

Screening Adults for Type 2 Diabetes: A Review of the Evidence for the U.S. Preventive Services Task Force

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Background: Type 2 diabetes mellitus is associated with a heavy burden of suffering. Screening for diabetes is controversial.

Purpose: To examine the evidence that screening and earlier treatment are effective in reducing morbidity and mortality associated with diabetes.

Data Sources: MEDLINE, the Cochrane Library, reviews, and experts, all of which addressed key questions about screening.

Study Selection: Studies that provided information about the existence and length of an asymptomatic phase of diabetes; studies that addressed the accuracy and reliability of screening tests; and randomized, controlled trials with health outcomes for various treatment strategies were selected.

Data Extraction: Two reviewers abstracted relevant information using standardized abstraction forms and graded articles according to U.S. Preventive Services Task Force criteria.

Data Synthesis: No randomized, controlled trial of screening for diabetes has been performed. Type 2 diabetes mellitus includes an

asymptomatic preclinical phase; the length of this phase is unknown. Screening tests can detect diabetes in its preclinical phase. Over the 10 to 15 years after clinical diagnosis, tight glycemic control probably reduces the risk for blindness and end-stage renal disease, and aggressive control of hypertension, lipid therapy, and aspirin use reduce cardiovascular events. The magnitude of the benefit is larger for cardiovascular risk reduction than for tight glycemic control. The additional benefit of starting these treatments in the preclinical phase, after detection by screening, is uncertain but is probably also greater for cardiovascular risk reduction.

Conclusions: The interventions that are most clearly beneficial during the preclinical phase are those that affect the risk for cardiovascular disease. The magnitude of additional benefit of initiating tight glycemic control during the preclinical phase is uncertain but probably small.

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The prevalence of type 2 diabetes mellitus (diabetes) in the United States is growing (1, 2); the burden of suffering caused by its complications is heavy (3) and may also be growing. These complications include increased risk for cardiovascular disease (CVD) (4), end-stage renal disease (ESRD) (5, 6), blindness (7), and amputation of the lower extremities (8, 9). The magnitude of the risk for these complications varies among persons with a new clinical diagnosis of diabetes. After 10 years, more than 20% of such persons will have had a major cardiovascular event (for example, myocardial infarction [MI], stroke, heart failure, or sudden death), fewer than 5% will have developed blindness, and fewer than 2% will have developed ESRD or had lower-extremity amputation (10).

Three general approaches to reducing the complications of diabetes are 1) preventing the occurrence of diabetes in the first place, 2) improving care for persons who have already received a diagnosis, and 3) screening asymptomatic persons for diabetes (11). By *asymptomatic*, we mean persons without both the direct symptoms of hyperglycemia (for example, polyuria) and the symptoms of associated conditions (for example, infections or angina pectoris). We distinguish between detection of diabetes due to the presence of these symptoms and detection of diabetes by screening, either systematic screening or the haphazard screening that occurs with frequent use of multichannel chemistry profiles. Our review focuses on the evidence for the effectiveness of systematic screening for diabetes as opposed to no screening.

Interest in screening has been prompted by research showing that approximately one third of persons who meet criteria for diabetes have not received a diabetes diagnosis (12). In 1996, the U.S. Preventive Services Task Force (USPSTF) found insufficient evidence to recommend for or against screening for diabetes (13). Since that USPSTF review, new evidence concerning the effectiveness of various treatments to prevent complications has fueled continued controversy about the effectiveness of screening (14–22). To assist the USPSTF in updating its recommendation, we performed a systematic review of the evidence concerning screening adults for diabetes.

METHODS

To guide our literature search, we used USPSTF methods to develop an analytic framework with linkages that represent five key questions in a logical chain between screening and health outcomes (23). We developed eligibility criteria for admissible evidence for each key question, focusing on screening strategies that are feasible in a primary care environment and on high-quality evidence about health outcomes (as contrasted with intermediate outcomes) of treatment for newly diagnosed diabetes.

We examined the critical literature from the 1996 USPSTF review and searched MEDLINE and the Cochrane Library for reviews and relevant studies published in English between 1 January 1994 and 30 July 2002. We also examined key articles published before 1994 and arti-

Table 1. Randomized, Controlled Trials of Tight Glycemic Control*

Study, Year (Reference)	Quality	Length of Study, y	Groups (Patients)	Glycemic Control	Renal Failure
UGDP, 1971 (48), 1978 (49)	Fair	8.75	Placebo (n = 204) Insulin variable (n = 198)	22.8% increase vs. 13.5% decrease†	NR
UKPDS 33, 1998 (10)	Good	10	Conventional therapy (n = 1138) Intensive therapy (n = 2729)	7.9% vs. 7.0%‡	<1% vs. <1% (P > 0.2)
UKPDS 34, 1998 (47)	Good	10.7	Conventional therapy, primarily diet (n = 411) Intensive therapy with metformin (n = 342)	8.0% vs. 7.4%‡	<1% vs. <1% (P > 0.2)
Kumamoto, 1995 (55), 2000 (51)	Fair	8	Conventional therapy (n = 50) Intensive therapy (n = 52)	9.4% vs. 7.1%‡	NR
VA CSDM, 1997 (52), 1996 (54), 1995 (56), 1999 (50), 2000 (57)	Fair	2.25	Standard therapy (n = 78) Intensive therapy (n = 75)	9.2% vs. 7.1%‡	NR
Steno 2, 1999 (53)	Fair	3.8	Standard therapy (n = 80) Intensive therapy (n = 80)	9.0% vs. 7.6%‡	0% vs. 0%

* CVD = cardiovascular disease; ECG = electrocardiographic; MI = myocardial infarction; NR = not reported; NS = nonsignificant; Steno = Steno type 2 randomized study; UGDP = University Group Diabetes Program; UKPDS = U.K. Prospective Diabetes Study; VA CSDM = VA Cooperative Study on Glycemic Control and Complications in Type 2 Diabetes.

† Change in fasting blood glucose from baseline.

‡ Median hemoglobin A_{1c} level.

cles found by examining the reference lists of pertinent reviews or suggested by experts.

The first author and at least one coauthor or trained assistant reviewed abstracts and articles to find those that met eligibility criteria (Appendix Table 1, available at www.annals.org). For included studies, two reviewers abstracted relevant information using standardized abstraction forms and graded the quality of the study according to USPSTF criteria (23). Important articles on which a recommendation could rest were examined and discussed by all authors. We distributed a draft systematic evidence review for external peer review, soliciting comments from experts, relevant professional organizations, and federal agencies, and made revisions based on feedback. A more complete account of the methods used in this review can be found in the Appendix (available at www.annals.org). The complete systematic evidence review is available on the Agency for Healthcare Research and Quality Web site (www.ahrq.gov) (24).

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RESULTS

For the USPSTF to conclude that screening reduces diabetic complications, the evidence must demonstrate that feasible screening tests can detect diabetes during a preclinical phase and that the knowledge of the diagnosis of diabetes in this phase will lead to earlier treatment that will reduce complications more than would treatment be-

gun after clinical detection. Furthermore, the magnitude of this “additional benefit” (that is, the reduction in complications from initiation of treatment in the preclinical phase minus the reduction in complications from starting treatment after clinical diagnosis) must be great enough to outweigh the harms and effort of screening.

Does Diabetes Have an Asymptomatic Preclinical Phase, and How Long Is It?

The natural history of diabetes includes an asymptomatic preclinical phase. Many people who meet criteria for diabetes have not received a diabetes diagnosis. In the third National Health and Nutrition Examination Study (NHANES III), conducted between 1988 and 1994, the prevalence of diagnosed diabetes among persons 20 years of age and older was 5.1%; the prevalence of previously undiagnosed diabetes was 2.7% (12). Rates of diagnosed diabetes for non-Hispanic black and Mexican-American persons were 1.6 and 1.9 times the rate for non-Hispanic white persons, and the rates of undiagnosed diabetes were similarly higher.

The length of this asymptomatic period is less clear. No study has compared a screened with a comparable un-screened sample to determine the difference in the time at which diabetes is diagnosed. One group used an indirect approach to calculate this interval. After making assumptions about the rate of development of diabetic retinopathy early in diabetes, Harris and colleagues (25, 26) estimated that the preclinical period lasted between 10 and 12 years. According to this calculation, screening a previously un-screened population would detect diabetes an average of 5 to 6 years before clinical diagnosis. Even if this estimate is accurate, however, it represents a mean value. Some people will have a longer and some a shorter asymptomatic period.

Table 1—Continued

Severe Visual Impairment	Myocardial Infarction	Stroke	Amputation	All-Cause Mortality
11.2% vs. 11.4% for acuity \leq 20/200 in either eye (NS)	20% vs. 17.6% for significant ECG abnormality (NS)	NR	1.5% vs. 1.6% (NS)	26.3% vs. 24.0% (NS)
11% vs. 11% for vision too poor to drive (NS)	16.3% vs. 14.2% ($P = 0.052$)	4.8% vs. 5.4% ($P > 0.2$)	1.6% vs. 1.0% ($P = 0.099$)	18.7% vs. 17.9% ($P > 0.2$)
3.2% vs. 3.5% for blindness in one eye ($P > 0.2$)	17.8% vs. 11.4% ($P = 0.001$)	5.6% vs. 3.5% ($P = 0.13$)	2.2% vs. 1.8% ($P > 0.2$)	21.7% vs. 14.6% ($P = 0.011$)
NR	1.3 events/100 person-years vs. 0.6 events/100 person-years for major CVD event (NS)			NR
9.0% vs. 6.7% for unilateral or bilateral visual impairment (NS)	5.1% vs. 6.7% (NS)	2.6% vs. 6.7% (NS)	0% vs. 1.3% (NS)	5.1% vs. 6.7% (NS)
9.0% vs. 1.3% for blindness in one eye ($P = 0.03$)	5.1% vs. 5.2% for nonfatal MI (NS)	10.2% vs. 1.3% for nonfatal stroke (NS)	5.1% vs. 5.2% (NS)	2.6% vs. 5.2% (NS)

The true mean length of this period and the distribution of its length are unknown.

How Accurate Are the Screening Tests?

Determining the accuracy of screening tests for diabetes is complicated by uncertainty about the most appropriate reference standard. Two standards of diagnosis are in general use: one based on the 2-hour postload plasma glucose test and the other based on the fasting plasma glucose (FPG) test (27–29). The standard cut-point for the 2-hour postload plasma glucose test is 11.1 mmol/L (200 mg/dL); the FPG cut-point is 7.0 mmol/L (126 mg/dL). Both tests require a second confirmation. Hemoglobin A_{1c}, using various cut-points, is a third test that has been proposed as a standard reference for diagnosing diabetes (30–32).

It is not clear which of these tests and cut-points most closely predict diabetic complications (33). The cut-point for the 2-hour postload plasma glucose test was based on a threshold that predicted retinopathy prevalence in several studies (27, 28). The FPG cut-point was chosen to correspond to that for the 2-hour postload plasma glucose test (27, 28). All three tests (2-hour postload plasma glucose, FPG, and hemoglobin A_{1c}) are associated with future cardiovascular events in a linear fashion both above and below the present diabetes cut-points, with no obvious threshold (34–39). However, experts have set the point at which hyperglycemia is termed diabetes without considering CVD prediction.

When a 2-hour postload glucose level of at least 11.1 mmol/L (\geq 200 mg/dL) is used as the reference standard, the specificity of an FPG level with a cut-point of 7.0 mmol/L (126 mg/dL) is greater than 95%; the sensitivity is about 50% and may be lower for persons older than 65 years of age (40). Among a general, previously nondiabetic sample of persons 40 to 74 years of age, a person with an

FPG level of 7.8 mmol/L or greater (\geq 140 mg/dL) has a 91% probability of having a 2-hour postload plasma glucose level at least 11.1 mmol/L (\geq 200 mg/dL). For an FPG level between 7.0 mmol/L (126 mg/dL) and 7.8 mmol/L (140 mg/dL), the probability is 47% (41). Hemoglobin A_{1c} level is more closely related to FPG than to 2-hour postload plasma glucose level (42), but it is not sensitive to low levels of hyperglycemia (30). Reliability is higher for FPG than for hemoglobin A_{1c} or 2-hour postload plasma glucose level (43–45). Although the reliability of the hemoglobin A_{1c} assay has been a concern, it is now not as grave a problem (43).

In clinical practice, requiring a screening test to be fasting (as with the FPG) or postload (as with the 2-hour plasma glucose test) presents logistical problems. In a recent study in primary care settings, random capillary blood glucose with a cut-point of 6.7 mmol/L (120 mg/dL) had a sensitivity of 75% and a specificity of 88% for detecting persons who have positive results on FPG assay or on 2-hour postload plasma glucose assay (46).

Does Earlier Knowledge of Diabetes after Screening Lead to Better Treatment and Improved Health Outcomes?

We examine here the extent to which earlier application of available treatments for diabetes would improve health outcomes.

Tight Glycemic Control

Five randomized, controlled trials (RCTs) have compared health outcomes in groups that differ with respect to glycemic control (10, 47–57) (Table 1). Four of these studies (48–56), although generally well conducted, were small and lacked power to detect clinically important differences between groups. The longest and largest study was

Table 2. Studies of Intensity of Treatment with Antihypertensive Medications*

Study, Year (Reference)	Quality	Population	Length of Study y	Patient Age	Groups (Patients)	Blood Pressure Control mm Hg
UKPDS 38, 1998 (60)	Fair	Patients with diabetes and hypertension	8.4	56–57	Less tight blood pressure control (n = 390) Tight blood pressure control (n = 758)	154/87 vs. 144/82
HOT, 1998 (59)	Fair	Diabetes subgroup	3.8	61.5	Target DBP ≤ 90 mm Hg (n = 501) Target DBP ≤ 85 mm Hg (n = 501) Target DBP ≥ 80 mm Hg (n = 499)	143.7/85.2 vs. 141.4/83.2 vs. 139.7/81.1
ABCD, 2000 (61)	Fair	Patients with hypertension and diabetes	5	57	Moderate blood pressure control (n = 233) Intensive blood pressure control (n = 237)	138/86 vs. 132/78
ABCD, 2002 (62)	Fair	Normotensive patients with diabetes	5.35	58–59	Moderate blood pressure control (n = 243) Intensive blood pressure control (n = 237)	137/81 vs. 128/75

* ABCD = Appropriate Blood Pressure Control in Diabetes; CVD = cardiovascular disease; DBP = diastolic blood pressure; ESRD = end-stage renal disease; HOT = Hypertension Optimal Treatment; NR = not reported; UKPDS = U.K. Prospective Diabetes Study.

the United Kingdom Prospective Diabetes Study (UKPDS), an RCT of 3867 people with newly diagnosed diabetes over 10 years (10). Because the UKPDS intervention was not blinded, outcomes that involve clinician judgment (such as whether to use retinal photocoagulation) could have been biased (58).

The primary UKPDS analysis found a nonsignificant trend (relative risk, 0.84 [95% CI, 0.71 to 1.0]) toward a reduction in MI for tight versus less tight glycemic control groups but no difference in any other cardiovascular outcome (10). The absolute difference in MI events was 2.1% over 10 years, entirely in nonfatal events. Three other studies found no statistically significant difference in cardiovascular outcomes from tight glycemic control (48, 49, 51, 52, 56). The most positive study, a UKPDS analysis, had puzzling results (47). It found that metformin reduced MI and all-cause mortality compared with conventional glycemic control (Table 1). Further analyses, however, showed that these benefits were out of proportion to the achieved glycemic control and disappeared when all patients taking metformin (including those who had metformin added to another treatment) were considered (47).

In three of the studies, tight glycemic control reduced the progression of albuminuria and retinopathy (10, 51, 57). Although this important finding in intermediate outcomes may herald future clinical benefits, few people in any group in these trials developed the clinical outcomes of ESRD or blindness (Table 1). One study of a multifactorial intervention that included more than tight glycemic control (53) found a statistically significant reduction in

severe visual impairment in the intervention group; in the other studies, groups did not differ in the development of severe visual impairment or ESRD.

Only two of these trials included persons with diabetes who had received recent diagnoses (10, 49); in neither study was diabetes detected primarily by screening. Thus, these studies provide information about the effect of tight glycemic control among persons whose diabetes has been detected clinically. Compared with tight glycemic control after clinical detection, the added benefit of earlier tight glycemic control after detection by screening (at a time when glycemic levels are often only slightly elevated) is unknown but probably small over at least 15 years after diagnosis.

Antihypertensive Treatment

Earlier knowledge of diabetes status could affect treatment for hypertension during the preclinical period by changing the intensity of treatment or the choice of antihypertensive drug. The optimal target blood pressure is lower for hypertensive patients with diabetes than for those without. The Hypertension Optimal Treatment (HOT) trial found that diabetic persons randomly assigned to a target diastolic blood pressure of 80 mm Hg had a reduction in CVD and all-cause mortality compared with diabetic persons in the group with a target of 90 mm Hg, but there were no differences among nondiabetic persons randomly assigned to the same blood pressure target groups (Table 2) (59). Three other randomized, controlled trials (one in normotensive diabetic persons) support the conclu-

Table 2—Continued

Myocardial Infarction	Stroke	Death from CVD Events	Non-CVD Outcomes
23.5 vs. 18.6 per 1000 person-years ($P = 0.13$)	11.6 vs. 6.5 per 1000 person-years ($P = 0.013$)	20.3 vs. 13.7 per 1000 person-years for diabetes-related death ($P = 0.019$)	2.3 vs. 1.4 per 1000 person-years for ESRD ($P > 0.2$) 19.4% vs. 10.2% for marked deterioration in vision ($P = 0.004$)
7.5 vs. 4.3 vs. 3.7 per 1000 person-years ($P = 0.11$)	9.1 vs. 7.0 vs. 6.4 per 1000 person-years ($P > 0.2$)	11.1 vs. 11.2 vs. 3.7 per 1000 person-years for CVD death ($P = 0.016$)	NR
No difference	No difference	10.7% vs. 5.5% for all-cause mortality ($P = 0.037$)	No difference in vision, ESRD, neuropathy
6.2% vs. 8.0% ($P > 0.2$)	5.4% vs. 1.7% ($P = 0.03$)	8.2% vs. 7.6% for all-cause mortality ($P > 0.2$)	No difference in creatinine clearance; vision not reported

sion that more intensive blood pressure control reduces stroke, diabetes-related death, and all-cause mortality in persons with diabetes (Table 2) (60–62).

These four RCTs were acceptable in quality. Although blinding caregivers and participants was difficult, end point assessment was blinded in all four trials. Four percent of participants or fewer were lost to follow-up for mortality end points. The trials used various antihypertensive drugs.

Ten RCTs and three meta-analyses have compared clinical outcomes among diabetic persons treated with various antihypertensive agents (62–76) (Tables 3 and 4). Two issues addressed by these studies are whether calcium antagonists provide less benefit to diabetic persons than to nondiabetic persons (and thus should be avoided) and whether agents that interrupt the renin–angiotensin system (for example, angiotensin-converting enzyme [ACE] inhibitors or angiotensin-receptor blocking [ARB] agents) provide greater benefit to diabetic than to nondiabetic persons (and thus should be prescribed).

The evidence concerning the effects of calcium antagonists among diabetic persons is mixed. Hypertensive persons taking calcium antagonists compared with those taking other drugs may have a somewhat increased risk for MI and congestive heart failure and a decreased risk for stroke; drug groups do not differ in all-cause mortality (Tables 3 and 4). Although these trends may be slightly more pronounced for diabetic persons, the effects of calcium antagonists are not qualitatively different between persons with and without diabetes (73).

Some evidence suggests that, compared with most

other antihypertensive drugs, ACE inhibitors or ARBs provide better protection against CVD events (more so for MI than for stroke) and renal disease, an effect that may be partly independent of blood pressure reduction. Five of six RCTs that have compared ACE inhibitors or ARBs with other agents in diabetic persons with hypertension have found a reduction in some CVD outcomes in the ACE inhibitor or ARB group, even after adjusting for differences in blood pressure (Table 3) (62–64, 66–68, 74–76). The Losartan Intervention for Endpoint reduction study, for example, found that, for diabetic patients with hypertension, the ARB losartan reduced all-cause mortality compared with the β -blocker atenolol, a result that was less certain for hypertensive patients without diabetes (75). Angiotensin-converting enzyme inhibitors or ARBs also reduce the development of diabetic nephropathy (77–82) and its progression to ESRD (71, 83, 84) more than most other antihypertensive agents.

One large study of hypertensive diabetic persons showed no benefit of an ACE inhibitor compared with a β -blocker for either CVD or renal outcomes (63); another study of normotensive diabetic persons found no difference in outcomes between treatment with an ACE inhibitor compared with a calcium antagonist (Table 3) (62). The discrepancy between these results and those of other studies has not been satisfactorily explained. The benefits of ACE inhibitors and ARBs over other antihypertensive drugs are also unclear for nondiabetic persons (68, 72, 74–76), especially those at lower CVD risk. A large meta-analysis of studies of predominantly nondiabetic persons

Table 3. Studies Comparing One Antihypertensive Drug with Another*

Study, Year (Reference)	Quality	Population	Length of Study	Patient Age	Groups (Patients)	Blood Pressure Control	Myocardial Infarction
				y		mm Hg	
UKPDS-39, 1998 (63)	Fair	Patients with diabetes	8.4	56	Captopril (n = 400) Atenolol (n = 358)	144/83 vs. 143/81	20.2 vs. 16.9 per 1000 person-years (P > 0.2)
CAPPP, 1999 (76), 2001 (68)	Fair	Diabetes subgroup	6.1	55–56	Captopril (n = 309) Conventional (n = 263)	155.5/89 vs. 153.5/88	3.9% vs. 10.3% (P = 0.002)
STOP-2, 2000 (66)	Fair	Diabetes subgroup	5.3	75–76	ACE inhibitors (n = 235) CA (n = 231) Conventional with diuretics and/or β-blockers (n = 253)	161.3/80.3 vs. 161.8/79.1 vs. 161.3/81.2	15.3 vs. 29.6 vs. 22.2 per 1000 person-years (P = 0.025)
ABCD, 1998 (64)	Fair	Patients with diabetes	5	57	Nisoldipine (n = 235) Enalapril (n = 235)	135/82 vs. 135/82	10.6% vs. 2.1% (P = 0.001)
FACET, 1998 (67)	Fair	Patients with diabetes	2.5	62–63	Fosinopril (n = 189) Amlodipine (n = 191)	157/88 vs. 153/86	1.8 vs. 2.4 per 100 person-years (P > 0.1)
NORDIL, 2000 (70)	Fair	Diabetes subgroup	4.5	60–61	Diltiazem (n = 351) Diuretics and/or β-blockers (n = 376)	152.2/87.6 vs. 149.1/87.4	11.2 vs. 11.1 per 1000 person-years (P > 0.2)
INSIGHT, 2000 (69)	Fair	Diabetes subgroup	4	65	Nifedipine (GITS) (n = 649) Co-amilofide (diuretic) (n = 653)	138/82 vs. 138/82	NR
Lewis et al., 2001 (71)	Good	Patients with diabetes	2.6	58–59	Irbesartan (n = 579) Amlodipine (n = 567) Placebo (n = 569)	140/77 vs. 141/77 vs. 144/80	NR
ABCD, 2002 (62)	Fair	Patients with diabetes	5.3	58–59	Nisoldipine (n = 234) Enalapril (n = 246)	132.1/78.0 vs. 132.4/78.0	7.7% vs. 6.5% (P > 0.2)
LIFE, 2002 (74, 75)	Good	Diabetes subgroup	4.7	67	Losartan (n = 586) Atenolol (n = 609)	146/79 vs. 148/79	7% vs. 8% (P > 0.2)

* ABCD = Appropriate Blood Pressure Control in Diabetes; ACE = angiotensin-converting enzyme; CA = calcium antagonist; CAPPP = Captopril Prevention Project; CV = cardiovascular; CVD = cardiovascular disease; ESRD = end-stage renal disease; FACET = Fosinopril versus Amlodipine Cardiovascular Events Randomized Trial; GITS = gastrointestinal-transport system; INSIGHT = Intervention as a Goal in Hypertension Treatment; LIFE = Losartan Intervention for Endpoint reduction in hypertension study; NORDIL = Nordic Diltiazem Study; NR = not reported; NS = nonsignificant; STOP-2 = Swedish Trial in Old Patients with Hypertension-2; UKPDS = U.K. Prospective Diabetes Study.

† Myocardial infarction, stroke, cardiovascular death, amputation, congestive heart failure.

‡ Doubling of creatinine concentration, ESRD, any death.

found that ACE inhibitors provided no CVD benefit over other types of drugs (mostly diuretics and β-blockers) in the treatment of hypertension (Table 4) (72) (see Addendum).

We should be cautious in drawing conclusions from these studies for several reasons. First, many trial participants required more than a single drug to attain their target blood pressures, making head-to-head comparisons of particular drugs difficult. Second, the meta-analyses grouped specific drugs within a class together. Drugs within a class, however, may have different effects. Third, the patients

studied in these trials differed in many respects, including age, presence of comorbid conditions, degree of hypertension, duration of diabetes, and presence of other cardiovascular risk factors. Nonetheless, the meta-analyses compared results across trials. Drug effects that vary by patient group make it more difficult to identify the effects of a single drug or drug class. Finally, although these trials are generally acceptable in quality, they vary in such important issues as blinding procedures and withdrawal rates (Table 3).

Thus, the current evidence favors the conclusion that diabetic patients benefit from more intensive blood pres-

Table 3—Continued

Stroke	CVD Events and Mortality	Non-CVD Outcomes	Adherence and Withdrawal	Blinding and Comments
6.8 vs. 6.1 per 1000 person-years ($P > 0.2$)	15.2 vs. 12.0 per 1000 person-years for diabetes-related death ($P > 0.2$)	No difference in vision, ESRD	22% vs. 35% for discontinuation of the study drug	Open-label; blinded outcome assessment
7.4% vs. 7.2% ($P > 0.2$)	6.5% vs. 12.9% for all-cause mortality ($P = 0.034$)	NR	One patient lost to follow-up; adherence to medications not reported	Open-label; blinded outcome assessment
31.6 vs. 26.9 vs. 34.7 per 1000 person-years ($P > 0.2$)	49.0 vs. 43.9 vs. 55.5 per 1000 person-years for all-cause mortality ($P = 0.20$)	NR	61.3% vs. 66.2% vs. 62.3% for taking study drug at study end; 0% withdrew	Open-label; blinded outcome assessment
4.7% vs. 3.0% (NS)	4.3% vs. 2.1% for CVD death (NS)	No difference in vision, ESRD	39.1% vs. 34.9% for discontinuation of the study drug	Double-blind; MI was a secondary end point; blinded outcome assessment
0.7 vs. 1.9 per 100 person-years ($P > 0.1$)	2.6 vs. 5.0 per 100 person-years for major CVD event ($P = 0.03$)	NR	19.0% vs. 27.2% for discontinuation of the study drug; 1% withdrew	Open-label; blinded outcome assessment
13.3 vs. 12.3 per 1000 person-years ($P > 0.2$)	29.8 vs. 27.7 per 1000 person-years for CVD events ($P > 0.2$)	NR	77% vs. 93% for taking study drug at study end; <1% withdrew	Open-label; blinded outcome assessment
NR	8.3% vs. 8.4% for CVD events (NS)	NR	33.1% vs. 39.9% for discontinuation of the study drug; 2.4% withdrew	Double-blind; blinded outcome assessment; randomization imbalance in diabetic subgroup
NR	23.8% vs. 22.6% vs. 25.3% for CV outcome† (NS)	32.6% vs. 41.1% ($P = 0.006$) vs. 39.0% for renal outcome ($P = 0.02$ for all)‡	<1% withdrew	Double-blind; blinded outcome assessment; randomized by central office
4.7% vs. 2.4% ($P = 0.18$)	8.1% vs. 7.7% for all-cause mortality ($P > 0.2$)	No differences in renal and visual outcomes	Participants were taking study drug approximately 70% of the time	Double-blind; placebo-controlled; blinded outcome assessment
9% vs. 11% ($P = 0.20$)	11% vs. 17% for all-cause mortality ($P = 0.002$)	NR	73% vs. 68% for taking study drug at study end	Double-blind; blinded outcome assessment

sure control than do nondiabetic persons. It remains uncertain whether diabetic patients should be treated with different antihypertensive medications than those given to nondiabetic persons. Although the studies reviewed included diabetic persons whose disease presumably had been detected clinically, CVD risk is still increased twofold or more among people with undiagnosed diabetes (34–39, 85). Direct evidence shows that among diabetic persons with this degree of risk, an aggressive approach is beneficial within a 5-year time frame, the estimated mean time before clinical diagnosis.

Treatment of Dyslipidemia and the Use of Aspirin

Although persons with diabetes do not have higher total cholesterol or low-density lipoprotein (LDL) cholesterol levels than similar nondiabetic persons, they have higher levels of triglycerides and lower levels of high-density lipoprotein (HDL) cholesterol (86). They may also have a tendency toward thrombosis (87, 88). Knowledge of diabetes during the preclinical period could influence treatment for coronary heart disease (CHD) risk by changing the use of aspirin or the intensity or type of treatment for dyslipidemia.

Table 4. Meta-Analyses of Comparisons of Antihypertensive Drugs*

Study, Year (Reference)	Quality	Population	Inclusion Criteria	Studies, n
Blood Pressure Trialists, 2000 (72)	Good	Patients with and without diabetes	Random assignment of patients between antihypertensive regimens; minimum of 1000 patient-years in each group; prespecified outcomes	8
Pahor et al., 2000 (73)	Good	Patients with and without diabetes	Studied patients with hypertension; compared CA with another drug; assessed CVD events; included 100 persons or more	9
Pahor et al., 2000 (65)	Good	Patients with diabetes only	RCT of ACE inhibitor vs. other drug for hypertensive patients with diabetics; 2-y follow-up; CVD outcomes	4 (ABCD, CAPPP, FACET, UKPDS) (heterogeneity)

* ABCD = Appropriate Blood Pressure Control in Diabetes; ACE = angiotensin-converting enzyme; CA = calcium antagonist; CAPPP = Captopril Prevention Project; CHD = coronary heart disease; CHF = congestive heart failure; CVD = cardiovascular disease; FACET = Fosinopril versus Amlodipine Cardiovascular Events Randomized Trial; MI = myocardial infarction; OR = odds ratio; RCT = randomized, controlled trial; RR = relative risk; UKPDS = U.K. Prospective Diabetes Study.

† Values <1.0 favor CAs.

‡ Values <1.0 favor ACE inhibitors.

Randomized, controlled trials of both primary and secondary prevention have shown that 3-hydroxy-3-methylglutaryl coenzyme A reductase inhibitors (statins) and fibric acid derivatives (fibrates) lower the risk for CHD events; relative risk reduction is similar (about 25% to 30%) in both diabetic persons and nondiabetic persons (89–101). Aspirin also effectively reduces CHD events in both diabetic persons and nondiabetic persons with a similar relative risk reduction (about 30%) (102–106).

To determine the value of knowing about diabetes status for lipid treatment, a study would ideally randomly assign both diabetic persons and nondiabetic persons without established vascular disease to groups that differed in target LDL cholesterol levels or class of drug. It could then be determined whether diabetic persons should be treated differently from other groups. No such trial has been completed.

Two other studies provide mixed evidence about this issue. A secondary analysis of two secondary prevention studies found that diabetic persons but not nondiabetic persons with LDL cholesterol levels below 3.2 mmol/L (<125 mg/dL) benefited from statin treatment (107). A recent large study of statin treatment that included diabetic persons without established vascular disease as well as nondiabetic persons with vascular disease found a similar relative risk reduction in CHD mortality for all groups, including those with initial levels of LDL cholesterol below 3.0 mmol/L (<116 mg/dL) (99). Thus, it is not clear whether clinicians should treat high levels of LDL cholesterol more aggressively in diabetic persons than in nondi-

abetic persons. Absolute benefit may be determined by overall CHD risk rather than diabetes status itself.

Furthermore, it is not certain whether the most effective target for diabetic persons is LDL cholesterol levels (which might lead to initial statin treatment) or HDL cholesterol levels (which might lead to initial fibrate treatment) and whether different strategies should be used in diabetic and nondiabetic persons. Expert groups recommend that lipid and aspirin treatment be based on CHD risk, for which diabetes status is an important determining factor (108). Thus, persons without previously diagnosed diabetes who would cross a threshold for initiation of aggressive treatment of lipids or use of aspirin in the presence of diabetes could potentially benefit from screening and earlier treatment.

The magnitude of added benefit from earlier detection of diabetes for treatment of lipids or the use of aspirin is uncertain. If one considers that undetected diabetes increases CHD risk by a factor of two or more and that aspirin and lipid treatment are clearly effective in reducing CHD events over 5 years, then the magnitude of this added benefit is potentially substantial.

Counseling for Diet, Physical Activity, and Smoking Cessation

For both diabetic persons and nondiabetic persons, dietary change, increased physical activity, and smoking cessation are important behavioral steps to reduce adverse health events. No study has found that counseling is more effective in changing long-term behavior for diabetic persons than for nondiabetic persons or that effective behav-

Table 4—Continued

Comparators			Comments
Calcium Antagonists	ACE Inhibitors	Calcium Antagonists	
RR vs. diuretics or β -blocker† CHD: 1.12 (1.00–1.26) Stroke: 0.87 (0.77–0.98) CHF: 1.12 (0.95–1.33) CVD events: 1.02 (0.95–1.10) Mortality: 1.01 (0.92–1.11)	No difference for any outcome vs. diuretics or β -blockers	RR vs. ACE inhibitor† CHD: 1.23 (1.03–1.47) Stroke: 0.98 (0.83–1.18) CHF: 1.22 (1.00–1.49) CVD events: 1.09 (0.99–1.20) Mortality: 0.97 (0.85–1.10)	Heterogeneity in trials comparing CAs and ACE inhibitors
OR vs. all other drugs, all participant† MI: 1.26 (1.11–1.43) Stroke: 0.90 (0.80–1.02) CHF: 1.25 (1.07–1.46) CVD events: 1.10 (1.02–1.18) Mortality: 1.03 (0.94–1.13)	OR vs. CAs, all participant† MI: 1.43 (1.15–1.76) Stroke: 1.01 (0.84–1.23) CHF: 1.24 (1.00–1.55) CVD events: 1.18 (1.04–1.33) Mortality: 0.97 (0.83–1.13)	OR vs. all other drugs, diabetic patient† MI: 1.53 (1.01–2.31) Stroke: 1.37 (0.86–2.20) CHF: 1.76 (0.97–3.21) CVD events: 1.44 (1.09–1.91) Mortality: 1.24 (0.84–1.83)	Diabetic patients were qualitatively the same as all participants, but with higher ORs
NA	RR vs. diuretics or β -blockers or CAs† MI: 0.37 (0.24–0.57) Stroke: 0.76 (0.48–1.22) CVD events: 0.49 (0.36–0.67) Mortality: 0.57 (0.38–0.87)	NA	Heterogeneity when UKPDS added; results are for other 3 trials without UKPDS

ioral change programs for diabetic persons should be designed differently from programs for nondiabetic persons.

Foot Care Programs

Although foot care programs may decrease the risk for amputation among persons with long-standing diabetes (109–111), no study has shown that initiation of such programs during the preclinical period provides additional benefit. Because the risk for amputation in the 10 years after clinical diagnosis is low (112), the additional benefit from starting such programs in the preclinical phase is uncertain but likely to be small.

Do Diagnosis and Treatment of Impaired Fasting Glucose or Impaired Glucose Tolerance Improve Health Outcomes?

Impaired fasting glucose and *impaired glucose tolerance* are terms for conditions among persons who do not meet criteria for diabetes but whose fasting glucose level or 2-hour postload plasma glucose level is in the top few percentiles of the nondiabetic population (12). These people have an increased risk for diabetes in the future but do not usually develop diabetic visual, neurologic, or renal complications while in this intermediate state. People with impaired fasting glucose or impaired glucose tolerance, however, have more CVD risk factors and higher CVD risk than nondiabetic persons (34–39, 85, 113–115). People with impaired fasting glucose or impaired glucose tolerance do not have symptoms of hyperglycemia; their state can be detected only by screening. In screening studies, more than twice as many persons have impaired fasting glucose or

impaired glucose tolerance as have undiagnosed diabetes (12, 41).

If interventions at the stage of impaired fasting glucose or impaired glucose tolerance can reduce diabetic complications, this would be a potential benefit of screening. Five RCTs have reported results from lifestyle or drug interventions in people with impaired fasting glucose or impaired glucose tolerance, using progression to diabetes as the relevant outcome (116–120). Three of these trials (the largest ones with the most intensive interventions) found that intensive lifestyle interventions reduced the development of diabetes by 42% to 58% over 3 to 6 years (117, 119, 120). In the largest, U.S.-based study, for example, the intensive behavioral and social program included a case manager with frequent meetings, group and individual support, diet and physical activity training, and enrollment at an exercise facility (121).

Although these trials convincingly demonstrate that intensive behavioral and social interventions can reduce the progression from impaired fasting glucose or impaired glucose tolerance to diabetes, determining the magnitude of additional health benefit from screening and intervening at this stage rather than waiting to intervene at clinical diagnosis is complex. The trials do not permit a clear estimate of the added impact on diabetic complications. Because the risk for severe visual impairment, ESRD, or amputation is low until 15 years or more after diabetes diagnosis, any benefit of treatment of impaired fasting glucose or impaired glucose tolerance to prevent these complications would be small for at least this period. The effect of life-

Table 5. Number Needed To Screen for Diabetes To Prevent One Adverse Event*

Prevalence of Undiagnosed Diabetes	Additional Time of Intensive Treatment Due to Screening	Tight Glycemic Control To Prevent One Case of Blindness in One Eye (Screening 1000 People with Given Prevalence)†		Tight Blood Pressure Control To Prevent One CVD Event (Screening 1000 Hypertensive Persons with Given Prevalence)‡	
		Increase in Persons with Tight Glycemic Control Due to Screening	Case of Blindness Averted (NNS)	Increase in Persons with Tight Blood Pressure Control Due to Screening	CVD Events Averted (NNS)
%	y	%	n (n)	%	n (n)
6	5	25	0.07 (15 400)	25	0.56 (1800)
		50	0.13 (7700)	50	1.13 (900)
		90	0.23 (4300)	90	2.03 (500)
3	2.5	25	0.02 (61 400)	25	0.14 (7200)
		50	0.04 (30 700)	50	0.28 (3600)
		90	0.07 (17 000)	90	0.51 (2000)

* CVD = cardiovascular disease; NNS = number needed to screen.

† Assumptions: 1.5% 5-year risk for blindness in one eye with no glycemic control; relative risk reduction for blindness with tight glycemic control is the same as relative risk reduction for photocoagulation (10).

‡ Assumptions: 7.5% 5-year risk for CVD event with usual blood pressure control (60); 50% relative risk reduction in CVD events with tight blood pressure control (59). Usual blood pressure control is equivalent to a diastolic goal of 90 mm Hg; tight blood pressure control is equivalent to a diastolic goal of 80 mm Hg. Hypertension is blood pressure ≥140/90 mm Hg.

style interventions on CVD events, independent of other risk factor modification, is also uncertain. Finally, the cost-effectiveness of offering lifestyle interventions only to persons who have positive results on a glucose screening test compared with offering these programs more generally to persons with such risk factors for diabetes as obesity or sedentary lifestyle is uncertain.

What Are the Harms of Screening and Treatment, and How Frequently Do They Occur?

Screening for diabetes could potentially cause harm in several ways. One way is by labeling people as diabetic. One study in a Veterans Affairs Medical Center screened a convenience sample of 1253 outpatients for diabetes and also administered a global measure of quality of life (122). The study found no differences in quality of life at baseline or 1 year later between patients newly detected by screening to have diabetes and those not found to have diabetes. Whether more sensitive measures in healthier samples would have similar findings is unclear. No study has examined the psychological effects of diabetes detection by screening compared with clinical detection. Because few studies have examined the harmful effects of screening, the possibility of labeling effects remains a potential harm. False-positive diagnoses may also cause unnecessary treatment and difficulty obtaining life or health insurance. Between 30% and 50% of people who receive a diagnosis of impaired glucose tolerance will revert to normoglycemia (123–128). Two studies found that between 12.5% and 42% of men who were found to have diabetes on screening reverted to normoglycemia after 2.5 to 8 years (129, 130).

Another potential harm of screening is subjecting patients to a potentially harmful or unnecessary treatment for a longer time. On the whole, treatments for diabetes are relatively safe. Tight glycemic control, especially at a time when glycemic levels are low (that is, the time between

screening and clinical detection), can induce hypoglycemia. In the UKPDS, 2.3% of persons taking insulin had a major hypoglycemic episode each year, as did 0.4% to 0.6% of persons taking oral hypoglycemic agents (10). The most common side effect of ACE inhibitors, a reversible cough, occurs in 5% to 20% of patients and is dose related (131). Angiotensin-converting enzyme inhibitors have fewer side effects than most antihypertensive agents and are associated with high rates of adherence. Statins also have low rates of serious adverse effects (132, 133).

Although the effect of tight glycemic control on quality of life has been a concern, three RCTs have indicated that better glycemic control actually improves quality of life (134–136). These studies were conducted in persons with a clinical diagnosis of diabetes, whose glycemic levels were presumably higher than those of persons who would be detected by screening.

DISCUSSION

No RCT of screening for diabetes has been performed. The natural history of diabetes includes an asymptomatic preclinical phase, and currently available screening tests can detect the disease during this period. The mean length and distribution of lengths of this preclinical period are unknown. A longer preclinical period provides a better opportunity for early treatment to reduce complications.

Early detection by screening could allow clinicians to offer a variety of interventions during the preclinical period, including tight glycemic control; more intensive use and targeted choice of antihypertensive agents; more aggressive use of lipid treatment and aspirin; institution of foot care programs; and counseling for dietary change, physical activity, and smoking cessation. Direct evidence shows that many of these interventions improve health

outcomes when initiated after clinical diagnosis. The magnitude of added benefit to initiating them earlier, during the preclinical period, however, must be extrapolated from indirect evidence.

The effect of earlier initiation of these interventions depends on the magnitude of the absolute risk reduction of the complications that they target. The impact of earlier initiation of interventions, such as tight glycemic control, that target blindness, ESRD, or lower-extremity amputation—complications that occur in a substantial number of diabetic persons only 15 years or more after diagnosis—is uncertain but probably small for some years. By contrast, the impact of earlier initiation of interventions, such as intensive blood pressure control, that target CVD events—complications that occur sooner and at a higher rate than blindness—is likely to be larger within the first 10 years after diagnosis.

Table 5 considers the number needed to screen (NNS) to prevent one case of blindness in one eye or one CVD event over 5 years, given various assumptions. Given favorable assumptions, including that tight glycemic control yields a 29% reduction in the risk for blindness in one eye among diabetic persons identified by screening (the relative risk reduction in retinal photocoagulation in the UKPDS trial) (10) and that screening increases the percentage of persons with tight control by 90%, then the NNS to prevent one case of blindness by tight glycemic control for 5 years is about 4300. Less optimistic assumptions result in higher NNS estimates.

If one screened only people with hypertension for diabetes, estimates of the NNS to prevent one CVD event with 5 years of intensive hypertension treatment events are lower. Realistic assumptions of the risk for CVD and the relative risk reduction from intensive hypertension control lead to an NNS estimate of 900, even with an increase of only 50% in the percentage of new diabetic persons with tight blood pressure control. With less favorable assumptions, the NNS calculations for preventing one CVD event are still lower than those for preventing blindness in one eye. The initial assumptions for the CVD calculations are based more on direct evidence and less on extrapolation than those in the blindness example.

Special Populations

A systematic review in 1994 found that nearly all minority groups in the United States have a higher prevalence of diabetes than white persons (137). Many of these groups also have a higher incidence and prevalence of such diabetic complications as ESRD and higher overall mortality rates (138). The RCTs of interventions cited in this review include predominantly white patients. Thus, the relative risk reduction for diabetic complications in minority groups must be extrapolated from data on white samples.

Assuming that the effectiveness of the interventions is similar in various ethnic groups, the most important issue from the standpoint of benefit from screening is whether

the rates of development of diabetic complications in minority groups are different from those of persons in the intervention trials. If, for example, ESRD in minority groups occurs earlier and in a larger proportion of diabetic persons than in the study samples, and if intervening earlier with tight glycemic control or more intensive blood pressure control substantially reduces the development of these complications, then screening might well be more beneficial in these groups. However, the evidence on these issues is insufficient to draw a conclusion.

Future Research

The most important gap in our understanding of screening for diabetes is our knowledge of the added benefit of starting various interventions earlier, during the preclinical period, compared with at clinical detection. Ideally, an RCT of screening, especially in populations that are not otherwise at high CVD risk, should be considered. Mounting such a study, although expensive and difficult, could teach us much about preventing diabetic complications and could assist us in developing the most effective and efficient strategy to reduce the burden of diabetes. Because some of these complications occur many years after clinical diagnosis, this study should include long-term follow-up.

In the absence of a trial of screening, natural experiments should be examined. Areas that adopt an aggressive screening approach (for example, among Native American groups) could be compared with areas that offer little screening. Registries of diabetic complications, including CVD events, should be established for monitoring. Because not all persons with abnormal results on glycemic tests are at equal risk for diabetic complications, studies that help define and identify high- and low-risk groups are needed to better target such interventions as screening.

Until we have better evidence about its benefits, harms, and costs, the role of screening as a strategy to reduce the burden of suffering of diabetes will remain uncertain. Current evidence suggests that the benefits of screening are more likely to come from modification of CVD risk factors rather than from tight glycemic control.

Addendum: The recently reported ALLHAT trial provides further evidence that ACE inhibitors have no special benefit, and calcium-channel blockers have no special adverse effects, in diabetic compared with nondiabetic patients. (Major outcomes in high-risk hypertensive patients randomized to angiotensin-converting enzyme inhibitor or calcium channel blocker vs diuretic: The Antihypertensive and Lipid-Lowering Treatment to Prevent Heart Attack Trial (ALLHAT). *JAMA*. 2002;288:2981-97. [PMID: 12479763]).

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APPENDIX Methods

The Research Triangle Institute–University of North Carolina Evidence-based Practice Center, together with members of the USPSTF, sought to clarify issues concerning screening adults for diabetes by performing a systematic review of the relevant scientific literature on this topic. Analytic Framework

The systematic evidence review examined the evidence for screening for diabetes, comparing systematic screening with no screening. **Appendix Figure 1** presents the analytic framework that we used to guide our literature search. The analytic framework describes the logical chain that evidence must support to link screening to improved health outcomes. Each arrow in the analytic framework represents a key question. We searched systematically for evidence concerning each key question in the analytic framework.

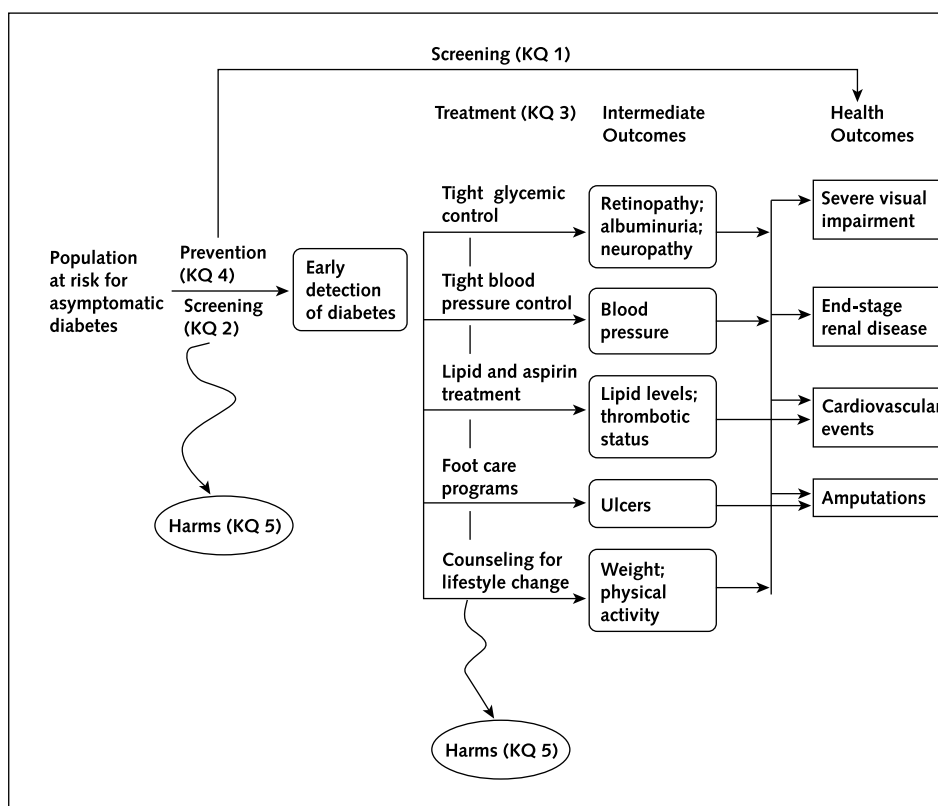
The analytic framework begins on the left side of the figure with a sample at risk for undiagnosed diabetes and moves to the right. The first key question (represented by the overarching arrow) examines direct evidence that screening improves health outcomes. Because no such studies were found, we continued to examine the indirect evidence in the following key questions, represented as linkages in the analytic framework.

Key question 2 examines the yield of screening, involv-

ing both the accuracy and reliability of various screening tests as well as the prevalence of undiagnosed diabetes in the population. Farther to the right in the analytic framework, the third key question examines the efficacy of various treatments to prevent diabetic complications, including tight glycemic control, cardiovascular risk reduction, foot care, or enhanced counseling for lifestyle changes. It is important to note that the critical issue here is the efficacy of the treatment among persons who would be detected by screening. Some studies examine treatment for persons with new clinically detected diabetes; these are useful only insofar as they allow extrapolation to the efficacy of treatment at screening detection. In addition, key question 3 actually implies that the issue of interest is the *added* efficacy of initiating treatment after screening detection as opposed to initiation after clinical detection. An additional treatment (key question 4) is lifestyle intervention programs for persons with impaired fasting glucose or impaired glucose tolerance. These interventions may reduce the intermediate outcome of developing diabetes, but the critical question is the extent to which they improve health outcomes.

In between the treatment arrows and health outcomes are a variety of “intermediate outcomes,” such as retinopathy and albuminuria. Although changes in these outcomes may herald later improved health outcomes, they may or

Appendix Figure 1. Analytic framework for screening for type 2 diabetes.



KQ = key question.

Appendix Table 1. Eligibility Criteria, Search Strategy, and Results of Searches*

Key Question	Eligibility Criteria	Articles Meeting Criteria	
		Articles Identified for Abstract Review	<i>n</i>
All	Published 1 January 1994 through 30 July 2002 English language MEDLINE, Cochrane Human subjects		
1. Efficacy of screening (direct evidence)	RCT of screening	130	0
2. Accuracy and reliability of screening tests	Population relevant to primary care Screening test offered to all Screening test compared with a valid reference standard, including all positive tests and at least a sample of negatives	487	7
3. Efficacy of knowledge of diabetes status for optimizing the following treatments:			
Tight glycemic control	RCT	436	5
Tight blood pressure control; type of drug	Follow-up ≥ 2 years $\geq 75\%$ of patients followed	426	13
Lipid and aspirin treatment	Health outcomes	191	8
Foot care programs		48	2
Counseling for lifestyle change		6	0
4. Lifestyle intervention for people with impaired fasting glucose or impaired glucose tolerance	RCT Intervention at impaired fasting glucose or impaired glucose tolerance stage Valid measure of development of diabetes	39	8
5. Harms of screening and treatment	Use of valid measurement instrument Follow-up for ≥ 12 months during treatment Comparison with similar untreated or unscreened control group	57	6

* RCT = randomized, controlled trial.

may not be sufficient in themselves to allow estimation of the magnitude of health benefit with reasonable certainty.

At the far right in the analytic framework are the health outcomes—the outcomes that people can experience and care about. These include the major diabetic complications: severe visual impairment, ESRD, lower-extremity amputation, and cardiovascular events. In the end, the indirect evidence must allow a reasonable estimation of the magnitude of benefit in these outcomes attributable to screening. At the bottom of the analytic framework is linkage and key question 5, the issue of the harms of screening (for example, labeling) or harms of treatment (for example, side effects).

Key Questions

Key question 1: Is there direct evidence from an RCT of screening that screening for diabetes improves health outcomes?

Key question 2: What is the yield of screening, both in terms of the accuracy and reliability of screening tests and the prevalence of undiagnosed diabetes in the population?

Key question 3: What is the added efficacy of initiating treatments (tight glycemic control, tight blood pressure control, lipid and aspirin treatment, foot care programs, counseling for lifestyle change) at screening detection com-

pared with clinical detection in improving health outcomes?

Key question 4: What is the efficacy of lifestyle intervention for people with impaired fasting glucose or impaired glucose tolerance in improving health outcomes?

Key question 5: What are the harms of screening or treatment?

Eligibility Criteria for Admissible Evidence

The Evidence-based Practice Center staff and USPSTF liaisons developed eligibility criteria for selecting the evidence relevant to answer the key questions (Appendix Table 1). For key question 1, we required a well-conducted RCT of screening of adequate size and length to estimate health outcomes with reasonable accuracy. For key question 2, we required cross-sectional or cohort studies in which screening tests were performed on a primary care or general unselected sample and compared with an acceptable reference standard. For key question 3, we accepted RCTs of treatments with health outcomes that provided information about disease duration and comorbid conditions in persons with diabetes. For key question 4, we accepted RCTs of persons with impaired fasting glucose or impaired glucose tolerance treated with lifestyle or other interventions in which diabetes incidence or development of diabetic complications was an outcome. For key ques-

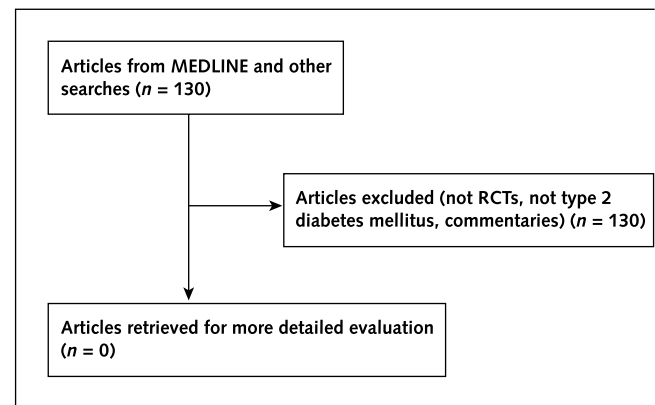
Appendix Table 2. Search Strategies*

Key Question	Search Strategy
1. Is there direct evidence from an RCT of screening that screening for diabetes improves health outcomes?	<i>Noninsulin-dependent diabetes</i> <i>Mass screening</i> <i>RCT</i>
2. What is the yield of screening?	<i>Noninsulin-dependent diabetes</i> <i>Prevalence, incidence</i> <i>Fasting glucose</i> <i>Random glucose</i> <i>Postload glucose</i> <i>Glucose tolerance test</i> <i>Mass screening</i> <i>Hemoglobin A_{1c}</i> <i>Glycosylated hemoglobin</i> <i>Diagnosis</i> <i>Sensitivity/specificity</i> <i>Predictive value</i> <i>Reproducibility</i> <i>Screening programs</i>
3. What is the added efficacy of initiating the treatments below at screening detection compared with clinical detection in improving health outcomes? Tight glycemic control Tight blood pressure control Lipid and aspirin treatment Foot care programs Counseling for lifestyle change	<i>Noninsulin-dependent diabetes</i> <i>Insulin</i> <i>Glycemic control</i> <i>Antihypertensives</i> <i>ACE inhibitors</i> <i>Calcium-channel blockers</i> <i>Statins</i> <i>Aspirin</i> <i>Counseling</i> <i>Smoking</i> <i>Tobacco</i> <i>Weight change</i> <i>Physical activity</i> <i>Oral hypoglycemics</i> <i>Foot care programs</i> <i>Therapeutics</i> <i>Treatment</i>
4. What is the efficacy of lifestyle intervention for people with impaired fasting glucose or impaired glucose tolerance in improving health outcomes?	<i>Noninsulin-dependent diabetes</i> <i>RCT</i> <i>Primary prevention</i> <i>Impaired glucose tolerance/ impaired fasting glucose</i>
5. What are the harms of screening or treatment?	<i>Therapeutics</i> <i>Treatment</i> <i>Noninsulin-dependent diabetes</i> <i>Mass screening</i> <i>Labeling</i> <i>Hypoglycemia</i> <i>Adverse effects</i> <i>Side effects</i> <i>Quality of life</i> <i>False positive</i> <i>False negative</i> <i>Predictive value</i>

* ACE = angiotensin-converting enzyme; RCT = randomized, controlled trial.

tion 5, we required RCTs of screened (or treated) versus nonscreened (or nontreated) samples. When we could not find such studies, we also examined cohort studies of screening-detected diabetic persons for evidence of quality of life or psychosocial harms.

Appendix Figure 2. Selection of articles based on key question 1.

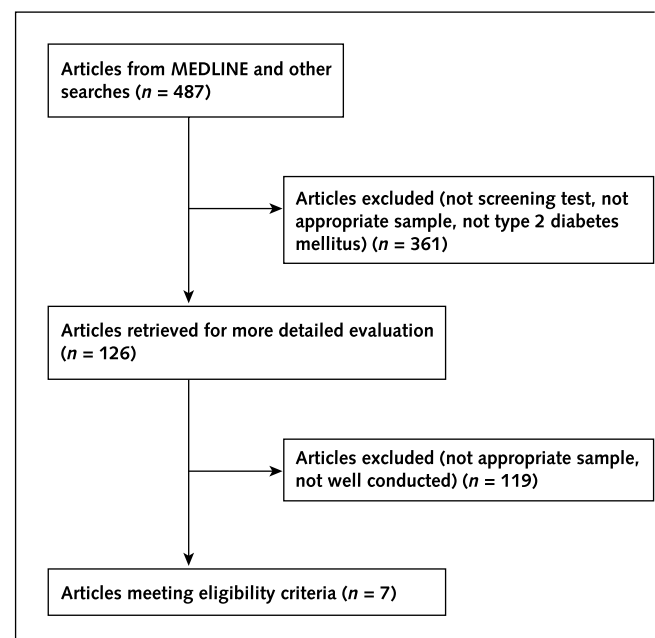


RCT = randomized, controlled trial.

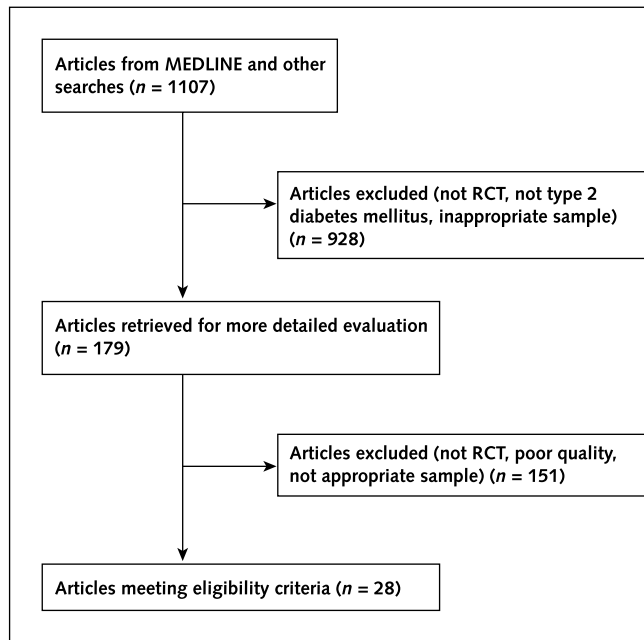
Literature Search Strategy, Results, and Review of Abstracts and Articles

The analytic framework and key questions guided our literature searches. We examined the critical literature described in the previous review of this topic by the USPSTF (published in 1996) and used our eligibility criteria to develop search terms. We used the search terms to search MEDLINE and the Cochrane Library for English-language articles that met inclusion criteria and were published between 1 January 1994 and 30 July 2002. We also examined the bibliographies of pertinent articles and contacted experts for other references. When we found that a key question could best be answered by older literature, we also examined these studies. The search strategies are given

Appendix Figure 3. Selection of articles based on key question 2.



Appendix Figure 4. Selection of articles based on key question 3.

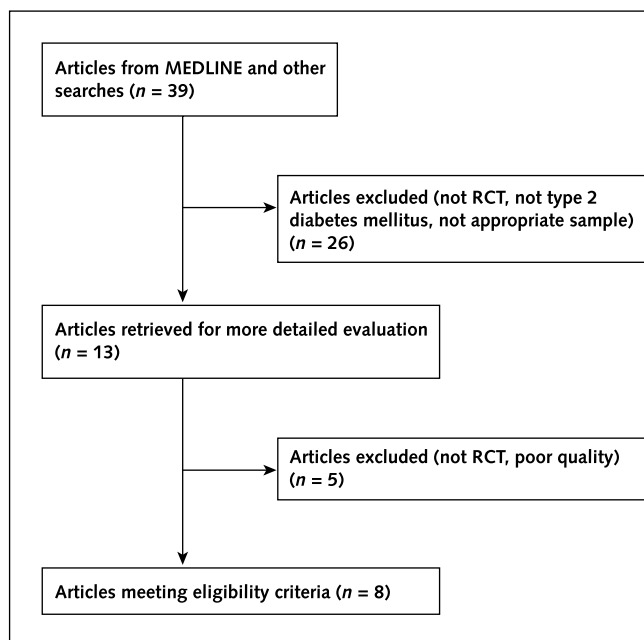


RCT = randomized, controlled trial.

in Appendix Table 2. All searches started with the term *noninsulin dependent diabetes*, and other terms were added as appropriate.

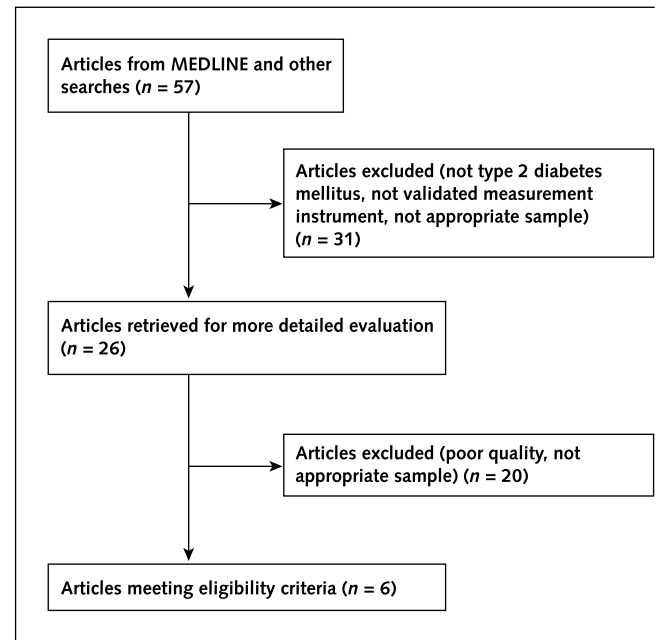
The first author and at least one other coauthor or trained assistant reviewed all abstracts to find those that

Appendix Figure 5. Selection of articles based on key question 4.



RCT = randomized, controlled trial.

Appendix Figure 6. Selection of articles based on key question 5.



met eligibility criteria. When either reviewer thought that an abstract might meet criteria, the article was copied for full review. The first author and at least one other coauthor or trained assistant reviewed each full article. Those that met eligibility criteria after full review and, when necessary, discussion, were abstracted. Appendix Figures 2 through 6 illustrate our selection process for each key question. We critically appraised each study using criteria developed by the USPSTF Methods Work Group. If we found an article that met criteria but had methodologically fatal flaws that invalidated its findings, it was excluded from further review. Abstracted articles that met eligibility criteria and had no fatal flaws were entered into predesigned evidence tables (see Appendix B in the systematic evidence review “Screening Adults for Type 2 Diabetes,” available at www.ahrq.preventiveservices.gov).

Development of the Systematic Evidence Review and Review of the Evidence Article

The authors presented an initial work plan, including a provisional analytic framework and key questions, to the entire Task Force. Interim reports were presented at subsequent meetings. The Task Force discussed and made important contributions to the review on several occasions. The two Task Force liaisons participated in every phase of the review, including several conference calls to discuss critical parts of the evidence.

A draft systematic evidence review was presented to the Task Force and then sent for broad peer review. The peer review included individual experts in the field, representatives of relevant professional organizations, and repre-

sentatives of appropriate federal agencies. We made revisions to the evidence review as appropriate after receiving peer review comments. The Task Force reviewed all information and voted on a recommendation. We then finalized the systematic evidence review for publication by the Agency for Healthcare Research and Quality and separately adapted it for journal publication.

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