

# A Systematic Review of Diabetes Disease Management Programs

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**Objective:** To systematically evaluate and synthesize published evidence regarding the effect of disease management programs for patients with diabetes mellitus on processes and outcomes of care.

**Study Design:** Systematic literature review and meta-analysis.

**Patients and Methods:** Computerized databases were searched for English-language controlled studies assessing the effect of diabetes disease management programs published from 1987 to 2001. Two reviewers extracted study data using a structured abstraction form. Pooled estimates of program effects on glycated hemoglobin were calculated using an empirical Bayes model.

**Results:** The pooled estimate of program effects on glycated hemoglobin was a 0.5–percentage point reduction (95% confidence interval, 0.3 to 0.6 percentage points), a modest but significant improvement. Evidence also supports program benefits in improving screening for retinopathy and foot lesions.

**Conclusions:** Diabetes disease management programs can improve glycemic control to a modest extent and can increase screening for retinopathy and foot complications. Further efforts will be required to create more effective disease management programs for patients with diabetes mellitus.

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Diabetes mellitus creates a significant clinical and economic burden on society.<sup>1-3</sup> For 1998, direct and indirect costs of diabetes mellitus and its complications are estimated at \$98.2 billion in the United States.<sup>1,2</sup> Standards of care for diabetes mellitus have been broadly disseminated since the 1980s<sup>2</sup> in the belief that improved processes of care can improve patient outcomes,<sup>4,5</sup> but primary care providers have been slow to implement patient care guidelines and recommendations.<sup>6,7</sup> Several barriers to guideline adherence and implementation have been identified,<sup>8,9</sup> including the perception that type 2 diabetes mellitus is not serious, that aggressive treatment cannot forestall complications,<sup>10,11</sup> that guidelines are not flexible enough to be useful in patient care,<sup>8</sup> and that patients with diabetes mellitus are unwilling to make needed lifestyle changes.<sup>12-14</sup>

Given their numbers and economic effect, improving care for patients with diabetes mellitus has become a priority for health plans, payers, and patients. The number and complexity of services required to manage such patients in accord with accepted guidelines have made diabetes mellitus the target of multiple disease manage-

ment efforts, as well as targeted efforts involving professional education and case management.

Other reviews have addressed the effectiveness of professional education and structure of care<sup>15</sup> and case management<sup>16</sup> in improving patient outcomes. The objective of this study is to systematically evaluate the published literature on the effectiveness of diabetes disease management programs—defined as structured, multifaceted, systematic approaches to care—on glycemic control and other relevant outcomes.

## METHODS

### Literature Review

A systematic review of the medical literature was performed with the assistance of an expert librarian, using the computerized bibliographic databases MEDLINE, HealthSTAR, and Cochrane Database of Systematic Reviews to identify assessments of disease management programs in different areas. English-language studies published between January 1987 and June 2001 were identified and reviewed, with the 1987 date reflecting the approximate beginning of widespread interest in disease management. Search terms included the following Medical Subject Headings: *patient care team, patient care planning, primary nursing care, case management, critical pathways, primary health care, continuity of patient care, guidelines, practice guidelines, disease management, comprehensive health care, ambulatory care*, and the title words *disease state management* and *disease management*. A

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hand search of bibliographies from relevant articles and reviews was also conducted, and the opinions from expert physicians and researchers in the field were solicited to identify other references.

We defined disease management according to a previously published definition used by Ellrodt et al.<sup>17</sup> Programs that used a systematic approach to care and included more than 1 intervention component (an appendix listing the classification of interventions is available from the authors upon request) were considered as using disease management. Trials of pharmacological agents were excluded. A systematic approach to care was defined as inclusion of any of the following components: guidelines, protocols, algorithms, care plans, or systematic patient or provider education programs. Unstructured professional education and case management programs were not included.

Specific inclusion and exclusion criteria were developed for reviewing titles, abstracts, and articles. Two reviewers (KK, EB) trained in health services research and in the principles of critical appraisal independently reviewed a 10% sample of randomly selected studies, with any discrepancies resolved by consensus. The remaining studies were distributed among reviewers only when a sufficient level of agreement was achieved ( $\kappa > 0.7$ ).

Titles were rejected if they did not deal with adult patients or were reviews, case reports, editorials, letters, or meeting abstracts. Abstracts were rejected if they did not report any objective measurements of disease management, referred to clinical trials comparing single pharmacological agents or diagnostic procedures, or did not use a systematic approach to care. Studies were rejected if they lacked sufficient information to measure the effect of an intervention on at least 1 outcome of interest and its variance. To measure the effect of a given intervention, studies should have used an experimental or quasi-experimental study design meeting the criteria established by the Cochrane Effective Practice and Organization of Care Group and should have included an appropriate comparison group. Acceptable designs included randomized clinical trials and controlled before-and-after studies (studies with a parallel nonrandomized comparison group, with baseline and follow-up assessments of both groups).<sup>18</sup>

From the pool of accepted disease management assessments, those aimed at the management of diabetes mellitus were selected. Study information was abstracted from the accepted articles using a standardized data abstraction form and included the following: study design, setting, intervention strategies, and outcomes of interest. All components of the disease management intervention were identified using classifications based

on definitions taken from the Cochrane Collaboration for providers, patients, and organizations.<sup>18</sup> Outcomes from the following 12 domains were collected: glycated hemoglobin (GHb) levels, serum lipids (low-density lipoprotein [LDL] cholesterol, high-density lipoprotein [HDL] cholesterol, and total cholesterol), systolic blood pressure, hospital admissions, mean number of GHb tests per patient, screening for retinopathy, screening for nephropathy, foot screening, foot self-care, patient knowledge, self-reported health status, and patient satisfaction. If a study reported outcome measures at multiple time points for a single domain, results from the longest follow-up were used. If the serum LDL cholesterol level was reported, it was used instead of the total cholesterol level. Systolic blood pressure was abstracted as it is a better predictor of cardiovascular events than diastolic blood pressure.<sup>19</sup> One observation per outcome was abstracted for each intervention arm, so studies evaluating more than 1 intervention could contribute more than 1 observation per program.

### Meta-analysis

To account for baseline differences in GHb levels between groups, the mean changes over baseline were compared. Given the fact that certain data elements may not be provided in the identified studies, we created a list of assumptions a priori to facilitate the meta-analysis. In the 3 instances in which baseline means were not reported, the assumption that the treatment and control group baseline means were equal was used. Variances of changes were rarely reported. In those instances lacking reported variances, the variance of the change was assumed to be equal to one half of the sum of the variances of the baseline and follow-up measures. In the absence of baseline variances, it was assumed that baseline variances in the treatment and control groups were equal to the follow-up variance in the control group.

A test for homogeneity was performed using the  $\chi^2$  test. The more conservative random-effects method (the empirical Bayes method proposed by Hedges and Olkin<sup>20</sup>) was used to pool the estimated program effects on GHb levels.<sup>21</sup> Results are reported as the pooled differences in change in GHb level in treated versus control subjects. Although there are subtle differences between the various species of GHb, all refer to and describe the modification of hemoglobin by a sugar (ie, glucose).<sup>22-26</sup>

### Publication Bias

As part of an exploratory data analysis, funnel plots were constructed by plotting each program's estimated effect on change in GHb against the inverse of its vari-

ance to assess potential publication bias.<sup>27,28</sup> We used the trim and fill method<sup>29</sup> to determine if adjustments for publication bias were warranted and, if so, to adjust the estimates. Stata 8 (StataCorp LP, College Station, Tex) was used to perform this analysis.

## RESULTS

### Literature Review

The initial search strategy identified 16 917 references. A total of 2963 titles were accepted for further screening, and 581 abstracts met inclusion criteria. Eighty-five percent (n = 493) of the accepted abstracts failed to meet inclusion criteria when the articles were reviewed. Bibliographic hand searches and expert consultation yielded an additional 53 articles for review, of which 16 were accepted. Twenty-four studies<sup>30-52</sup> dealt with diabetes mellitus.

Of 24 studies meeting our inclusion criteria, 19 studies were randomized clinical trials and 5 studies<sup>33,39,41,42,44</sup> were nonrandomized controlled studies. Five<sup>31,37,47,50,52</sup> of 19 randomized trials used a cluster randomization scheme for treatment allocation. The aggregate sample size for the 24 studies was 6421 patients, and the total number of patients studied in each report ranged from 38 to 1939. More than half (15/24) of the studies were conducted in the United States, 4 were carried out in the United Kingdom, and the remaining 5 were conducted in Israel, Argentina, Austria, and the Netherlands. Study duration ranged from 3 months<sup>38</sup> to 30 months,<sup>46</sup> while the duration of the disease management intervention ranged from several days<sup>37</sup> to 30 months.<sup>46</sup> Key characteristics of identified studies are available from the author.

Most (20/24) studies were funded by research grants provided by governmental offices, academia, or research foundations. Four studies<sup>38-40,42</sup> received additional support from pharmaceutical companies. Four studies<sup>34-36,41</sup> assessed disease management costs in relation to a primary care or health maintenance organization setting, while cost per patient<sup>43,45</sup> and cost of program implementation<sup>31,50</sup> were assessed in 2 studies each. Different interventions were used, ranging from patient education sessions to centrally administered provider reminders to integrated multidisciplinary team approaches.

### Glycemic Control

Twenty studies,<sup>30,33-46,48-50,52,53</sup> contributing 24 observations and involving 3720 patients, were included in the meta-analysis to evaluate the effect of disease management on GHb level. Of these 24 treatment-control comparisons, 9 (38%)<sup>35,36,39-41,44,49,52,53</sup> reported statistically significant differences favoring the treatment

group. The rest showed no significant differences; in one<sup>52</sup> of those studies, a treatment arm experienced an increase in GHb level relative to the comparison arm. Significant heterogeneity in results was confirmed by the results of our test for homogeneity ( $P < .001$ ). Overall, the pooled result (using a random-effects model) showed that disease management programs resulted in a statistically significant reduction in GHb level (mean reduction, 0.5 percentage point; 95% confidence interval [CI], 0.3 to 0.6 percentage points). We also calculated results based on geographic location (US vs non-US studies). The mean reduction in GHb level for US observations (n = 16) was 0.6 percentage point (95% CI, 0.4 to 0.9 percentage points), while the mean reduction for non-US observations (n = 8) was 0.32 percentage point (95% CI, 0.01 to 0.54 percentage points). However, the small number of trials in countries outside the United States limits conclusions.

Programs associated with the greatest estimated changes in GHb levels include 1 program involving pharmacists counseling patients and medication adjustment<sup>40</sup> and 2 programs involving combined physician and patient interventions.<sup>49,52</sup> Small sample size limits generalizations with regard to effects of different types of programs. A study by Vinicor et al,<sup>52</sup> including arms with structured physician education alone and in combination with patient education, demonstrated improved results with the combination program. The **Figure** is a forest plot displaying estimated program effects on GHb.

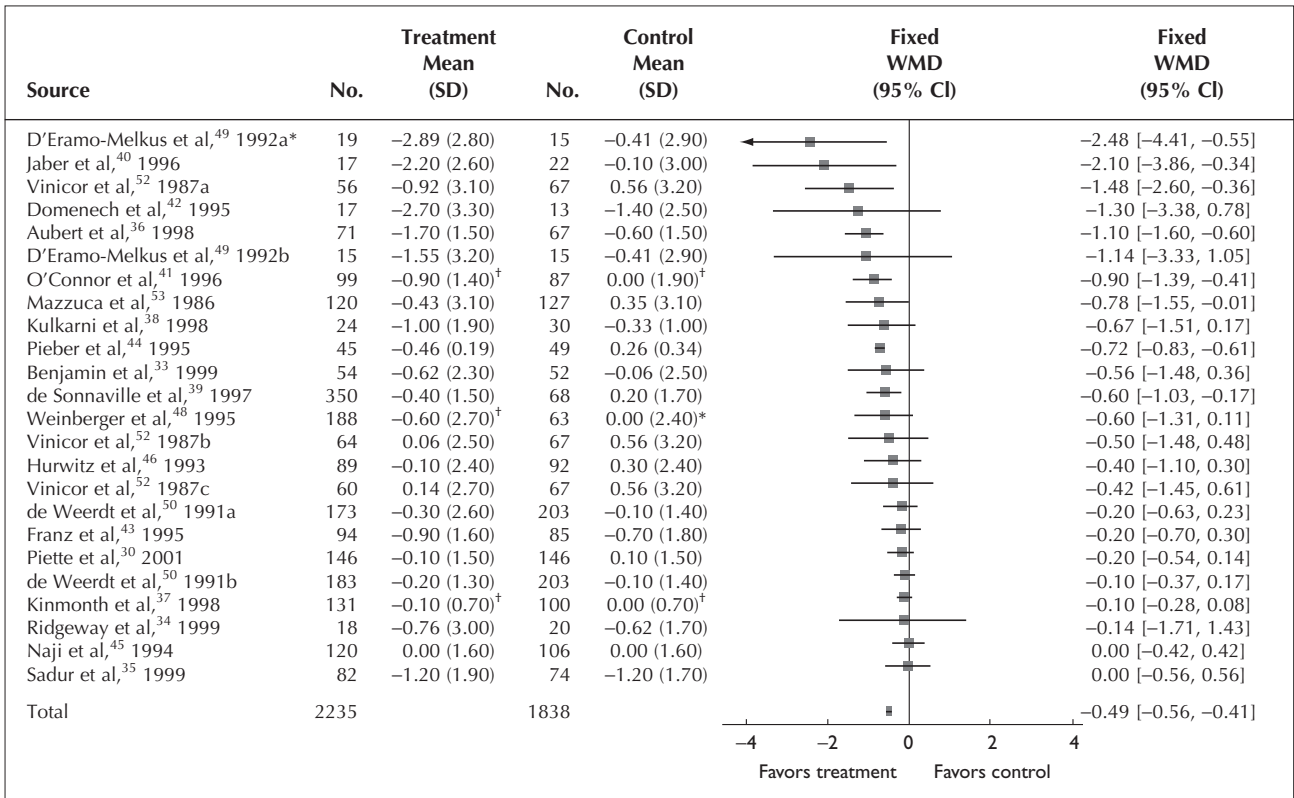
### Frequency of Glycemic Monitoring

Four studies,<sup>30,41,45,46</sup> involving 958 patients, assessed the effect of disease management on the frequency of glycemic monitoring (**Table 1**). These measured the mean number of GHb tests per patient, percentage of patients who had a GHb test, and mean number of self-monitored blood glucose levels. Two studies<sup>45,46</sup> reported significant increases in the frequency of GHb tests performed in intervention patients. A third study<sup>41</sup> showed no change in the percentage of patients who received at least 1 GHb test. The study by Piette et al,<sup>30</sup> involving 292 subjects, found that program patients were more likely to perform home glucose monitoring than control patients.

### Screening for Retinopathy

Three studies,<sup>30,45,46</sup> with 708 patients, investigated the effect of disease management on the frequency of retinal examinations (**Table 1**). Two studies<sup>45,46</sup> evaluated the mean number of retinal examinations performed per patient, while the third study<sup>30</sup> examined the percentage of patients receiving an ophthalmologic examination. Two studies<sup>45,46</sup> showed a small but statistically

**Figure.** Forest Plot of the Estimated Program Effects on Glycemic Control



\*a = comparison 1; b = comparison 2; c = comparison 3.  
<sup>†</sup>Baseline values not reported, assumed to equal control group follow-up values.  
 SD indicates standard deviation; WMD, weighted mean difference; CI, confidence interval.

significant improvement in the frequency of retinal examinations. One study<sup>30</sup> reported that a slightly higher proportion of patients in the intervention group received an eye examination.

**Screening for Nephropathy**

Three studies,<sup>37,40,46</sup> involving 447 patients, assessed program effects on screening for nephropathy (Table 1). One study<sup>37</sup> reported that slightly more patients in the intervention group were screened for nephropathy. Another study<sup>46</sup> showed that the mean number of screening tests for nephropathy was similar in the intervention and control groups. The last study<sup>40</sup> demonstrated a statistically significant decrease in serum creatinine levels in the intervention patients.

**Foot Screening and Podiatrist Referral**

Three studies,<sup>31,45,47</sup> involving 1912 patients, examined the effects on the frequency of foot screening (Table 1). Of these, 2 studies<sup>31,47</sup> evaluated the percentage of patients receiving foot examinations, while another study<sup>45</sup> evaluated the mean number of foot

examinations performed per patient. All 3 studies showed that programs increased the number of foot examinations performed, with the study by Naji et al<sup>45</sup> demonstrating a statistically significant improvement with disease management.

Two studies<sup>46,47</sup> with 547 patients evaluated the proportion of patients referred to a podiatrist. One study<sup>47</sup> showed an increase in referrals from primary care physicians to a podiatrist, while the other study<sup>46</sup> reported fewer referrals in intervention patients.

**Foot Self-care**

Three studies,<sup>30,35,47</sup> with 817 patients, evaluated patient foot self-care (Table 1). One study<sup>30</sup> found that the control group patients examined their feet significantly more frequently than those in the treatment group. Another study<sup>35</sup> showed that patients in the intervention group examined their feet more often than those in the control group. The third study<sup>47</sup> reported that intervention patients practiced more appropriate foot care behaviors compared with control patients. This difference was statistically significant.

**Table 1.** Studies Assessing the Effect of Disease Management Programs on Processes of Care (Provider and Patient Compliance)\*

Source	Outcome	Treatment No.	Control No.	Treatment Results	Control Results	Difference (95% CI)
<b>Monitoring glycemic levels</b>						
Hurwitz et al, <sup>46</sup> 1993	No. of GHb tests per patient per year	86	78	2.4 (0.4)	0.9 (0.1)	1.5 (0.9-2.1)
Naji et al, <sup>45</sup> 1994	No. of GHb tests performed per patient at end of follow-up	124	111	4.5 (0.1)	1.3 (0.1)	3.2 (3.0-3.4)
O'Connor et al, <sup>41</sup> 1996	Patients who had a GHb test, %	134	133	91	91	0
Piette et al, <sup>30</sup> 2001	Score on self-reported home glucose monitoring test	146	146	0.2 (0.1)	0 (0.1)	0.2 (0.004-0.4)
<b>Screening for retinopathy</b>						
Hurwitz et al, <sup>46</sup> 1993	No. of retinal examinations per patient per year	89	92	1.1 (0.08)	0.9 (0.08)	0.2 (0.04-0.36)
Naji et al, <sup>45</sup> 1994	No. of retinal examinations performed per patient	124	111	1.1 (0.05)	0.9 (0.07)	0.2 (0.08-0.32)
Piette et al, <sup>30</sup> 2001	Patients receiving an ophthalmologic examination, %	146	146	40	38	2
<b>Screening for nephropathy</b>						
Hurwitz et al, <sup>46</sup> 1993	No. of urine tests per patient for microalbuminuria	89	92	3 (0.48)	2.3 (0.15)	0.7 (-0.01 to 1.4)
Jaber et al, <sup>40</sup> 1996	Change in serum creatinine level	17	22	-18 (8.4)	0 (3.9)	-18 (-31 to -5)
Kinmonth et al, <sup>37</sup> 1998	Patients tested for urinary microalbuminuria/creatinine ratio, %	126	101	28.6	26.7	1.9
<b>Foot screening and referral to podiatrist</b>						
Donohoe et al, <sup>31</sup> 2000	Patients receiving an annual foot examination, %	652	642	76	67	9
Hurwitz et al, <sup>46</sup> 1993	Patients referred to podiatrist, %	86	78	8	13	-5
Litzelman et al, <sup>47</sup> 1993	Patients referred to podiatrist, %	185	198	10.6	5	5.6
Litzelman et al, <sup>47</sup> 1993	Patients who received foot examinations, %	185	198	68	28	40
Naji et al, <sup>45</sup> 1994	No. of foot examinations performed per patient	124	111	1.4 (0.09)	0.5 (0.06)	0.9 (0.8-1.0)
<b>Patient foot care</b>						
Litzelman et al, <sup>47</sup> 1993	Mean (SE) scores on self-reported foot care behaviors (lower scores denote better foot care)	185	198	1.9 (0.03)	2.12 (0.03)	-0.22 (-0.28 to -0.16)
Piette et al, <sup>30</sup> 2001	No. of self-reported foot inspections	146	146	0.3 (0.1)	0.4 (0.1)	-0.1 (-0.2 to -0.004)
Sadur et al, <sup>35</sup> 1999	Frequency of self-examining feet, No./wk	80	62	6.6 (4.4)	5.7 (4.4)	0.9 (-0.55 to 2.35)

GHb indicates glycated hemoglobin; CI, confidence interval.

\*Data are given as mean (SE) unless otherwise indicated.

### Systolic Blood Pressure

Five studies<sup>37,39,44,45,52</sup> (7 observations), with 1239 patients, assessed program effects on systolic blood pressure (Table 2). Control group patients from the Vinicor study were accounted for once to avoid double counting.<sup>52</sup> Of these 7 assessments, 5 reported a decrease in systolic blood pressure in the treatment group.<sup>37,44,52</sup> However, only 1 of these yielded a statistically significant

reduction.<sup>52</sup> Two showed a slight improvement in the control group relative to the intervention group, but the results were not statistically significant.<sup>39,45</sup>

### Low-density Lipoprotein Cholesterol or Total Cholesterol Levels

Eight studies<sup>34,36,37,39,43,44,49,51</sup> (9 observations), with 1181 patients, assessed program effects on LDL cholest-

**Table 2.** Studies Looking at Mean Change in Systolic Blood Pressure\*

Source	Treatment No.	Control No.	Treatment Results	Control Results	Difference (95% CI)
de Sonnaville et al, <sup>39</sup> 1997	350	68	0.8 (22.2)	-0.1 (23.5)	0.9 (-5.2-7.0)
Kinmonth et al, <sup>37</sup> 1998 <sup>†</sup>	138	107	0.2	1.3	-1.1 (-3.3-1.1)
Pieber et al, <sup>44</sup> 1995	45	49	-17 (20.5)	-7 (22.5)	-10 (-18.2-1.2)
Naji et al, <sup>45</sup> 1994	120	106	5.6 (26.1)	2.5 (25.3)	3.1 (-3.6-9.8)
Vinicor et al, <sup>52</sup> 1987 (patient education)	69	67	-1.0 (16.5)	7.7 (18.0)	-8.7 (-14.5 to -2.9)
Vinicor et al, <sup>52</sup> 1987 (physician education)	62	67	3.9 (20.9)	7.7 (18.0)	-3.8 (-10.6-3.0)
Vinicor et al, <sup>52</sup> 1987 (patient and physician education)	58	67	4.6 (21.1)	7.7 (18.0)	-3.1 (-10.1-3.9)

\*Data are given as mean (SD).

<sup>†</sup>Standard deviations were not reported; however, the standard error for the change between groups was calculated using a reported *P* value.

terol or total cholesterol levels (**Table 3**). Control group patients from the D'Eramo-Melkus study were accounted for once to avoid double counting.<sup>49</sup> Three observations evaluated LDL cholesterol levels, and 6 evaluated total cholesterol levels. One study<sup>34</sup> reported a significant reduction in LDL cholesterol levels in the treatment group. Another study<sup>36</sup> reported a larger, nonsignificant reduction in LDL cholesterol in the control group; however, the reduction did not reach statistical significance.

**High-density Lipoprotein Cholesterol Levels**

Five studies,<sup>34,36,39,43,51</sup> with 822 patients, examined program effects on HDL cholesterol levels (Table 3). One study<sup>51</sup> showed a statistically significant increase in HDL cholesterol levels in program subjects. Two studies<sup>36,43</sup> reported nonsignificant improvements in HDL cholesterol levels in the treatment groups.

**Other Pertinent Outcomes**

The effects of disease management on quality of life (self-reported health status, physical functioning, and patient satisfaction), healthcare use (emergency department visits, hospital admissions, and visits to primary care physicians), and condition-specific knowledge (provider and patient) were also evaluated (data not shown). Although results varied across studies, positive trends supporting disease management were observed.

**Publication Bias**

Estimates of program effects on GHb were distributed asymmetrically, suggesting publication bias. However, trim and fill analysis did not support adjustment of the estimates.

**DISCUSSION**

Results of this analysis suggest that disease management programs on average have a modest, but clinically and statistically significant, effect on glycemic control in patients with diabetes mellitus (pooled estimate, 0.5–percentage point reduction; 95% CI, 0.3 to 0.6 percentage points). By comparison, the Diabetes Control and Complications Trial,<sup>54</sup> an intensive glycemic control program for type 1 patients, demonstrated a mean 2–percentage point reduction in GHb, while the UK Prospective Diabetes Study,<sup>55</sup> an intensive program for newly diagnosed type 2 patients, demonstrated a 0.9–percentage point reduction.

The Diabetes Control and Complications Trial<sup>54</sup> and the UK Prospective Diabetes Study<sup>55</sup> showed strong relationships between the risks of developing microvascular complications and glycemic levels over time. Furthermore, the UK Prospective Diabetes Study established that, for every percentage point decrease in hemoglobin A<sub>1c</sub> (eg, 9 to 8 percentage points), there was a 35% reduction in the incidence of microvascular complications. Application of this result to the pooled estimate of improvement in GHb levels in the studies we reviewed implies a reduction in the incidence of microvascular complications of approximately 15%. Given the prevalence of diabetes mellitus in the US population and the poor degree of glycemic control in many patients,<sup>56</sup> this degree of improvement would be important if applied to all patients with diabetes mellitus.

In addition, some programs improved other patient outcomes (screening for retinopathy and foot complications, systolic blood pressure, and serum lipids).

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However, disease management did not affect screening for nephropathy, hospital admissions, health status, or patient knowledge. The lack of demonstrated effect on these outcomes may, in part, be because of the small number of studies evaluating them.

The included studies varied in terms of the number of interventions used, study setting, and outcome measures reported. For example, 20 (83%) of the 24 studies evaluated program effects on glycemic control, whereas only one study<sup>46</sup> evaluated effects on hospital admission rates and another study<sup>36</sup> evaluated effects on mortality. Interestingly, multiple interventions were used in all studies. One study<sup>46</sup> assessed the effectiveness of a combination of 8 disease management interventions, while another study<sup>38</sup> examined the effect of 2 interventions on processes of care and patient outcomes.

For the purposes of our analysis, disease management was defined according to a previously published definition.<sup>17</sup> However, other definitions may have led to the inclusion of different studies and yielded different results.

Therefore, it is possible that these findings depend on the specific operational definition of disease management.

Significant heterogeneity exists among the studies in this analysis with respect to effects on glycemic control, as the results of our test for homogeneity suggest ( $P < .001$ ). These findings may also be affected by publication bias, as suggested by the funnel plot constructed from our exploratory data analysis. Studies, particularly small ones, with negative results may be less likely to be published, especially if they contradict prevailing opinion in the literature and in the professional community. More likely, there is incomplete representation of disease management program evaluations in journal publications; a great deal of disease management activity occurs in health plans, sometimes implemented by third-party disease management vendors for accreditation from the National Committee for Quality Assurance and similar organizations. These organizations may lack the funding or expertise to properly evaluate and publish their findings, or they may choose not to publicize their results.

**Table 3.** Studies Looking at Serum Lipids (LDL Cholesterol or Total Cholesterol and HDL Cholesterol)\*

Source	Outcome	Treatment No.	Control No.	Treatment Results	Control Results	Difference (95% CI)
<b>LDL cholesterol or total cholesterol</b>						
Aubert et al, <sup>36</sup> 1998 <sup>†</sup>	LDL cholesterol	71	67	-6	-10.2	4.2 (-8-16.3)
D'Eramo-Melkus et al, <sup>49</sup> 1992	Total cholesterol (patient education alone)	15	15	-18.6 (39.8)	0.8 (54.9)	-19.4 (-54.1-15.5)
D'Eramo-Melkus et al, <sup>49</sup> 1992	Total cholesterol (patient education and individual follow-up)	19	15	-19.7 (54.9)	0.8 (54.9)	-20.5 (-58.0-19.3)
de Sonnaville et al, <sup>39</sup> 1997	Total cholesterol	350	68	-11.6 (46.4)	0 (38.7)	-11.6 (-23.2-0)
Franz et al, <sup>43</sup> 1995	LDL cholesterol	89	75	-3.5 (34.4)	0.4 (41.8)	-3.9 (-15.5-7.7)
Kinmonth et al, <sup>37</sup> 1998 <sup>†</sup>	Total cholesterol	130	101	1.9	0	1.9 (-34.8-38.7)
Pieber et al, <sup>44</sup> 1995	Total cholesterol	45	49	-15.5 (45.2)	-1.9 (66.1)	-13.6 (-38.7-3.9)
Raz et al, <sup>51</sup> 1988	Total cholesterol	23	26	-12.3 (40.2)	5.8 (58.1)	-18.1 (-46.4-10.2)
Ridgeway et al, <sup>34</sup> 1999	LDL cholesterol	18	20	-7 (7.5)	6 (5.1)	-13 (-17.2 to -8.8)
<b>HDL cholesterol</b>						
Aubert et al, <sup>36</sup> 1998	HDL cholesterol	71	67	2 (5.9)	0.7 (5.9)	1.3 (-0.7-3.3)
de Sonnaville et al, <sup>39</sup> 1997	HDL cholesterol	350	68	-1.9 (11.6)	-0.4 (15.5)	-1.5 (-3.9-3.9)
Franz et al, <sup>43</sup> 1995	HDL cholesterol	94	85	-0.8 (11.6)	-2.7 (15.5)	1.9 (-3.9-7.7)
Raz et al, <sup>51</sup> 1988	HDL cholesterol	23	26	2.6 (4.3)	-0.6 (4.5)	3.2 (0.7-5.7)
Ridgeway et al, <sup>34</sup> 1999	HDL cholesterol	18	20	-4 (1.3)	-3 (1.2)	-1 (-5.1-3.1)

HDL indicates high-density lipoprotein; LDL, low-density lipoprotein.

\*Data are given as mean (SD) change (except for Ridgeway et al, which are given as mean [SE] change) in milligrams per deciliter. To convert cholesterol to millimoles per liter, multiply by 0.0259.

<sup>†</sup>Standard deviations were not reported.

The argument can be made that patients' motivation to participate can affect outcomes. To mitigate this concern, we included only studies using a parallel comparison group design. Of 24 estimates of program effects on GHb levels, 5 were derived from studies<sup>33,39,41,42,44</sup> using a quasi-experimental study design (ie, controlled before-and-after studies) according to the Cochrane Collaboration's criteria for acceptable study designs. These observations produced a mean reduction in GHb levels of 0.7 percentage point (95% CI, 0.6 to 0.8 percentage points). In comparison, observations from randomized clinical trials (n = 19) produced a mean reduction of 0.4 percentage point (95% CI, 0.2 to 0.5 percentage points). Although a larger reduction was observed for quasi-experimental studies, both reductions attained statistical significance. While selection of more motivated patients into intervention groups might bias results to some extent, the magnitude of any bias in our analysis is likely to be limited given that most results are from randomized trials.

Finally, these findings may reflect the fact that the methodology for implementing disease management and for measuring its effect is in its infancy. As the field of disease management continues to evolve and mature, and as measurement tools are refined, views on the effectiveness of these programs are likely to change as well.

Although this analysis reveals that disease management holds the potential to improve long-term outcomes because of better glycemic control and provider compliance with recommended standards, the overall effect on glycemic control appears modest. Provider compliance with treatment recommendations improved, but outcomes such as mortality, hospitalization, patient satisfaction, patient knowledge, and patient compliance showed no significant improvements. In our previous assessment of which interventions were effective in disease management programs,<sup>57</sup> we found that programs incorporating provider education, provider feedback, provider reminders, patient education, patient reminders, and patient financial incentives were associated with improvements in provider adherence to guidelines and patient disease control. Further research is needed to understand which program characteristics (eg, type and intensity) are most effective and how the science of disease management may be improved and the programs refined to optimize outcomes for patients with diabetes mellitus.

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