

Kaiser Permanente Research Brief

Diabetes

This brief summarizes the contributions of Kaiser Permanente Research on the topic of diabetes since 2007, including type 1, type 2, and gestational diabetes.

The Centers for Disease Control and Prevention estimates that 30.3 million people in the United States – more than 9% of the population – are living with diabetes, and an additional 34% of U.S. adults have prediabetes.¹ The prevalence of both diabetes (25%) and prediabetes (48%) is higher among adults age 65 or older than among those under age 65.

Diabetes is an active area of study for Kaiser Permanente Research. Scientists across the organization have used our rich, comprehensive, longitudinal data to advance understanding of risk, improving patient outcomes, and translating research findings into policy and practice. We have published more than 1,100 articles related to diabetes since 2007; together, they have been cited approximately 55,000 times.²

These articles are the product of observational studies, randomized controlled trials, meta-analyses, and other studies led by Kaiser Permanente scientists. The unique environment – which includes our fully integrated care and coverage model – in which our research scientists, clinicians, medical groups, and health plan leaders collaborate enables us to contribute generalizable knowledge on diabetes and many other topics of research.

Understanding Risk

Kaiser Permanente researchers have contributed to understanding the risk of developing diabetes, as well as the other risks that people with diabetes face.

Kaiser Permanente Publications Related to Diabetes since 2007



Source: Kaiser Permanente Publications Library and PLUM metrics, as of October 19, 2020.

a Number of citing journal articles, according to Scopus.

b Number of references in PubMed guidelines.

c Citations in DynaMed Plus, a point-of-care clinical reference tool.

This brief summarizes a selection of the publications contained within the Kaiser Permanente Publications Library, which indexes journal articles and other publications authored by individuals affiliated with Kaiser Permanente. The work described in this brief originated from across Kaiser Permanente's eight regions and was supported by a wide range of funding sources including internal research support as well as both governmental and non-governmental extramural funding.

Who is at risk for developing diabetes?

In adults, we have studied who is most at risk for developing type 2 diabetes. A selection of the risk factors for diabetes that Kaiser Permanente studies have assessed include obesity,^{3,4} fasting plasma glucose levels,⁵ levels of circulating acylcarnitine metabolites,⁶ use of antidepressant medications,^{7,8} and use of antihypertensive medication combination therapy.⁹ People whose spouses or partners are diagnosed with diabetes have been found to be at greater risk of diabetes themselves.¹⁰ Factors that reduce diabetes risk, such as weight loss,¹¹ dietary quality,¹² social support,¹³ and successful treatment of other health conditions,^{14,15} have also been the subject of Kaiser Permanente research.

Gestational diabetes is an important health concern for pregnant women. One Kaiser Permanente study using data from 1999 to 2005 reported a stable prevalence of gestational diabetes among our members, after adjusting for the increasing prevalence of preexisting diabetes.¹⁶ Factors that increase the risk of developing gestational diabetes¹⁷⁻²³ have been studied widely, as has risk of recurrence of gestational diabetes in subsequent pregnancies,²¹ and the risk of sustained glycose dysregulation after pregnancy among women with a history of gestational diabetes.²⁴⁻²⁸

Among youth, Kaiser Permanente researchers have found significant increases over time in both incidence and prevalence of type 1 and type 2 diabetes,^{29,30} with minorities impacted more heavily.^{31,32} A substantial volume of work has addressed diabetes risk factors among youth, including dietary, physical activity, and weight loss factors,³³⁻³⁷ as well as risks linked to maternal gestational diabetes status and other perinatal and neonatal factors.³⁸⁻⁴¹

What other health risks do people with diabetes face?

People with diabetes face added health risks, including risks related to the use of medications for treating diabetes. Kaiser Permanente research scientists have authored studies evaluating the risks of complications of diabetes (for

example, nephropathy, neuropathy, or retinopathy) and common comorbidities (for example, hypertension or arterial stiffness),⁴²⁻⁴⁷ the risk of developing various cancers,⁴⁸⁻⁵³ the risk of bone fractures,^{54,55} and other adverse outcomes.⁵⁶ In children with type 1 or type 2 diabetes, these complications and comorbidities often appear as early as adolescence and early adulthood, with a greater burden among those with type 2 diabetes.⁵⁷⁻⁵⁹ Studies have also demonstrated an increase in dementia risk for people with diabetes who have experienced hypoglycemic episodes, those with poor glucose control, and those with comorbid depression.⁶⁰⁻⁶⁴ Kaiser Permanente research has also investigated risks related to chronic conditions that are often comorbid with diabetes, such as pulmonary, kidney, and cardiovascular diseases.^{49,59,65-70}

Diabetes Remission for Patients With Type 2 Diabetes Who Received Bariatric Surgery Versus Non-Surgical Approaches

Severely Obese Adults With Diabetes

1,395
BARIATRIC SURGERIES

62,322
NON-SURGICAL APPROACHES

Diabetes Remission at 2 years

73.7%
95% CI: 70.7-76.5

6.9%
95% CI: 6.9-7.1

Hazard Ratios for Secondary Outcomes

Relapse
Lower for surgery group



0.19
95% CI: 0.15-0.23

Death
No difference between groups



0.54
95% CI: 0.22-1.30

Arterburn, D., et al., *Comparative effectiveness of bariatric surgery vs. nonsurgical treatment of type 2 diabetes among severely obese adults*. *Obes Res Clin Pract*, 2013. 7(4): p. e258-68

Bariatric surgery is an increasingly common risk-mitigation strategy for people with diabetes and obesity. Studies have shown that – particularly for people who are less severely obese – bariatric surgery can result in diabetes remission and a host of related benefits,⁷¹⁻⁷⁷ including improved life expectancy.^{78,79} Even for people who experience a relapse of diabetes after a period of remission, the remission has been linked to longer-term health benefits, such as reduced risk of microvascular complications of diabetes.⁷¹

Also important are the risks for babies born to women who experience gestational diabetes, as well as those with type 1 or type 2 diabetes. Among these risks are fetal and neonatal macrosomia,⁸⁰⁻⁸³ impaired glucose tolerance,⁸⁴ hypoglycemia,⁸³ hyperbilirubinemia,⁸³ childhood obesity,⁸⁵⁻⁸⁹ and development of autism^{90,91} and ADHD.⁹²

Improving Patient Outcomes

What strategies are effective in preventing diabetes?

For people at risk of type 2 diabetes, making a timely diagnosis of prediabetes creates an opportunity to encourage lifestyle changes that can reduce the risk of developing diabetes.^{93,94} Kaiser Permanente researchers have studied the performance of various approaches to detecting prediabetes,^{95,96} and the rate of progression from first-recorded impaired fasting glucose (an intermediate state of hyperglycemia that is abnormal but does not meet the threshold for diabetes diagnosis) to diabetes.⁹⁷

Approaches to prevention or risk reduction studied by Kaiser Permanente researchers include increasing knowledge about diabetes among youth,^{33,98} lifestyle interventions for high-risk adults;^{99,100} targeted interventions in spouses, partners, and other family members of patients with diabetes;¹⁰¹ and personalized genetic-risk counseling.¹⁰²

How does early identification of diabetes affect outcomes?

Early diagnosis of diabetes relies on screening of people at risk. Early recognition of type 1 and

type 2 diabetes can confer substantial treatment and outcome benefits. For example, people who are diagnosed early can enter treatment before consequences of uncontrolled diabetes occur, such as diabetic ketoacidosis.¹⁰³

What are the key factors in effective treatment of people with diabetes?

Glucose Control. For people with diabetes, glucose control – through self-management activities including lifestyle adaptations,¹⁰⁴ self-monitoring of blood-glucose, and medication adherence – is essential to effective treatment.^{105,106} Our research has emphasized the value of addressing food insecurity among patients with diabetes, as this has been linked to poor diabetes control and higher rates of hospitalizations and emergency room visits.¹⁰⁷ Diabetes-care guidelines suggest an escalating medication treatment strategy for people with type 2 diabetes based on glucose control and responsiveness to medications. However, medications are not always escalated as recommended, even when glycemic control is inadequate,¹⁰⁸⁻¹¹⁰ in part because of barriers to insulin initiation,^{111,112} medication costs,¹¹³ and the complexity of the medication regimen.^{114,115} Use of common glucose-lowering medications in the management of gestational diabetes is controversial, as their safety in pregnant women has not been clearly established,¹¹⁶ and the use of insulin during pregnancy is frequently a negative, anxiety-provoking experience.¹¹⁷ In young adults with childhood-onset diabetes, glucose control may be adversely affected during the transition between pediatric and adult primary care.¹¹⁸

For most adults with diabetes, the goal of treatment is to maintain a hemoglobin A1c (HbA1c) of less than 7%. Kaiser Permanente studies have compared the effectiveness of alternative insulin regimens¹¹⁹⁻¹²² and glucose control targets.¹²³ In particular, researchers have recently studied the appropriateness of low glycemic targets for older adults and concluded that relaxing glucose control targets (for example, up to HbA1c of 7.5%) for older adults can avoid hypoglycemic events and other adverse outcomes, with few negative consequences.¹²⁴⁻¹²⁶ More recent studies have suggested opportunities for reducing prescribing of higher-risk treatments in older

patients.^{127,128} Other work conducted by our scientists has found that glycemic control among Latino patients with limited English proficiency can be improved by matching them to bilingual primary care physicians.¹²⁹ Such real-world studies conducted within our large membership provide valuable insights that complement clinical trials,¹³⁰ which frequently exclude older adults and people with comorbidities.

Complications of Diabetes. Appropriate screening for serious complications of diabetes is an essential component of effective treatment. Recommended processes of care include eye exams, foot exams, and influenza immunizations. Kaiser Permanente studies have shown that documentation of these care processes is incomplete in administrative claims data,¹³¹ and also have measured the impact of insurance continuity or coverage type on receiving recommended preventive care.^{132,133} Even among insured people, gaps in recommended care processes are common for adults^{134,135} and youth.¹³⁶

Comorbid Conditions. People with diabetes and multiple comorbid conditions face added challenges and risks. One of these is polypharmacy: the concurrent use of multiple prescription medications. Kaiser Permanente research has demonstrated that medication burden increases substantially for adult patients newly diagnosed with diabetes.¹³⁷ Polypharmacy is linked with decreased medication adherence¹³⁸ and increased medication interactions.¹³⁹ Furthermore, polypharmacy has been associated with patient falls in adults with diabetes.¹⁴⁰

In addition, chronic and acute conditions can be more difficult to treat in the context of diabetes than for people without diabetes. For example, surgical care of patients with diabetes and surgical treatment of diabetic foot infections are complicated by microvascular diseases that inhibit wound healing.^{141,142} Studies have also demonstrated that people with comorbid diabetes and hypertension, hyperlipidemia, hyperglycemia, and chronic kidney disease often experience both treatment nonadherence and lack of appropriate treatment intensification for these comorbidities, leading to worse outcomes.¹⁴³⁻¹⁴⁶

Translating Research Findings Into Policy and Practice

How has Kaiser Permanente research contributed to changes in policy and practice?

Kaiser Permanente is a learning health care system that works to systematically use research to inform and improve practice both within Kaiser Permanente and more broadly.

Within Kaiser Permanente, research, clinical, and operational partners have tested a range of interventions to prevent diabetes or improve diabetes outcomes. These have included strategies such as education, wellness, and behavior change programs focused on exercise, diet, and medication adherence;¹⁴⁷⁻¹⁵² collaborative care programs for patients with diabetes and comorbid behavioral health problems;¹⁵³⁻¹⁵⁷ pharmacist-led diabetes management;¹⁵⁸ workplace screening and wellness programs;^{147,159} a virtual reading center for diabetic retinopathy screening;¹⁶⁰ mail-order pharmacy delivery for diabetes medications;^{161,162} and educational interventions specifically for women with gestational diabetes¹⁶³ and youth.⁹⁸ Within Kaiser Permanente, studies have also evaluated the role of electronic health records (and other data assets) in improving quality of diabetes care, identifying diabetes medication nonadherence, and recognizing prediabetes and other outcomes.¹⁶⁴⁻¹⁷⁶

Disease management programs, often offered by third-party vendors, are increasingly popular in the United States, and are widely used by state Medicaid programs and others. Our studies that assess online and telephonic disease management or coaching programs have found that they can be effective but are not uniformly so.^{148,177,178} Furthermore, these programs have been shown to face challenges related to low uptake among eligible individuals who might benefit¹⁷⁹ and suboptimal levels of engagement with the platform over time.¹⁸⁰ Researchers have also found that linking these efforts back to primary care is challenging, even in an integrated care setting with a mature electronic health record system.^{181,182}

Kaiser Permanente research contributes to policy and practice change within our delivery system, and has advanced the national knowledge of diabetes. To date, Kaiser Permanente authors have been cited nearly 450 times within recent consensus statements and clinical practice guidelines published by a wide range of entities, including the American Diabetes Association, American Heart Association, and the American Geriatrics Association, among others. In addition, Kaiser Permanente research and clinician scientists have directly contributed as authors of practice guidelines and systematic reviews. These include reviews published by the U.S. Preventive Services Task Force,¹⁸³ and the American Association of Clinical Endocrinologists and American College of Endocrinology's consensus statements on the type 2 diabetes management algorithm.¹⁸⁴⁻¹⁸⁶ Finally, our scientists have co-authored a report on research gaps in gestational diabetes for the National Institute of Diabetes and Digestive and Kidney Diseases.¹⁸⁷

Each of Kaiser Permanente's regional research centers participates in the Health Care Systems Research Network, a national research network that aims to improve individual and population health through research.¹⁸⁸ The SUPREME-DM study, focused on diabetes and led by a Kaiser Permanente researcher, is one of HCSRN's cornerstone projects. Kaiser Permanente researchers have led or collaborated on many notable studies and trials related to diabetes epidemiology, prevention, risk factors, and treatment.

Kaiser Permanente's nearly 170 research scientists and more than 1,600 support staff are based at 8 regional research centers and 1 national center. There are currently more than 2,400 studies underway, including clinical trials. Since 2007 our research scientists have published more than 12,000 articles in peer-reviewed journals. Kaiser Permanente currently serves more than 12.4 million members in 8 states and the District of Columbia.

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