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Effectiveness of Interventions to Promote Screening for Diabetic Retinopathy

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Objective: To assess the effectiveness of interventions aimed to increase retinal screening among people with diabetes.

Methods: A systematic literature search was conducted of multiple electronic bibliographic databases up to May 2005. Studies were included if interventions were used to promote screening for diabetic retinopathy in any language and with any study design.

Results: Forty-eight studies (12 randomized controlled trials [RCTs], four nonrandomized studies, and 32 pre–post studies) with a total of 162,157 participants, examined a wide range of interventions, which focused on one or more of the following: (1) patients or populations, (2) providers or practices, and (3) healthcare system infrastructure and processes. Four of five RCTs focusing on patients demonstrated that interventions increased screening significantly, with relative risk ranging from 1.05 (95% confidence interval [CI]=1.01–1.08) to 2.01 (95% CI=1.48–2.73). Five RCTs with a focus on the system all demonstrated significant increases in screening with relative risk ranging from 1.12 (95% CI=1.03–1.22) to 5.56 (95% CI=2.19–14.10). Thirty-six non-RCTs, which included interventions with single or multiple foci, also generally demonstrated positive effects.

Conclusions: Increasing patient awareness of diabetic retinopathy, improving provider and practice performance, and improving healthcare system infrastructure and processes, can significantly increase screening for diabetic retinopathy. Further research should explore strategies for increasing the rate of retinal screening among diverse or disadvantaged populations and the economic efficiency of effective interventions in large community populations.

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Introduction

Diabetic retinopathy is a highly specific microvascular complication of diabetes and the leading cause of blindness in the United States among adults aged 24 to 75 years.[1] The number of people with diabetic retinopathy and vision-threatening diabetic retinopathy currently is high (4.1 million and 899,000 people, respectively), and is expected to increase by 2020 to 7.2 million and 1.6 million, respectively, among the general U.S. population aged 40 years and older.[2] Blindness due to diabetes costs the U.S. about $500 million annually in healthcare and associated services.[3]

The natural history of diabetic retinopathy is well defined and understood. Early detection and timely treatment are key strategies for reducing the burden associated with diabetic retinopathy and resulting visual impairment. Empirical evidence from clinical trials indicates that diabetic retinopathy can be prevented or delayed through adequate control of blood glucose and blood pressure levels[4,5] and effectively treated when timely retinal photocoagulation treatment is performed.[6,7] Because retinal screening is crucial for reaching the goal of early detection and timely treatment, medical organizations recommend regular retinal screening for preventing blindness related to diabetic retinopathy. The American Diabetes Association recommends an annual dilated eye examination beginning 5 years after diagnosis of type 1 diabetes and at the time of diagnosis of type 2 diabetes, unless patients are otherwise indicated to be at low risk for retinopathy by their eye care provider.[8] Other organizations that support regular retinal screening include the World Health Organization (WHO),[9] the National Committee

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for Quality Assurance,[10] the National Eye Institute (National Eye Health Education Program),[11] and the Centers for Disease Control and Prevention (National Diabetes Education Program).[12] The latter two organizations have developed awareness programs for the public and for healthcare providers to promote annual dilated eye examination.

Despite evidence supporting the effectiveness of periodic screening for diabetic retinopathy,[4–7] screening rates consistently fall far below recommended levels.[1] One of the U.S. national health objectives for 2010 is to increase the proportion of people with diabetes screened annually for diabetic retinopathy to 75% from the level of 47% in 1998.[13] In 1999, the WHO, along with the International Agency for the Prevention of Blindness, launched Vision 2020: The Right to Sight initiative with the goal of eliminating avoidable blindness in the world by 2020.[9] A systematic review of the effectiveness of interventions to promote screening for diabetic retinopathy is a key foundational step to develop sound national strategies to improve the early detection and treatment of vision-threatening diabetic retinopathy.

A systematic review was conducted to assess the effect of interventions to increase the use of retinal screening among people with diabetes. The primary objective was to examine which interventions are effective. Secondary objectives were to explore (1) what characteristics of the diabetic population correlate with improved screening, (2) what characteristics of the provider delivering or associated with the intervention modify the effect of interventions on screening, and (3) what characteristics of the healthcare system modify the effect of interventions on screening.

Methods

Data Sources

A systematic review protocol was developed using the methods of the Cochrane Collaboration.[14] In consultation with a medical research librarian, search strategies were formulated using an iterative process that used medical subject headings and key search terms, including diabetic retinopathy, retinal disease, vision screening, and related terms (available from the authors on request). The following databases were searched for studies published between 1980 and May 2005: MEDLINE, EMBASE, CINAHL, Web of Science, Cochrane Library, and Cochrane Controlled Trials Register (including DARE). In addition, the following journals (expected to have the highest relevance) were manually searched for relevant articles published from 1980 to May 2005: *Diabetes Care*, *Ophthalmology*, *Archives of Ophthalmology*, and *Acta Ophthalmologica*.

Systematic searches were performed for relevant reviews of interventions to promote screening for diabetic retinopathy. Reference lists of all included studies and relevant reviews were examined for additional citations. Authors of original studies were contacted when data were unclear or missing.

Study Selection and Data Extraction

A search was conducted for both published and unpublished studies in any language that used interventions to promote screening for diabetic retinopathy. The following types of study designs were included: randomized clinical trials (RCTs), controlled clinical trials, controlled before-and-after trials, interrupted time series, and pre–post studies. A sufficient number of RCTs and controlled clinical trials (quasi-randomized studies) were sought for pooled estimates, but other types of comparative design studies would have been considered if a sufficient number of RCTs were not found.

Titles and abstracts were screened for studies that fulfilled the inclusion criteria, and the full text was retrieved for all relevant articles. One author reviewed each article for inclusion, and when there was uncertainty as to its inclusion, a second author reviewed the paper to achieve consensus. Data from included studies were abstracted by two reviewers (one conducted formal abstraction and another checked for accuracy) and all data were reviewed again by a third author.

Data abstracted included participant characteristics, treatment regimens for diabetes and other medical conditions, setting, mode of delivery of the intervention, intervention characteristics, and study designs. All interventions were classified on the basis of their target groups into one of three categories: (1) interventions focusing on patients or populations, (2) interventions focusing on providers or practices, and (3) interventions focusing on healthcare system infrastructure and processes. If an intervention focused on more than one target group, it was classified as a multifoci intervention.

The methods of the Cochrane Collaboration were followed and quality assessments were conducted for potential selection, attrition, and detection bias.[14] The quality of studies was assessed using (1) participant sampling method, (2) Jadad score (RCTs only), (3) randomization procedure (RCTs only), (4) allocation concealment (RCTs only), (5) attrition, (6) blinding, and (7) baseline comparability. Studies were not excluded on the basis of poor quality, but a sensitivity analysis was performed to compare results between studies with high versus low risk of bias if data were sufficient. A funnel plot method was used to test for publication bias of included studies.

Data Analysis and Synthesis

The objective of this review was to determine the effectiveness of interventions for a broad range of populations and settings. Recognizing the potential for bias from confounding and secular trends in studies without randomization,[15] when these studies were included, they were analyzed separately from RCTs. Potential sources of bias were identified, and how they might have affected results was determined.

Relative risk (RR)[16] was used as the primary measure of effect. For RCTs, the RR was calculated as the prevalence of retinopathy screening at follow-up among an intervention group divided by the prevalence at follow-up among a control group. For studies other than RCTs, the RR was calculated as the prevalence of retinopathy screening after intervention divided by the prevalence at baseline.[16] Clinical and methodologic diversities were assessed in order to determine if a meta-analysis was appropriate.[14] To test for statistical heterogeneity, the chi-square test[14] was used, stratifying by study

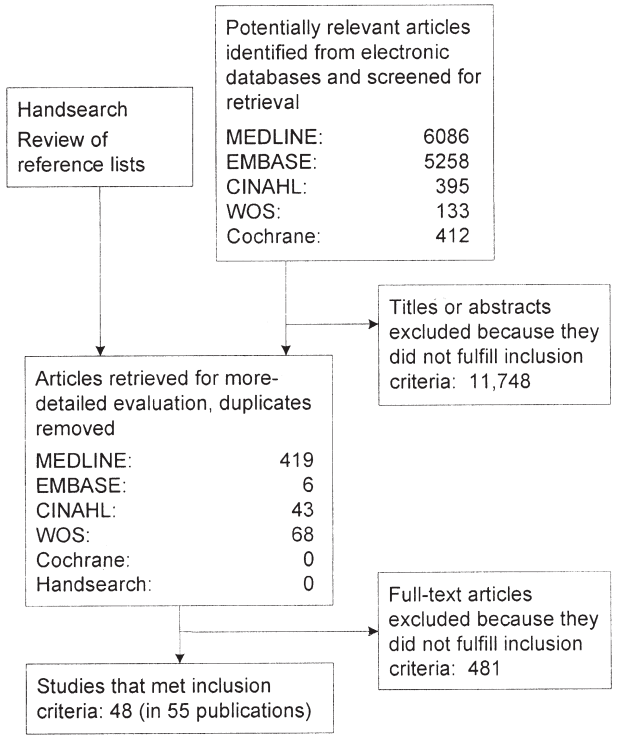

Figure 1. Study flow diagram.
WOS, Web of Science.

design and intervention type. If there was substantial diversity among studies, results were presented in narrative fashion with a forest plot. Because the magnitude of improvement might be strongly influenced by baseline retinal screening,[16] absolute levels of screening were reported also for the intervention and comparison groups.

Results

The results of computerized searches were depicted in Figure 1. Hand searches did not yield additional studies. Forty-eight eligible studies[17–64] with seven companion papers[65–71] were identified, including 12 RCTs,[18,21,30,32,35,39,40,44,52–54,56] four nonrandomized studies,[23,29,31,38] and 32 pre–post studies.[17,19,20,22,24–28,33,34,36,37,41–43,45–51,55,57–64] The 48 studies had a total of 162,157 participants (range, 30 to 27,270) and follow-up periods ranging from 4 months to 4 years. Thirty-two studies were conducted in the U.S.,[18,20–25,27–32,34–36,38,40,44,45,47,48,51,52,54–59,61,62] four in Australia,[46,50,53,60] three in the United Kingdom,[26,39,42] three in Israel,[33,49,64] one in Saudi Arabia,[17] and a few in other developed countries.[19,41,43,63] (See Table 1.)

The mean age of participants in the 28 studies reporting age was 60.2 years (unweighted, standard deviation [SD]=12.7). Study populations were 53.6% female, on average (21 studies did not report the gender of participants). Most studies did not provide information related to race/ethnicity, and only two studies targeted black populations exclusively.[18,21] Mean duration of diabetes was 9.4 years (SD=7.9) (20 studies). Nineteen studies provided information regarding diabetes treatment,[17–19,21,28,29,31,38,39,41,43,44,48,49,54,59,60,63,64] and insulin was the treatment most often used.[18,19,21,28,29,31,38,41,43,44,48,49,54,60,63,64]

The quality of the studies varied; in particular, randomization procedure and allocation concealment among RCTs were rarely reported, and a funnel plot suggested the possibility of publication bias. Attrition ranged from 0% to 14.9% among the seven studies reporting these data.[19,28,32,39,40,43,53] The leading sources of attrition were as follows: (1) moved out of the area, (2) death, (3) poor health, (4) loss of interest, and (5) transportation difficulties.

Table 2 shows the intervention focus, the RRs, and absolute retinal screening rates for each study. Among RCTs, five studies focused on patients and population,[21,35,44,56,65] five studies focused on the healthcare system,[30,39,40,52,54] one study focused on both patients and providers,[32] and one study focused on both patients and the healthcare system.[53] Among studies with designs other than RCTs, 14 focused on the healthcare system infrastructure and processes,[17,19,24,29,36,41–43,49,55,57,58,60,62] five on patients or population,[28,34,51,63,64] and four on provider and practice.[23,37,50,59] Among the interventions with multiple foci, most studies focused on both patients and providers.[20,22,25–27,31,38,46,47]

There was significant diversity among populations, settings, and interventions so that a meta-analysis within each intervention type was not justified. The tests for statistical heterogeneity (Q, $p<0.0001$) supported the assessment of diversity.

The three-group categorization of interventions reflected the major foci of the interventions. This categorization encompassed the main mechanisms through which interventions increased retinal screening. Patient-focused interventions included (1) increased awareness of diabetic retinopathy among people with diabetes,[18,20,25,27,38,44,51,56,63,64] and (2) improved adherence to recommendations among patients.[22,27,47,58] Provider-focused interventions included (1) improved adherence to recommendations among providers,[22,27,47,50,58,59] (2) reduced negligence of practices,[25,34,51] and (3) improved flexibility of providers and practices.[28,45,61] System-focused interventions included (1) adequate access to health care,[18,21,39,41,43,63] (2) improved availability of a healthcare delivery system,[17,29,49,57] (3) more complete records and databases,[22,23,25,42] (4) creation of a screening system with registration and recall or reminder systems,[24–26,35,47,52,55,62] (5) improved services in a resource-poor agency,[18,39] and (6) addressed other barriers to healthcare or cultural obstacles.[17,18,30,53,60]

Four of five RCTs that focused on patients or population demonstrated that interventions increased screening significantly,[21,35,44,56,65] the RR ranged from 1.05 (95% confidence interval [CI]=1.01–1.08)[35] to

Table 1. Characteristics of study participants and intervention type

Study	Study design Intervention focus	Sample size	Length of follow-up (weeks)	Age at baseline in years (mean [SD])[a]	Gender (% female) Race/ethnicity	Duration of diabetes (mean [SD]) Diabetes treatment	Attrition (%)	Setting, providers, country
Randomized controlled trials								
Anderson (2003),[18] Anderson (2002)[66]	RCT Patients or population	132	52	54.8 (NR)	62.1 100% black	7.9 (NR) 50% on insulin	NR	Community-based clinics, ophthalmologists, U.S.
Basch (1999)[21]	RCT Patients or population	280	26	54.7 (12.8)	65.7 100% black	7.9 (7.3) Insulin	NR	Clinics, primary care physicians, U.S.
Davis (2003)[30]	RCT Healthcare system infrastructure and process	59	0	NR	NR 90% black	NR NR	NR	Primary care, U.S.
Glasgow (2004)[32]	RCT Patients or population, and provider and practice	886	26	63.0 (NR)	52.0 80.9% white, 2.2% black, 12.6% Hispanic	NR NR	5.1	Primary care physicians, U.S.
Halbert (1999)[35]	RCT Patients or population	19,523	52	NR	NR NR	NR NR	NR	HMO, U.S.
Hurwitz (1993)[39]	RCT Healthcare system infrastructure and process	181	130	62.6 (10.0)	42.0 NR	7.0 (4.9) Diet or oral agents	0	General practitioner clinics, optometrists, UK
Ilag (2003)[40]	RCT Healthcare system infrastructure and process	154	104	59.7 (11.4)	43.8 87.7% white, 6.2% black, 6.2% other	9.3 (10.3) NR	2.7	Diabetes and endocrinology research center, PCP in MCO, U.S.
Lafata (2002)[44]	RCT Patients or population	3,309	52	59.7 (NR)	52.3 53.9% white	NR Oral agents, insulin	NR	Primary care, PCP, U.S.
McCulloch (1998)[52]	RCT Healthcare system infrastructure and process	600	104	NR	NR NR	NR NR	NR	Primary care, U.S.
McDermott (2001),[53] McDermott (2003)[71]	RCT Patients or population, and healthcare system infrastructure and process	678	52	52.3 (13.5)	62.0 NR	7.5 (5.3) NR	6.7	Primary care clinics, Australia
Montori (2002),[54] Dinneen (2002),[67] Gorman (2000)[68]	RCT Healthcare system infrastructure and process	200	104	70.4 (12.0)	57.8 NR	NR Diet, oral agents, insulin	NR	Community-based care, U.S.

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Table 1. Characteristics of study participants and intervention type (*continued*)

Study	Study design Intervention focus	Sample size	Length of follow-up (weeks)	Age at baseline in years (mean [SD])[a]	Gender (% female) Race/ethnicity	Duration of diabetes (mean [SD]) Diabetes treatment	Attrition (%)	Setting, providers, country
Prela (2000)[56]	RCT Patients or population	6,546	26	NR	54.7 NR	NR NR	NR	Community-based care, opthalmologists and optometrists, U.S.
Other designs								
Al-Khaldi (2002),[17] Al-Khaldi (2002)[65]	Pre–post Healthcare system infrastructure and process	198	104	55.3 (12.2)	38.4 NR	7.1 (6.0) Diet, oral agents	NR	Clinic, GP, Saudi Arabia
Backlund (1998)[19]	Pre–post Healthcare system infrastructure and process	5,490	208	68.0 (median)	48.0 NR	6 (median) Diet, oral agents, insulin	1.0	Primary care clinics, Sweden
Baker (1993)[20]	Pre–post Patients or population, and provider and practice	4,171	312	60.0 (12.5)	71.0 53% black, 30% Hispanic, 6% white	NR NR	NR	Community-based health centers, health educators, U.S.
Brooks (1996)[22]	Pre–post Patients or population, and provider and practice	20,782	156	NR	NR NR	NR NR	NR	Primary healthcare, physicians in HMO, U.S.
Brooks (2002)[23]	Nonrandomized trial Provider and practice	27,270	52	NR	NR NR	NR NR	NR	Primary care practices, U.S.
Brown (2000)[24]	Pre–post Healthcare system infrastructure and process	11,758	104	62.9 (15.3)	NR NR	NR NR	NR	Optometrist or ophthalmologist in HMO, U.S.
Buonaccorso (1999)[25]	Pre–post Patients or population, and provider and practice	15,000	52	NR	NR NR	NR NR	NR	BlueCross, BlueShield, physician, nurses, data analyst, and health educator, U.S.
Burnett (1998)[26]	Pre–post Patients or population, and provider and practice	509	52	NR	NR NR	NR NR	NR	Clinics, GP, and optometrists, UK
Chicoye (1998)[27]	Pre–post Patients or population, and provider and practice	5,100	52	NR	NR NR	NR NR	NR	Primary care in HMO, U.S.

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Table 1. (*continued*)

Study	Study design Intervention focus	Sample size	Length of follow-up (weeks)	Age at baseline in years (mean [SD])[a]	Gender (% female) Race/ethnicity	Duration of diabetes (mean [SD]) Diabetes treatment	Attrition (%)	Setting, providers, country
Clark (2001)[28]	Pre–post Patients or population	370	52	64.0 (NR)	NR 76% white, 7% black, 7% Hispanic	10.7 (NR) Diet, oral agents, insulin, exercise	14.9	Primary care clinics in MCO, physicians, U.S.
Davidson (2000)[29]	Nonrandomized trial Healthcare system infrastructure and process	181	104	53.3 (NR)	48.6 66.9% Hispanic	8.7 (NR) Diet, oral agents, insulin	NR	Primary care clinics, U.S.
Deeb (1988)[31]	Nonrandomized trial Patients or population, and provider and practice	636	104	58.9 (NR)	70.4 48% black, 30.9% white, 21.1% Hispanic	9.7 (NR) Diet, oral agents, insulin	NR	Primary care centers, physicians, nurse, U.S.
Goldfracht (2000)[33]	Pre–post Provider and practice, and healthcare system infrastructure and process	815	104	67.5% ≥60 years	52.0	28% <5 years, 47.9% 5–15 years, 24.1% >15 years NR	NR	Primary care, physicians, Israel
Gross (1999)[34]	Patients or population	100	26	NR	NR NR	NR NR	NR	Primary care, physicians, U.S.
Harwell (2002)[36]	Pre–post Healthcare system infrastructure and process	590	68	51.0 (13.3)	58.0 NR	NR NR	NR	Community-based care, U.S.
Hastings (1998)[37]	Pre–post Provider and practice	331	156	NR	NR NR	NR NR	NR	Clinics, general practices, UK
Hempel (1990)[38]	Controlled before-after Patients or population, and provider and practice	203	52	58.4 (NR)	63.7 39.6% white, 60% black	NR Diet, oral agents, insulin	NR	Family practice clinics, U.S.
Jin (2003)[41]	Pre–post Healthcare system infrastructure and process	339	52	NR	59.0 Aboriginal, Canada	46% ≥5 years Oral agents, insulin	NR	Mobile diabetes care, physician, nurse, and ophthalmologist, Canada

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Table 1. Characteristics of study participants and intervention type (*continued*)

Study	Study design Intervention focus	Sample size	Length of follow-up (weeks)	Age at baseline in years (mean [SD])[a]	Gender (% female) Race/ethnicity	Duration of diabetes (mean [SD]) Diabetes treatment	Attrition (%)	Setting, providers, country
Johnston (2000)[42]	Pre–post Healthcare system infrastructure and process	1,243	156	NR	NR NR	NR NR	NR	Community-based diabetes care, UK
Kristinsson (1997)[43]	Pre–post Healthcare system infrastructure and process	175	208	31.6 (12.3)	43.0 NR	16.7 (10.2) Insulin	14.6	Eye clinic, ophthalmologist, Iceland
Larsen (2003)[45]	Pre–post Provider and practice, and healthcare system infrastructure and process	5,785	208	NR	NR NR	NR NR	NR	Population-based care, U.S.
Lee (2000),[46] Lee (2000),[70] Harper (1998)[69]	Pre–post Patients or population, and provider and practice	1,197	104	64.1 (NR)	48.5 NR	8.4 (9.1) NR	NR	Community-based care, ophthalmologist, Australia
Legorreta (1997)[47]	Pre–post Patients or population, and provider and practice	8,591	104	NR	54.5 NR	NR NR		Primary care, physicians in HMO, U.S.
Letassy (2003)[48]	Pre–post Provider and practice, and healthcare system infrastructure and process	61	52	56.9 (12.3)	NR 70% black, 25% white	8.6 (7.6) Lifestyle, oral agents, insulin	NR	Family medicine center, physicians, U.S.
Maislos (2002)[49]	Pre–post Healthcare system infrastructure and process	492	26	60.0 (11.0)	58.0 NR	10.0 (8.0) Diet, oral agents, insulin	NR	Mobile tertiary clinic, Israel
Mak (2003)[50]	Pre–post Provider and practice	744	80	51.0 (12.0)	59.7 76.1% aboriginal	>2 years NR	NR	Community-based clinics, Australia
Maliszewski (1988)[51]	Pre–post Patients or population	338	52	NR	NR NR	>5 years NR	NR	Clinics, nurses, U.S.
Nagykaldi (2003)[55]	Pre–post Healthcare system infrastructure and process	595	16	NR	NR NR	NR NR	NR	Primary care practices, U.S.

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Table 1. (*continued*)

Study	Study design Intervention focus	Sample size	Length of follow-up (weeks)	Age at baseline in years (mean [SD])[a]	Gender (% female) Race/ethnicity	Duration of diabetes (mean [SD]) Diabetes treatment	Attrition (%)	Setting, providers, country
Rubin (1998)[57]	Pre–post Healthcare system infrastructure and process	4,194	52	NR	NR NR	NR NR	NR	Multicenter, U.S.
Sawin (2004)[58]	Pre–post Healthcare system infrastructure and process	9,578	208	65 years for men, 60 for women	NR NR	NR NR	NR	Primary care in Veterans Affairs facilities, U.S.
Schectman (2004)[59]	Pre–post Provider and practice	789	26	58.7 (16.1)	60.5 60.8% white, 37.8% black, 1.4% other	NR Oral agents	NR	Clinics, physicians, U.S.
Simmons (2003)[60]	Pre–post Healthcare system infrastructure and process	30	40	54.0 (13.0)	65.0 NR	13.0 (10.0) Oral agents, insulin	NR	Rural clinics, GP and nurse, Australia
Snyder (2001)[61]	Pre–post Patients or population, provider and practice, and healthcare system infrastructure and process	729	52	NR	NR NR	NR NR	NR	MCO-owned clinics, care coordinator and nurse, U.S.
Snyder (2003)[62]	Pre–post Healthcare system infrastructure and process	300	156	NR	NR NR	NR NR	NR	Primary care practices, U.S.
Varroud-Vial (1999)[63] 1999	Pre–post Patients or population	505	52	61.9 (NR)	37.0 NR	9.0 (NR) Diet, oral agents, insulin	NR	GP practices, France
Vinker (2003)[64]	Pre–post Patients or population	420	52	65.8 (12.9)	51.1 NR	NR Diet, oral agents, insulin	NR	Community-based clinics, physicians, Israel
Mean (SD) or total for all studies		Total= 162,157 Mean= 3,378	Mean=89	60.2 (12.7)[a]	Mean=53.6[a]	9.4 (7.9)[a]		
Range (for all studies)		30–27,270	16–208				0–14.9	

[a]Mean (SD) not weighted by sample size.

GP, general practitioner; HMO, health maintenance organization; MCO, managed care organization; PCP, primary care practitioner; RCT, randomized controlled trial; SD, standard deviation; NR, not reported.

Table 2. Intervention effects and relative risk of retinal screening

Study	Intervention focus	Interventions	Intervention effects	Relative risk (95% confidence interval)	Screening rates
Randomized controlled trials					
Anderson (2003),[18] Anderson (2002)[66]	Patients or population	Letter with a friendly phone care in 10 days for IG and a letter without phone call for CG.	Personalized follow-up intervention increased patient awareness.	1.86 (1.28–2.69)	IG: 24.2%/65.7% CG: 26.2%/ 35.4%
Basch (1999)[21]	Patients or population	Eucation program to increase knowledge about diabetic retinopathy.	Education intervention increased patient awareness of diabetic retinopathy.	2.01 (1.48–2.73)	IG: NR/54.7% CG: NR/27.3%
Halbert (1999)[35]	Patients or population	Educational material and reminders to increase patient awareness of retinopathy screening.	Education combined with reminder increased patients awareness and their participation in preventive care.	1.05 (1.01–1.08)	IG: 25.4%/37.0% CG: 24.3%/ 35.4%
Lafata (2002)[44]	Patients or population	Mailed reminders to increase patient awareness.	Reminder increased patients awareness and their participation in preventive care.	1.13 (1.04–1.23)	IG: 49.9%/43.8% CG: 47.1%/ 38.8%
Prela (2002)[56]	Patients or population	Direct mail intervention to increase retinal exam rates.	Mail intervention increased patients awareness and their participation in preventive care.	1.02 (0.94–1.10)	IG: 32.1%/32.9% CG: 33.0%/ 32.4%
Davis (2003)[30]	Healthcare system infrastructure and process	Telemedicine retinal screening program to improve patient access to retinopathy screening services.	Telemedicine program helped to overcome barriers to preventive care in rural and ethnically diverse communities.	5.56 (2.19–14.10)	IG: NR/76.7% CG: NR/13.8%
Hurwitz (1993)[39]	Healthcare system infrastructure and process	Prompting system to enable GPs to structure diabetic care without setting up miniclinics.	Infrastructure intervention increased provider adherence to practice guideline.	1.12 (1.03–1.22)	IG: NR/97.8% CG: NR/87.0%
Ilag (2003)[40]	Healthcare system infrastructure and process	Annual diabetes assessment program to improve diabetes care.	System with complete records and databases improved performance of healthcare delivery services.	1.27 (1.05–1.54)	IG: NR/84.3% CG: NR/66.2%
McCulloch (1998)[52]	Healthcare system infrastructure and process	Program including continually updated online registry and practice redesign to improve primary care.	Screening system with registration increased patient participation in preventive care.	1.19 (1.07–1.33)	IG: 52.4%/57.5% CG: 51.8%/ 48.2%
Montori (2002),[54] Dinneen (2000),[67] Gorman (2000)[68]	Healthcare system infrastructure and process	Diabetes electronic management system to improve community-based diabetes care.	Electronic management system increased patient participation in preventive care and provider implementation of pratice guideline.	1.92 (1.43–2.57)	IG: 31.0%/69.0% CG: NR/36.0%

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Table 2. (*continued*)

Study	Intervention focus	Interventions	Intervention effects	Relative risk (95% confidence interval)	Screening rates
Glasgow (2004)[32]	Patients or population, and provider and practice	Intervention to improve physician service and patient awreness, knowledge, and self-management.	Program increased patient awareness and improved provider adherence to practice guideline.	1.13 (1.04–1.22)	IG: 67.7%/76.8% CG: 59.5%/ 68.1%
McDermott (2001),[53] McDermott (2003)[71]	Patients or population, and healthcare system infrastructure and process	Intervention including registers, recall and reminder systems, and basic training for GP in clinical diabetes care.	Healthcare delivery system with reminder helped increase patient awareness and overcome geographic barriers.	1.30 (1.12–1.50)	IG: 21.0%/59.2% CG: 18.0%/ 45.7%
Other designs					
Clark (2001)[28]	Patients or population	Comprehensive diabetes management program to educate, consult, and remind patients.	Comprehensive diabetes care improved flexibility of providers and practices.	1.49 (1.29–3.64)	52.9%/80.3%
Gross (1999)[34]	Patients or population	Survey on receipt of preventive care from hospitalized patients and survey results to their providers.	Patients feedback helped reductions in negligence of practices.	0.32 (0.02–5.01)	21.4%/0%
Maliszewski (1988)[51]	Patients or population	Education program to increase patient awareness of retinal screening.	Education increased patient knowledge and changed behaviors regarding diabetic eye care.	1.78 (1.50–2.12)	40.2%/71.7%
Varroud-Vial (1999)[63]	Patients or population	Cooperation program between GPs and diabetes specialists, including patient feedback and education.	Cooperation program provided patients with structured diabetes care and better access to specialist services.	1.12 (1.02–1.22)	61.0%/68.0%
Vinker (2003)[64]	Patients or population	Program including phone call and written reminder to increase patient awareness of retinal screening.	Involvement of both patients and providers in preventive care increased patient awareness.	1.80 (1.59–2.03)	42.1%/75.7%
Brooks (2002)[23]	Provider and practice	Diabetic Self-Audit Tool, registery of patients, to improve practices of primary care.	Disease-specific system improved provider adherence to practice guideline.	1.07 (0.98–1.16)	53.9%/57.5%
Hastings (1998)[37]	Provider and practice	Record card to prompt provision of eye examination by providers, community optometrists.	Cooperation card prompted screening rates by increasing provider adherence to practice guideline.	1.32 (1.16–1.51)	52.5%/69.5%

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Table 2. Intervention effects and relative risk of retinal screening (*continued*)

Study	Intervention focus	Interventions	Intervention effects	Relative risk (95% confidence interval)	Screening rates
Mak (2003)[50]	Provider and practice	Staff training and credentialing program to improve quality of retinal screening.	Training providers helped to overcome geographic barriers to preventive care in remote areas.	1.48 (1.29–1.69)	58.2%/85.9%
Schectman (2004)[59]	Provider and practice	Physician feedback and action checklist on diabetes care measures to improve diabetes care.	Physician feedback helped increase their adherence to practice guideline.	1.36 (1.16–1.60)	23.4%/31.9%
Al-Khaldi (2002),[17] Al-Khaldi (2002)[65]	Healthcare system infrastructure and process	Miniclinic using referral letter, diabetic card, health education pamphlets to remind patients.	Miniclinic improved access to preventive care and increased availability of healthcare delivery system.	1.65 (1.30–2.09)	32.8%/52.0%
Backlund (1998)[19]	Healthcare system infrastructure and process	Community-wide fundus photography for early detection of diabetic retinopathy by mobile teams.	Community-based program improved access to preventive care.	5.46 (5.17–5.78)	18.3%/100.0%
Brown (2000)[24]	Healthcare system infrastructure and process	Electronic diabetes registry for population-based primary care management program.	Electronic register improved use of database and increased the efficacy of screening systems.	1.35 (1.32–1.38)	50.4%/68.0%
Davidson (2000)[29]	Healthcare system infrastructure and process	Pharmacist-managed diabetes care program to serve patients with consultations.	Pharmacist-managed program provided greater availability of healthcare delivery systems.	1.24 (0.92–1.69)	41.0%/51.0%
Harwell (2002)[36]	Healthcare system infrastructure and process	Computerized diabetes monitoring system and specific interventions to optimize diabetes care.	Office-based electronic system improved delivery of preventive services to under-served patients.	2.17 (1.61–2.91)	13.9%/30.0%
Jin (2003)[41]	Healthcare system infrastructure and process	Mobile diabetes care telemedicine clinic to impove aboriginal population access to diabetes care.	Telemedicine improved access to preventive care and provided adequate services in geographically remote areas.	2.13 (1.90–2.39)	46.9%/100.0%
Johnston (2000)[42]	Healthcare system infrastructure and process	Clinical management system to help identify patients and recall them for review.	Computerized system provided complete records and database and further increased screening rates.	1.00 (0.98. 1.02)	94.9%/94.9%

(*continued on next page*)

Table 2. (*continued*)

Study	Intervention focus	Interventions	Intervention effects	Relative risk (95% confidence interval)	Screening rates
Kristinsson (1997)[43]	Healthcare system infrastructure and process	National diabetic eye screening program to improve diabetic retinopathy care.	National screening program provided adequate access to preventive care.	1.17 (1.11–1.24)	85.4%/100.0%
Maislos (2002)[49]	Healthcare system infrastructure and process	Mobile diabetes clinic provided comprehensive, interdisciplinary care to patients.	Mobile clinic provided greater availability of healthcare delivery systems.	2.49 (2.19–2.84)	34.9%/87.0%
Nagykaldi (2003)[55]	Healthcare system infrastructure and process	Personal digital assistant–based diabetes management system to improve diabetes care.	Electronic screening system improved delivery of preventive services.	1.48 (1.32–1.66)	41.0%/60.7%
Rubin (1998)[57]	Healthcare system infrastructure and process	Comprehensive diabetes management program to improve diabetes care.	Comprehensive program provided greater availability of healthcare delivery systems.	1.74 (1.63–1.85)	23.0%/40.0%
Sawin (2004)[58]	Healthcare system infrastructure and process	Computerized clinical reminders to improve diabetes care.	Computerized system increased provider adherence to practice guideline.	1.52 (1.49–1.56)	44.0%/67.0%
Simmons (2003)[60]	Healthcare system infrastructure and process	Diabetes care promoter integrated primary and specialist care for patient identification, administration.	Integrated care helped to overcome barriers to preventive care by providing resources and approaches.	1.12 (0.95–1.30)	86.7%/96.7%
Snyder (2003)[62]	Healthcare system infrastructure and process	Diabetes disease management program, Diabetes Decisions, to improve diabetes care.	Information system involved both patients and providers in preventive care and improved performance of care.	4.07 (3.16–5.26)	17.3%/70.6%
Baker (1993)[20]	Patients or population, and provider and practice	Patient and professional education program to increase knowledge, skills, and self-management abilities.	Cooperation model increased patient awareness and provider adherence to practice guideline.	3.25 (2.90–3.64)	8.0%/26.0%
Brooks (1996)[22]	Patients or population, and provider and practice	Letter to physicians with list of members needing eye exams, and letter to patients with recommendation.	Reminder letters helped decrease negligence of practices and increase patient awareness.	1.25 (1.22–1.28)	35.9%/44.8%
Buonaccorso[25] (1999)	Patients or population, and provider and practice	Group meeting to improve physician service, and education brochure to increase patient awareness.	Education approach helped decrease negligence of practices and increase patient awareness.	1.36 (1.33–1.39)	42.8%/58.1

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Table 2. Intervention effects and relative risk of retinal screening (*continued*)

Study	Intervention focus	Interventions	Intervention effects	Relative risk (95% confidence interval)	Screening rates
Burnett (1998)[26]	Patients or population, and provider and practice	Information leaflet and reminder letters to patients; and specialist training program for GPs.	Prompted recall program increased patient awareness and training program improved provider adherence to guideline.	1.17 (1.03–1.32)	47.9%/55.9%
Chicoye (1998)[27]	Patients or population, and provider and practice	Reminder to HMO members, and group education programs for patients and providers.	Program worked for both patients and providers and increased patient awareness and provider adherence to guideline.	1.15 (1.08–1.23)	26.0%/30.0%
Deeb (1988)[31]	Patients or population, and provider and practice	Professional education program for primary care staff service, and education module for patients.	Education program increased patient awareness and improved provider performance.	4.16 (3.10–5.58)	11.3%/46.9%
Hempell (1990)[38]	Patients or population, and provider and practice	Diabetic flow sheet for provider service, and weekly diabetes education for patient awareness.	Program increased patient awareness and decreased negligence of practices.	1.20 (0.92–1.55)	38.6%/46.2%
Lee (2000),[46] Lee (2000),[70] Harper (1998)[69]	Patients or population, and provider and practice	Community-based screening program using letters, brochures, and education materials for GPs and patients.	Community-based program worked for both patients and providers and increased patient awareness and provider adherence to guideline.	1.93 (1.83–2.04)	51.8%/100.0%
Legorreta (1997)[47]	Patients or population, and provider and practice	American Diabetes Association guidelines and education materials for physician and patient compliance with diabetes care.	Reminder increased patient awareness and provider adherence to practice guideline.	1.25 (1.19–1.31)	20.9%/26.1%
Goldfracht (2000)[33]	Provider and practice, and healthcare system infrastructure and process	Continuing education, and establishing guidelines and diabetes registers.	Program increased provider adherence to guideline and improved performance of healthcare system.	1.77 (1.61–1.96)	38.5%/68.3%
Larsen (2003)[45]	Provider and practice, and healthcare system infrastructure and process	Population-based management system, including education program, feedback, and reminder system.	Program improved performance of healthcare delivery system and decreased negligence of practices.	1.19 (1.16–1.23)	52.0%/62.0%

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Table 2. (*continued*)

Study	Intervention focus	Interventions	Intervention effects	Relative risk (95% confidence interval)	Screening rates
Letassy (2003)[48]	Provider and practice, and healthcare system infrastructure and process	Diabetes flow sheet, physician prompt form, consultation form, and continuing education.	Cooperation program provided greater availability of health care and increased provider adherence to guideline.	1.51 (1.09–2.08)	44.3%/66.7%
Snyder (2001)[61]	Patients or population, provider and practice, and healthcare system infrastructure and process	Extensive physician and patient education, guideline dissemination, and information systems to track patients.	Physician feedback helped improve performance of healthcare system. and education increased patient awareness.	1.63 (1.45–1.83)	35.0%/57.1%

CG, control group; GP, general practitioner; HMO, health maintenance organization; IG, intervention group; NR, not reported.

2.01 (95% CI=1.48–2.73).[21] Similar results were noted among the nonrandomized study designs,[28,34,51,63,64] the RR ranged from 1.12 (95% CI=1.02–1.22)[63] to 1.80 (95% CI=1.59–2.03).[64]

Five RCTs focusing on the healthcare system infrastructure and processes also demonstrated that interventions increased screening significantly[30,39,40,52,54]; the RR ranged from 1.12 (95% CI=1.03–1.22)[39] to 5.56 (95% CI=2.19–14.10).[30] Most of the nonrandomized studies also demonstrated improvements[17,19,24,36,41,43,49,55,57,58,62]; the RR ranged from 1.17 (95% CI=1.11–1.24)[43] to 5.46 (95% CI=5.17–5.78).[19]

No RCTs focused only on provider and practice. Three of four studies with designs other than RCTs demonstrated increased screening[23,37,50,59]; the RR ranged from 1.32 (95% CI=1.16–1.51)[37] to 1.48 (95% CI=1.29–1.69).[50]

Among RCTs, only two studies had multiple foci. One focused on both patients and providers (RR 1.13 [95% CI=1.04–1.22])[32] and another focused on both patients and the system (RR 1.30 [95% CI=1.12–1.50]).[53] Among studies with nonrandomized study designs and multiple foci, eight of nine that focused on both patients and providers demonstrated significantly increased screening[20,22,25–27,31,38,46,47]; the RR ranged from 1.15 (95% CI=1.08–1.23)[27] to 4.16 (95% CI=3.10–5.58).[31] Three studies focusing on both provider and system demonstrated increased screening as well[33,45,48]; the RR ranged from 1.19 (95% CI=1.16–1.23)[45] to 1.77 (95% CI=1.61–1.96).[33] One study that focused on all three—patients, providers, and system—also increased screening (RR 1.63 [95% CI=1.45–1.83]).[61] In general, studies with non-RCT designs were conducted in more diverse populations and settings than RCTs.

As shown in Figure 2, all RCTs with interventions focusing on the healthcare system significantly increased retinal screening. The highest increase in retinal screening was reflected by an RR of 5.56 (95% CI=2.19–14.10).[30] Further, 11 out of 12 RCTs demonstrated that effects can be sustained for >1 year.

Some characteristics of diabetic populations and healthcare systems were found to be related to the effect of interventions. Interventions were less likely to reach the goal of increased screening if they were conducted in rural residences,[60] in a population consisting of a higher proportion of ethnic minorities,[29,38] and in a large study population.[23,56] By contrast, interventions were more likely to reach the goal if healthcare systems were equipped with computerized registration systems or databases.[22–25,26,35,47,52,55,62] There was also evidence that interventions were more likely to succeed if they were involved in multidisciplinary collaboration and comprehensive multicomponent interventions.[24,27,56,60,62]

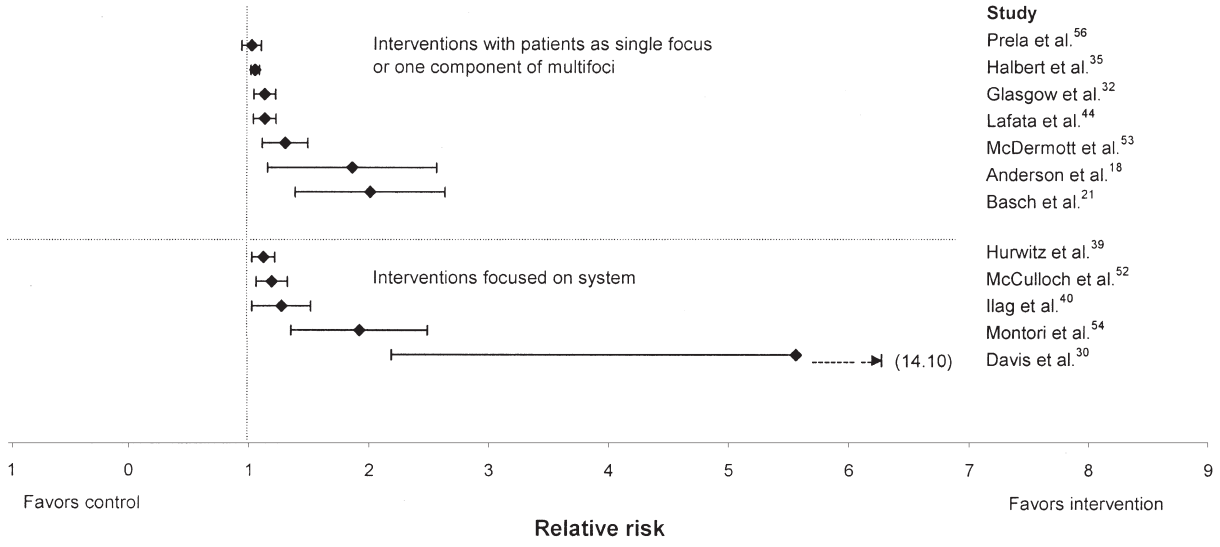

Figure 2. Relative risk of retinopathy screening among randomized controlled trials: interventions compared to usual care.

Discussion and Conclusion

Many of these studies showed significant improvements in retinal screening in intervention groups, suggesting that a variety of interventions can be effective. In all but one RCT[56] reviewed, interventions achieved statistically significant increases in retinal screening in the intervention group compared to the control group. Studies showed that the following interventions were effective: increasing patient and provider awareness of diabetic retinopathy, improving access to health care, introducing computer-based registration or reminder systems, collaboration among local organizations that provide retinal screening, and developing a community-based healthcare system. These interventions, like many other chronic care interventions, improved the screening for diabetic retinopathy in the health system settings at the community, organization, practice, and patient levels. These findings were also consistent with the mechanisms as a chronic care model demonstrated.[72] When all elements of the chronic care model, such as the community, the health system, self-management support, delivery system design, decision support, and clinical information systems, were combined, the combination could foster productive interactions between informed patients who took an active part in their care and providers with resources and expertise.[72]

Awareness by patients and providers of the risk of diabetic retinopathy is crucial for successfully intervening to improve retinal screening use. Within this review, a "reminder" was the most frequently used intervention to promote the retinal screening,[18,26,34,43,46,55,63] and it was more effective if sent to both physicians and patients.[64] Furthermore, this approach could be applicable on a national level if health plans and physicians had a collaborative relationship.[47] Although a reminder can increase patients' awareness and improve their adherence to diabetic retinal screening recommendations,[27] one study found that sustaining the effect can be difficult.[56] Evidence also suggests that there is only small improvement in screening rates after the second reminder and no incremental improvement with additional reminders.[35] This ceiling effect may occur because people who are contemplating action are moved to action, while the remaining population is resistant to obtaining the desired services. One study suggests that further screening rate increases may require other approaches, such as education programs.[35]

Register, review, and recall were found to be powerful components of interventions to improve rates of retinal screening.[32,51,52] These components also support administrative measures in quality improvement, because they provide an efficient mechanism for tracking and monitoring the successful delivery of health care.[32,51,52] The wide application of electronic medical record systems and electronic management systems[18,23,35,41,53,54] have facilitated this implementation of these components, although a registry and a basic paper tracking mechanism can also be used.[23] A simple physician feedback tool with a paper checklist worked efficiently in one setting to improve the rate of retinal screening.[59]

An increase in retinal screening depends not only on patients' adherence to diabetes care recommendations, but also on physicians' adherence to recommended guidelines for an annual examination.[18,21] This review showed the importance of both patients and providers participation. Eight of nine studies with nonrandomized designs and multiple foci on both patients and providers demonstrated significantly increased screening.[20,22,25–27,31,38,46,47] The dual patient/physician approach fosters patients' participation in the process of their own medical care. Such participation can be less

costly and less labor intensive.[22] Studies also showed that the effectiveness of education intervention depends to a great degree on such dual participation.[30,50] Fostering patients' participation in their care, therefore, significantly improves the quality of care delivered to patients with diabetes,[31] and should be made the primary goal of strategies to promote retinal screening.[51]

Diabetes management is a complex process, and studies demonstrated that multidisciplinary collaboration or comprehensive multicomponent interventions can achieve higher screening rates.[24,27,56,60,62] A multifaceted approach to improving diabetes management—increasing physicians awareness and knowledge on the one hand and improving their clinical performance by use of incentives on the other—was found to address the complexity of the diabetes treatment process.[45]

Adequate access to health care is a primary determinant of success of interventions focusing on healthcare systems. This review revealed that the rate of retinal screening could be improved through improving access to primary care.[18,20,29,38,40,45,48,49,65] In the systematic review, the identified inadequate access included financial constraints,[20,38,65] cultural tensions,[18,45] and maldistribution of the healthcare workforce or geographic components.[29,48,49]

One study[66] found that for under-served ethnic-minority populations, the lack of health insurance or healthcare availability hindered intervention to further increase recommended screening. Many community-based organizations serving inner-city residents were strapped for resources.[66] A solution may be collaboration with community-based organizations.[66] Focusing an intervention on high-risk subgroups is a valid strategy for improving overall rates.[21] In an under-served inner-city area, structured prompting of community care—enabling general practitioners to structure diabetic care—was proven to be an efficient way to increase retinal screening.[39]

Cultural factors such as language may also influence the effectiveness of an intervention. A culturally tailored approach in a community-based screening program played a role in promoting retinal screening.[46] This program provided patients with a brochure in both English and the main languages spoken within specific ethnic areas (e.g., in rural areas of the La Trobe and Coulburn Valleys, Australia).[46] Backlund et al.[19] reported that examining patients in a more familiar and reassuring environment within their own primary healthcare centers minimized barriers to access.

In rural and ethnically diverse communities, use of telemedicine could bridge barriers to access, such as transportation.[30] A mobile diabetes clinic was used to improve access in a geographically spread-out population.[40,48] A program of training, credentialing, and ongoing professional development for retinal practitioners was found to be effective in a remote rural area in which providers were scarce.[50]

This review has several limitations. Heterogeneity among study designs, types of interventions, the length of follow-up, and the characteristics of participants made quantitative synthesis and between-study comparisons difficult. As mentioned previously, all studies were divided into three groups on the basis of their primary intervention foci. There was, however, considerable diversity of interventions within each of the three groups. For example, within the group focused on patients and populations, one study may have used an education program to promote patient awareness of retinal screening, while another study may have used reminders for patients. This diversity made syntheses difficult and precluded a quantitative synthesis. The characteristics of healthcare systems were variable; thus, specific interventions may be applicable to certain settings, regions, or countries. Publication bias (i.e., positive studies are more likely to get published than negative studies) likely exists, affecting the conclusions.

The findings of this systematic review demonstrated that by increasing patient awareness of diabetic retinopathy, improving the performance of providers and practices, and improving healthcare system infrastructure and processes, interventions can significantly improve screening rates for diabetic retinopathy. Further research should explore strategies for increasing retinal screening among diverse or disadvantaged populations and the economic efficiency of effective interventions in large community populations.

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