percent by 2050.

How is diabetes managed?

Before the discovery of insulin in 1921, everyone with type 1 diabetes died within a few years after diagnosis. Although insulin is not considered a cure, its discovery was the first major breakthrough in diabetes treatment.

Today, healthy eating, physical activity, and taking insulin are the basic therapies for type 1 diabetes. The amount of insulin must be balanced with food intake and daily activities. Doctors may also prescribe another type of injectable medicine. Blood glucose levels must be closely monitored through frequent blood glucose checking. People with diabetes also monitor blood glucose levels several times a year with a laboratory

test called the A1C. Results of the A1C test reflect average blood glucose over a 2- to 3-month period.

Healthy eating, physical activity, and blood glucose testing are the basic management tools for type 2 diabetes. In addition, many people with type 2 diabetes require one or more diabetes medicines—pills, insulin, and other injectable medicine—to control their blood glucose levels.

Adults with diabetes are at high risk for cardiovascular disease (CVD). In fact, at least 65 percent of those with diabetes die from heart disease or stroke. Managing diabetes is more than keeping blood glucose levels under control—it is also important to manage blood pressure and cholesterol levels through healthy eating, physical activity, and the use of medications, if needed. By doing so, those with diabetes can lower their risk. Aspirin therapy, if recommended by a person's health care team, and smoking cessation can also help lower risk.

People with diabetes must take responsibility for their day-to-day care. Much of the daily care involves keeping blood glucose levels from going too low or too high. When blood glucose levels drop too low—a condition known as hypoglycemia—a person can become nervous, shaky, and confused. Judgment can be impaired, and if blood glucose falls too low, fainting can occur.

A person can also become ill if blood glucose levels rise too high.

People with diabetes should see a health care provider who will help them learn to manage their diabetes and who will monitor their diabetes control. Most

people with diabetes get care from primary care physicians—internists, family practice doctors, or pediatricians. Often, having a team of providers can improve diabetes care. A team can include

- a primary care provider such as an internist, a family practice doctor, or a pediatrician
- an endocrinologist—a specialist in diabetes care
- a dietitian, a nurse, and other health care providers who are certified diabetes educators—experts in providing information about managing diabetes
- a podiatrist—for foot care
- an ophthalmologist or an optometrist—for eye care

The team can also include other health care providers, such as cardiologists and other specialists. The team for a pregnant woman with type 1, type 2, or gestational diabetes should include an obstetrician who specializes in caring for women with diabetes. The team can also include a pediatrician or a neonatologist with experience taking care of babies born to women with diabetes.

The goal of diabetes management is to keep levels of blood glucose, blood pressure, and cholesterol as close to the normal range as safely possible. A major study, the Diabetes Control and Complications Trial (DCCT), sponsored by the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), showed that keeping blood glucose levels close to normal reduces the risk of developing major complications of type 1 diabetes.

This 10-year study, completed in 1993, included 1,441 people with type 1 diabetes. The study compared the effect of two treatment approaches—intensive management and standard management—on the development and progression of eye, kidney, nerve, and cardiovascular complications of diabetes. Intensive treatment aimed to keep A1C levels as close to normal—6 percent—as possible. Researchers found that study participants who maintained lower levels of blood glucose through intensive management had significantly lower rates of these complications. More recently, a follow-up study of DCCT participants showed that the ability of intensive control to lower the complications of diabetes has persisted more than 10 years after the trial ended.

The United Kingdom Prospective Diabetes Study, a European study completed in 1998, showed that intensive control of blood glucose and blood pressure reduced the risk of blindness, kidney disease, stroke, and heart attack in people with type 2 diabetes.

Hope through Research

The NIDDK conducts research in its own laboratories and supports a great deal of basic and clinical research in medical centers and hospitals throughout the United States. It also gathers and analyzes statistics about diabetes. Other Institutes at the NIH conduct and support research on diabetes-related eye diseases, heart and vascular complications, autoimmunity, pregnancy, and dental problems.

Other Government agencies that sponsor diabetes programs are the CDC, the Indian Health Service, the Health Resources and Services Administration, the Department of Veterans Affairs, and the Department of Defense.

Many organizations outside the Government support diabetes research and education activities. These organizations include the American Diabetes Association (ADA), the Juvenile Diabetes Research Foundation International (JDRF), and the American Association of Diabetes Educators.

In recent years, advances in diabetes research have led to better ways of managing diabetes and treating its complications. Major advances include

- development of quick-acting and long-acting insulins
 - better ways to monitor blood glucose and for people with diabetes to check their blood glucose levels
 - development of external insulin pumps that deliver insulin, replacing daily injections
 - laser treatment for diabetic eye disease, reducing the risk of blindness
 - successful kidney and pancreas transplantation in people whose kidneys fail because of diabetes
 - better ways of managing diabetes in pregnant women, improving their chances of a successful outcome
 - new drugs to treat type 1 and type 2 diabetes and better ways to manage these forms of diabetes through weight control
 - evidence that intensive management of blood glucose reduces and may prevent development of diabetes complications
- demonstration that two types of antihypertensive drugs, angiotensin-converting enzyme (ACE) inhibitors and angiotensin receptor blockers (ARBs), are more effective than other antihypertensive drugs in reducing a decline in kidney function in people with diabetes
 - advances in transplantation of islets—clusters of cells that produce insulin and other hormones—for type 1 diabetes
 - evidence that people at high risk for type 2 diabetes can lower their chances of developing the disease through diet, weight loss, and physical activity

What will the future bring?

Researchers continue to look for the cause or causes of diabetes and ways to manage, prevent, or cure the disorder. Scientists are searching for genes that may be involved in type 1 or type 2 diabetes. Some genetic markers for type 1 diabetes have been identified, and it is now possible to screen relatives of people with type 1 diabetes to determine whether they are at risk.

Type 1 Diabetes

A number of federally funded research studies and clinical trials are under way. Studies focus on the prevention and causes of type 1 diabetes as well as experimental treatments such as islet transplantation.

Diabetes Prevention Trial–Type 1 (DPT–1)

The NIDDK and other groups sponsored DPT–1, which showed that people at risk for developing type 1 diabetes can be identified. The DPT–1 researchers discovered ways to

identify two populations at risk of developing type 1 diabetes within 5 years—those at high risk, with at least a 50 percent chance, and those at intermediate risk, with a 25 to 50 percent risk. Then researchers explored possible ways of preventing type 1 diabetes in both groups. Although the study found that neither low-dose insulin injections nor insulin capsules taken orally prevented or delayed type 1 diabetes in the study population, research that follows up on DPT-1 findings is under way. For more information about DPT-1, see www.niddk.nih.gov/patient/dpt_1/dpt_1.htm.

The Environmental Determinants of Diabetes in the Young (TEDDY) Consortium

The main mission of the TEDDY consortium, an international group of clinical centers, is to identify infectious agents, dietary factors, or other environmental factors—including psychosocial events—that trigger type 1 diabetes in those who are genetically susceptible. In addition, the consortium aims to

- create a central repository of data and biological samples for use by researchers
- develop novel approaches to finding the causes of type 1 diabetes
- find ways to understand how the disease starts and progresses
- discover new methods to prevent, delay, and reverse type 1 diabetes

TEDDY is funded by the NIDDK, the National Institute of Allergy and Infectious Diseases (NIAID), the National Institute of Child Health and Human Development (NICHD), the National Institute of Environmental Health Sciences, the CDC, the

JDRF, and the ADA. For more information, see <http://teddy.epi.usf.edu>.

Type 1 Diabetes Genetics Consortium (T1DGC)

The T1DGC is a group of researchers from around the world who are studying the genetics of type 1 diabetes. They are studying families with siblings who have type 1 diabetes to look for genes that may show a person's risk of getting type 1 diabetes or might keep someone from getting type 1 diabetes. For more information, see www.t1dgc.org.

Type 1 Diabetes TrialNet

Type 1 Diabetes TrialNet is a network of experts and facilities dedicated to developing new approaches to the understanding, prevention, and treatment of type 1 diabetes. Clinical centers are located in the United States, Canada, Europe, and Australia.

TrialNet studies are focusing on

- understanding the natural history of type 1 diabetes to determine its causes and progression
- preventing type 1 diabetes in those at risk
- developing ways to preserve the function of the insulin-producing cells in the pancreas in people recently diagnosed with type 1 diabetes

For more information, see www.DiabetesTrialNet.org or call 1-800-HALT-DM1 (1-800-425-8361).

TrialNet will identify people at risk who may be eligible for clinical trials. In addition, TrialNet will conduct trials to save beta cell function in those with new onset type 1 diabetes.

TrialNet is funded by the NIDDK, NICHD, and NIAID. The JDRF and ADA also support this effort.

The Immune Tolerance Network

TrialNet works closely with the Immune Tolerance Network, another international, collaborative consortium. Its goal is to find safe and effective ways to induce long-term immune tolerance—prevention of an unwanted immune response by the body. For example, type 1 diabetes might be prevented if scientists could learn how to prevent the immune system from mistakenly attacking the insulin-producing cells in the pancreas. Effective immune tolerance could possibly

- prevent the body’s rejection of organ or tissue transplants
- prevent or treat autoimmune diseases
- prevent or treat allergies and asthma

For more information, see www.immunetolerance.org or call 415-514-2530.

The Trial to Reduce IDDM in the Genetically at Risk (TRIGR)

The TRIGR study will help determine whether delayed exposure to cow’s milk can prevent type 1 diabetes in infants at risk of developing the disease. Instead of receiving cow’s milk, infants in the TRIGR study will primarily breastfeed. Babies whose mothers cannot breastfeed will be given a special formula made with milk proteins that may be easier for babies to tolerate. The TRIGR study will help clarify whether infant feeding practices are related to the development of diabetes. For more information, see www.trignorthamerica.org or call 1-888-STOP-T1D (1-888-786-7813).

Islet Transplantation

Researchers are working on a way for people with type 1 diabetes to live without daily insulin injections. In an experimental procedure called islet transplantation, islets are taken from a donor pancreas and transferred into a person with type 1 diabetes. Once implanted, the beta cells in these islets begin to make and release insulin.

Although scientists have made many advances in islet transplantation in recent years, transplanted islets tend to lose function over time, and few transplant recipients are able to stop using insulin for very long. But even partial islet function can help patients reduce their need for insulin, achieve better glucose stability, and reduce problems with hypoglycemia.

Problems with islet transplantation include the severe shortage of islets available for transplants and the need for patients to take drugs with significant side effects to stop the immune system from rejecting the transplanted islets. Researchers are seeking solutions to these problems.

For more information about islet transplantation, see the fact sheet *Pancreatic Islet Transplantation* at www.diabetes.niddk.nih.gov/dm/pubs/pancreaticislet.

Type 2 Diabetes

Diabetes Prevention Program

In 1996, the NIDDK launched its Diabetes Prevention Program (DPP). The goal of this research effort was to learn how to prevent or delay type 2 diabetes in people with impaired glucose tolerance, a strong risk factor for type 2 diabetes.

The findings of the DPP, released in August 2001, showed that people at high risk for type 2 diabetes could sharply lower their chances of developing the disorder through

diet and exercise. In addition, treatment with the oral diabetes drug metformin also reduced diabetes risk, though less dramatically. Metformin lowers the amount of glucose released by the liver and also fights insulin resistance, a condition in which the body doesn't use insulin properly.

Participants randomly assigned to intensive lifestyle intervention reduced their risk of getting type 2 diabetes by 58 percent. On average, this group maintained their physical activity at 30 minutes per day, usually with walking or other moderate intensity exercise, and lost 5 to 7 percent of their body weight. Participants randomized to treatment with metformin reduced their risk of getting type 2 diabetes by 31 percent.

Of the 3,234 participants enrolled in the DPP, 45 percent were from minority groups that suffer disproportionately from type 2 diabetes: African Americans, Hispanics/Latinos, Asian Americans and Pacific Islanders, and American Indians. The DPP also recruited other groups known to be at higher risk for type 2 diabetes, including individuals ages 60 or older, women with a history of gestational diabetes, and people with a first-degree relative with type 2 diabetes.

Participants are still being followed to check for long-term effects of the interventions, including the effects on CVD. Recent analyses of data from the DPP have added to the evidence that lifestyle changes are especially effective in helping to reduce the risk of developing conditions associated with type 2 diabetes, including high blood pressure and the metabolic syndrome. Researchers also confirmed that study participants carrying two copies of a gene variant that significantly increased their risk of developing diabetes benefited from lifestyle changes as much as or more than those without the gene variant.

Type 2 Diabetes in Children and Teens

Two studies focusing on type 2 diabetes in children and teens are under way. The Treatment Options for type 2 Diabetes in Adolescents and Youth (TODAY) study, a 13-site study sponsored by the NIDDK, will compare treatments for type 2 diabetes in children and teens. Participants will undergo one of three treatments:

- taking one diabetes medication—metformin
- taking two diabetes medications—metformin and rosiglitazone, another medication that fights insulin resistance
- taking metformin and participating in an intensive lifestyle change program designed to promote weight loss by cutting calories and increasing physical activity

The main goal of the study is to determine how well each type of treatment controls blood glucose levels. The study also will evaluate how long each type of treatment is effective.

Current NIDDK-sponsored research includes the HEALTHY study, which is part of a broad research initiative called STOPP T2D (Studies to Treat or Prevent Pediatric Type 2 Diabetes). The study explores whether improving nutrition, promoting physical activity, and making changes in behavior can lower risk factors for type 2 diabetes in children from 42 middle schools across the country. Participating schools are randomly assigned to a program group, which implements the changes, or to a comparison group, which continues to offer food choices and physical education programs typically found in middle schools

across the country. Students in the program group will have healthier choices available in the cafeteria and vending machines; longer, more intense periods of physical activity; and activities and awareness campaigns that promote long-term healthy behaviors. Results from the HEALTHY study are expected in 2009.

Preventing and Treating CVD in People with Type 2 Diabetes

CVD is the main killer of people with type 2 diabetes. For this reason, the NIH is studying the best strategies to prevent and treat CVD in people with diabetes in three major studies. These studies are all joint efforts of the NIDDK and the National Heart, Lung, and Blood Institute (NHLBI).

The Look AHEAD (Action for Health in Diabetes) trial is the largest clinical trial to date to examine the long-term health effects of voluntary weight loss. This multicenter, randomized clinical trial is studying the effects of a lifestyle intervention designed to achieve and maintain weight loss over the long-term through decreased caloric intake and increased exercise. Look AHEAD will focus on the disorder most associated with being overweight or obese, type 2 diabetes, and on the outcome that causes the greatest morbidity and mortality in people with type 2 diabetes, CVD. Results after 1 year of the study show that people receiving the lifestyle intervention lost an average of 8.6 percent of their initial body weight. In addition, they showed improved control of diabetes as well as improvements in cardiovascular risk factors, such as high blood pressure and blood fat levels.

The Action to Control Cardiovascular Risk in Diabetes (ACCORD) trial, a multicenter, randomized trial, is studying three approaches to preventing major cardiovascular events in individuals with type 2 diabetes. ACCORD was designed

to compare current practice guidelines with more intensive glycemic control in 10,000 individuals with type 2 diabetes, including those at especially high risk for cardiovascular events because of age, evidence of subclinical atherosclerosis, or existing clinical CVD. More intensive control of blood pressure than is called for in current guidelines and a medication to reduce triglyceride levels and raise HDL, or “good,” cholesterol levels will also be studied in subgroups of these 10,000 volunteers. Each treatment strategy will be accompanied by standard advice regarding lifestyle choices, including diet, physical activity, and smoking cessation, appropriate for individuals with diabetes.

The primary outcome to be measured is the first occurrence of a major cardiovascular event, specifically heart attack, stroke, or cardiovascular death. In addition, the study will investigate the impact of the treatment strategies on other cardiovascular outcomes; total mortality; limb amputation; eye, kidney, or nerve disease; health-related quality of life; and cost-effectiveness.

In February 2008, the NHLBI decided to stop one part of the study—the intensive glycemic control treatment—before the end of the entire trial because of safety concerns. However, the trial will continue with the other treatments until the planned end in 2009.

The Bypass Angioplasty Revascularization Investigation 2 Diabetes (BARI 2D) trial, a 5-year, multicenter clinical trial, is comparing medical versus early surgical management of patients with type 2 diabetes who also have coronary artery disease and stable angina or ischemia. At the same time, BARI 2D will study the effect of two different strategies to control blood glucose—providing insulin versus increasing the sensitivity of the body to insulin—on the risk of cardiovascular mortality and morbidity.

Participants in clinical trials can play a more active role in their own health care, gain access to new research treatments before they are widely available, and help others by contributing to medical research. For information about current studies, visit www.ClinicalTrials.gov.

Points to Remember

What is diabetes?

- a disorder of metabolism—the way the body uses or converts food for energy and growth

What are the main types of diabetes?

- type 1 diabetes
- type 2 diabetes
- gestational diabetes

What is the impact of diabetes?

- It affects 23.6 million people—7.8 percent of the U.S. population.
- It is a leading cause of death and disability.
- It costs \$174 billion per year.

Who gets diabetes?

- people of any age
- people with a family history of diabetes
- others at high risk for type 2 diabetes: older people, overweight and sedentary people, African Americans, Alaska Natives, American Indians, Asian Americans, Native Hawaiians, some Pacific Islander Americans, and Hispanics/Latinos

For More Information

To learn more about type 1, type 2, and gestational diabetes, as well as diabetes research, statistics, and education, contact

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You may also find additional information about this topic by visiting MedlinePlus at www.medlineplus.gov.

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