Kaiser Permanente Research Brief

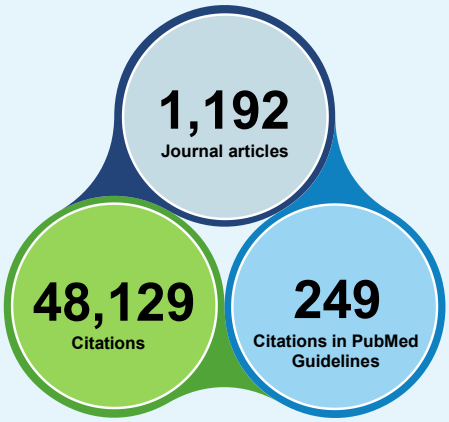
Diabetes

This brief summarizes the contributions of Kaiser Permanente Research since 2012 on the topic of diabetes, including type 1, type 2, and gestational diabetes.

The Centers for Disease Control and Prevention estimates that 38.4 million people in the United States — more than 11% of the population — are living with diabetes, and an additional 38% of U.S. adults have prediabetes. The prevalence of both diabetes (29%) and prediabetes (49%) is higher among adults age 65 or older than among those under age 65.[1]

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, improve patient outcomes, and translate research findings into policy and practice. We have published nearly 1,200 articles related to diabetes since 2012; together, they have been cited approximately 48,000 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 research topics.

Kaiser Permanente publications related to diabetes since 2012



Source: Kaiser Permanente Publications Library and Scite metrics, as of August 20, 2024.

Understanding risk

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; 6] levels of circulating acylcarnitine metabolites,[7] genetic factors,[8; 9] use of antidepressant medications,[10] and use of antihypertensive medication combination therapy.[11] Recent work has also suggested that COVID-19 infection and breast cancer may be associated with an elevated risk of diabetes.[12-14] People whose spouses or partners are diagnosed with diabetes have been found to be at greater risk of diabetes themselves.[15] Factors that reduce diabetes risk, such as weight loss,[16] dietary quality,[17; 18] social support,[19] and successful treatment of other health conditions,[20; 21] have also been the subject of Kaiser Permanente research.

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 8 regions and was supported by a wide range of funding sources including internal research support as well as both governmental and nongovernmental extramural funding.

Gestational diabetes is an important health concern for pregnant women. Factors that increase the risk of developing gestational diabetes[22-27] have been studied widely, as has the risk of recurrence of gestational diabetes in subsequent pregnancies,[28] and the risk of sustained glucose dysregulation and type 2 diabetes after pregnancy among women with a history of gestational diabetes.[29-32]

Among youth, Kaiser Permanente researchers have found significant increases over time in both incidence and prevalence of type 1 and type 2 diabetes,[33-37] with people of color impacted more heavily.[38; 39] A substantial volume of work has addressed diabetes risk factors among youth, including dietary, physical activity, weight loss factors,[40-45] and perceived stigma of having diabetes,[46] as well as risks linked to maternal gestational diabetes status and other perinatal and neonatal factors.[47; 48]

What other health risks do people with diabetes face?

People with diabetes face added health risks, including higher mortality[49; 50] and 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),[30; 51-56] the risk of developing various cancers,[57-59] risks of falls and bone fractures,[60-63] and other adverse outcomes.[61; 64] 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.[65-67] Studies have also demonstrated an increase in risks of cognitive decline and dementia for people with diabetes who have experienced hypoglycemic episodes, those with poor glucose control, and those with comorbid depression.[68-75] Kaiser Permanente research has also investigated risks related to chronic conditions that are often comorbid with diabetes, such as pulmonary, kidney, and cardiovascular diseases.[67; 76-79]

Diabetes remission for patients with type 2 diabetes who received bariatric surgery versus non-surgical approaches

Adults with severe obesity and diabetes

1,395	62,322
Bariatric surgeries	Non-surgical approaches

Diabetes in remission at 2 years

73.7%	6.9%
95% CI: 70.7-76.5	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,[80-93] including improved life expectancy.[94; 95] 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.[82]

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,[96; 97] impaired glucose tolerance,[98] hypoglycemia,[97] childhood obesity,[99-102] and development of autism[103; 104] and ADHD.[105]

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.[3; 106-108] Kaiser Permanente researchers have studied the performance of various approaches to detecting prediabetes[5; 107; 109] and the rate of progression from pre-diabetic states to diabetes.[3; 110]

Approaches to prevention or risk reduction studied by Kaiser Permanente researchers include increasing knowledge about diabetes among youth;[111] lifestyle interventions (including vitamin D supplementation) for high-risk adults;[112-116] peer support;[117] targeted interventions in spouses, partners, and other family members of patients with diabetes;[118] and personalized genetic-risk counseling.[119]

How does early identification of diabetes affect outcomes?

Early diagnosis of diabetes relies on screening of people at risk.[120] 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.[121-123]

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

Glucose Control. For people with diabetes, glucose control — through self-management activities including lifestyle adaptations,[124] self-monitoring of blood glucose,[125] and medication adherence — is essential to effective treatment.[126; 127] Our research has emphasized the value of addressing food insecurity and other unmet basic needs among patients with diabetes, as these needs have been linked to poor diabetes control, adverse outcomes, and higher rates of hospitalizations and emergency room visits.[128-133] Timely initiation of glucose-lowering pharmacotherapy is key, and Kaiser Permanente scientists have found racial disparities in rates of treatment initiation for patients with lower glycated hemoglobin, or HbA1c, values.[134] Our research also found evidence that disruptions in care during the COVID-19 pandemic had negative impacts on many aspects of diabetes management, including control of HbA1c.[135; 136] Diabetes care guidelines suggest an escalating medication treatment strategy for people with type 2 diabetes based on glucose control and responsiveness to medications.[137; 138] However, discontinuation of treatment is common,[139] and medications are not always escalated as recommended, even when glycemic control is inadequate,[140; 141] in part because of barriers to insulin initiation,[141-143] medication costs,[144] and the complexity of the medication regimen.[145; 146] As such, it is not unusual for patients with type 2 diabetes to experience extended periods of suboptimal glucose control.[147] 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,[148] and the use of insulin during pregnancy is frequently a negative, anxiety-provoking experience.[149] In young adults with earlier onset of diabetes, glucose control may be adversely affected by factors such as support from family members,[150] or the transition between pediatric and adult primary care.[151-153]

There are 3 components of effective blood glucose control for diabetes

- **Lifestyle management**
  - **Diet**
  - **Physical activity**

- **Self-monitoring of glucose levels**

- **Medication**
  - **Addressing adherence**
  - **Intensification if needed**

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 medication regimens[154-157] and glucose control targets. 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.[158; 159] Kaiser Permanente studies have suggested opportunities for reducing prescribing of higher-risk treatments in older patients.[160-162] Other work conducted by our scientists has found that glycemic control among Latino patients with limited English proficiency can be improved by matching them with bilingual primary care physicians.[163] Finally, our researchers have explored the efficacy of continuous glucose monitoring in insulin-treated patients with type 2 diabetes.[164; 165] Such real-world studies conducted within our large membership provide valuable insights that complement clinical trials, which frequently exclude older adults and people with comorbidities.

Screening for 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 measured the impact of insurance continuity or coverage type on receiving recommended preventive care.[166-168] Even among insured people, gaps in recommended care processes are common.[169; 170]

Managing Comorbid Conditions. People with diabetes and multiple comorbid conditions face added challenges and risks. One of these is polypharmacy, or the concurrent use of multiple prescription medications. Kaiser Permanente research has demonstrated that medication burden increases substantially for adult patients newly diagnosed with diabetes.[171] Polypharmacy is linked with decreased medication adherence.[172]

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.[173; 174] 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.[175-177]

Translating Research Findings Into Policy and Practice

Kaiser Permanente is a learning health care organization 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;[178-181] collaborative care programs for patients with diabetes and comorbid behavioral health problems;[182-186] pharmacist-led diabetes management;[187] workplace screening and wellness programs;[181; 188] a virtualized reading center for diabetic retinopathy screening;[189] mail-order pharmacy delivery for diabetes medications;[190; 191] and educational interventions specifically for women with gestational diabetes[192] and youth.[111] 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, recognizing prediabetes and other outcomes, including diabetes complications, and identifying diabetes patients with lower life expectancy.[109; 193-205]

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.[180; 206] Furthermore, these programs have been shown to face challenges related to low uptake among eligible individuals who might benefit.[207] 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.[208]

Kaiser Permanente research contributes to policy and practice change within our own care delivery model and has advanced the national knowledge of diabetes. To date, Kaiser Permanente authors have been cited nearly 250 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[209-211] and the Precision Medicine in Diabetes Initiative,[212] and the American Association of Clinical Endocrinologists and American College of Endocrinology's consensus statements on the type 2 diabetes management algorithm.[213-216] 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.[217]

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.[218] 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. Our researchers are part of a team recently awarded a $5.6 million grant by the Patient-Centered Outcomes Research Institute, studying the cardiovascular health effects of second-line medications for type 2 diabetes,[219] as well as the Hyperglycemia and Adverse Pregnancy Outcome – Cardiovascular Health (HAPO-CVH) study, which will investigate the cardiovascular wellness of children born to mothers who experienced gestational diabetes during the original HAPO study. Kaiser Permanente scientists are also part of the Assessing the Burden of Diabetes by Type in Children, Adolescents, and Young Adults (DiCAYA) Network, a CDC-sponsored project aimed at increasing the effectiveness of diabetes surveillance using electronic health records.[220; 221]

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