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A Meta-analysis of Interventions to Improve Care for Chronic Illnesses

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Objective: To use empirical data from previously published literature to address 2 research questions: (1) Do interventions that incorporate at least 1 element of the Chronic Care Model (CCM) result in improved outcomes for specific chronic illnesses? (2) Are any elements essential for improved outcomes?

Study Design: Meta-analysis.

Methods: Articles were identified from narrative literature reviews and quantitative meta-analyses, each of which covered multiple bibliographic databases from inception to March 2003. We supplemented this strategy by searching the MEDLINE database (1998-2003) and by consulting experts. We included randomized and nonrandomized controlled trials of interventions that contained 1 or more elements of the CCM for asthma, congestive heart failure (CHF), depression, and diabetes. We extracted data on clinical outcomes, quality of life, and processes of care. We then used random-effects modeling to compute pooled standardized effect sizes and risk ratios.

Results: Of 1345 abstracts screened, 112 studies contributed data to the meta-analysis: asthma, 27 studies; CHF, 21 studies; depression, 33 studies; and diabetes, 31 studies. Interventions with at least 1 CCM element had consistently beneficial effects on clinical outcomes and processes of care across all conditions studied. The effects on quality of life were mixed, with only the CHF and depression studies showing benefit. Publication bias was noted for the CHF studies and a subset of the asthma studies.

Conclusions: Interventions that contain at least 1 CCM element improve clinical outcomes and processes of care—and to a lesser extent, quality of life—for patients with chronic illnesses.

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Approximately 90 million persons in the United States live with 1 or more chronic illnesses.[1] The management of healthcare delivery for persons with chronic illnesses has advanced substantially in recent decades, yet considerable deficiencies in the quality of chronic-illness care remain.[2-6] Critics argue that systems of care designed to deal with acute episodes do not serve the needs of patients with chronic illness well.[7] Chronic illnesses rank among the nation's costliest conditions[8]; and 5 chronic illnesses—asthma, diabetes, heart disease, hypertension, and mood disorders—account for nearly one half of US healthcare expenditures.[9] Managed care organizations are increasingly becoming the main source of healthcare services for persons with chronic illnesses such as diabetes[10] and may be particularly well suited to adopting reforms to optimize care for such patients.

The Chronic Care Model (CCM) is a primary care–based framework aimed at improving the care of patients with chronic illnesses.[11-14] The model integrates a number of elements into a plausible package designed to foster more productive interactions between prepared, proactive teams and well-informed, motivated patients. Details on the concept, implementation, and evidence base of the CCM are available at http://www.improvingchroniccare.org.

Although individual components of the CCM have been rigorously studied, accounts of the CCM's beneficial effects as a whole on processes, outcomes, and/or costs come largely from self-reported, uncontrolled studies.[11,14,15] Therefore, we sought in this meta-analysis to classify previously published studies according to the CCM component(s) implemented, in order to address 2 related research questions: (1) To what extent do interventions that incorporate 1 or more elements of the CCM result in improved outcomes of interest for specific chronic illnesses? (2) Are some elements of the CCM more effective than others? Although the CCM is intended to be generic, applicable across all types of chronic illnesses,[11,16] we focused on evaluating the effects of diverse interventions on clinical outcomes, quality of life, and processes of care for 4 chronic illnesses that would be of particular interest to managed care organizations: asthma, congestive heart failure, depression, and diabetes.

METHODS

Conceptual Model

The CCM identifies 6 elements deemed to be essential for providing high-quality care to patients with

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chronic illnesses: delivery system design, self-management support, decision support, clinical information systems, community resources, and healthcare organization.[11,13,14] Because of the limited information available in published descriptions of interventions, and because the CCM elements are broadly defined, we categorized interventions according to the CCM elements they incorporated (**Box**).[17] Any given intervention could contain more than 1 element, up to a maximum of 6.

Article Selection and Data Abstraction

One author (ACT) was responsible for all aspects of study selection and data abstraction. First, we used MEDLINE and the Cochrane Library to identify 20 recently published systematic reviews and meta-analyses of the 4 chronic illnesses of interest: asthma,[18-22] congestive heart failure,[23-28] non–insulin dependent diabetes mellitus,[29-35] and depression.[36,37] These 20 reviews, in addition to 3 other reviews that were not condition specific,[38-40] formed the primary substrate for identifying studies for potential inclusion in our study sample. These previously published reviews covered multiple databases—including the Cumulative Index to Nursing and Allied Health Literature (CINAHL), the Cochrane Library, the Dissertation Index, Embase, Healthstar, the Health Management Information Service (HELMIS), MEDLINE, PsycINFO, PsychLit, and the System for Information on Grey Literature in Europe (SIGLE)—from inception to March 2003 (depending on the date the review was published). We also performed a MEDLINE search for more recent studies (January

Box. Classification of Studies According to the Chronic Care Model

Delivery System Design
- Care management roles
- Team practice
- Care delivery/coordination
- Proactive follow-up
- Planned visit
- Visit system change

Self-management Support
- Patient education
- Patient activation/psychosocial support
- Self-management assessment
- Self-management resources and tools
- Collaborative decision making with patients
- Guidelines available to patients

Decision Support
- Institutionalization of guidelines/prompts
- Provider education
- Expert consultation support

Clinical Information Systems
- Patient registry system
- Use of information for care management
- Feedback of performance data

Community Resources
- For patients
- For community

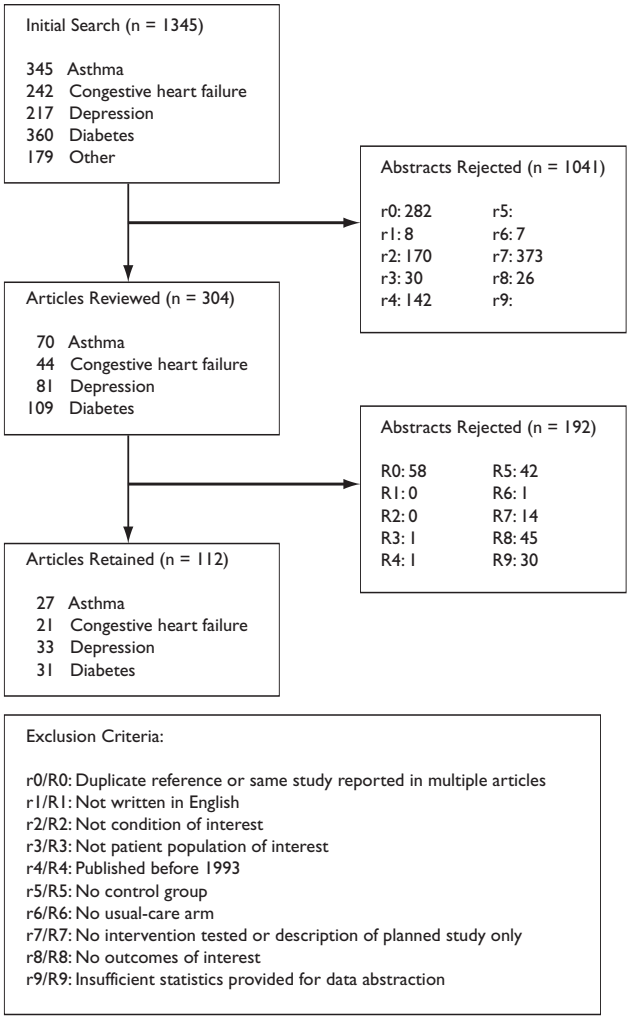
Health Care Organization
- Leadership support
- Provider participation
- Coherent system improvement and spread

Table 1. Outcomes of Interest

	Clinical Outcome			
Chronic Condition	**Continuous Variable**	**Dichotomous Variable**	**Quality of Life**	**Process of Care**
Asthma	None selected*	Number with ED visit during study period	Quality of life	Number receiving prescription for long-acting asthma medication
Congestive heart failure	None selected*	Number readmitted during study period	Quality of life	Number receiving prescription for ACE inhibitor
Depression	Depression scale	Number classified as depressed or symptomatic	Quality of life/SF-36 mental component summary	Number receiving prescription for antidepressant medication
Diabetes	HbA_{1c} level	Number with HbA_{1c} level >7%	Quality of life	Number tested for HbA_{1c} level

ACE indicates angiotensin-converting enzyme; ED, emergency department; HbA_{1c} glycosylated hemoglobin; SF-36, SF-36® Health Survey.
*For asthma and congestive heart failure, we originally collected data from studies that reported the clinical outcomes as either continuous or dichotomous variables, but we abandoned the analyses on the continuous variables because of inadequate sample sizes.

Figure 1. Flow of Evidence



1998-June 2003) that may have been missed. Finally, additional studies were identified by consulting experts and searching independently maintained bibliographies (eg, the Chronic Care Bibliography[41]).

In identifying abstracts and articles for potential inclusion in our sample, the authors and their affiliations were not masked. We screened all identified abstracts for potentially relevant studies that assessed the effects of interventions containing 1 or more of the CCM elements. Randomized and nonrandomized controlled studies were eligible for inclusion. Uncontrolled studies were excluded, as were studies written in a language other than English. Because we sought to include only the most recent decade of published evidence in our report, we excluded studies published before 1993.

These studies used a wide range of outcome variables. We identified a clinical outcome, a quality-of-life outcome, and a key process of care for each condition (**Table 1**). To make the analysis more tractable and to maximize our ability to pool data, we opted to collect data on the variables that were reported by the greatest number of studies (eg, for the diabetes studies we selected glycosylated hemoglobin [HbA_{1c}] as the clinical outcome rather than cholesterol level, and HbA_{1c} monitoring as the key process of care rather than funduscopic testing). We also accepted a variety of similar measures for some domains. For example, we accepted any of the most commonly used measures for the clinical outcome among the depression studies, including the Hopkins Symptom Checklist-20 (9 studies), the Hamilton Depression Rating scale (6 studies), and the Center for Epidemiological Studies–Depression scale (6 studies). The most commonly used measures of disease-specific quality of life were the St. George's Respiratory Questionnaire (4 studies), the Juniper Asthma Quality of Life Questionnaire (4 studies), and the Minnesota Living with Heart Failure Questionnaire (3 studies).

Among the selected studies with data on the clinical outcomes, some reported data as count variables or continuous variables, whereas others reported data as dichotomous variables. We extracted data in both forms where possible. Too few studies on asthma and congestive heart failure reported the clinical outcome data as count variables (number of emergency department visits or readmissions during the study period), so for those 2 condition-specific analyses we used only the data that were reported as dichotomous variables (number with any emergency department visit during study period, number readmitted during study period).

Using a standardized data collection form, we abstracted data on study characteristics, including CCM elements incorporated in the interventions and effects on clinical outcomes, quality of life, and processes of care. If the results of a study were reported in multiple articles, data were abstracted from all articles and attributed to the primary citation. If a study reported comparisons at multiple follow-up times, we abstracted data on outcomes closest to 12 months of follow-up. For each study that reported data as continuous variables, the mean and standard deviation values were extracted (if available). For studies that did not report a standard deviation value at follow-up, the standard deviation was assumed to be equal to one quarter of the theoretical range for that measure. This imputation approach is based on the assumption that the underlying distributions were approximately normal, and it is a very conservative assumption in that the multiplication factor for truly normal distributions should be closer to one sixth. For the clinical outcomes, a higher score represented a worse outcome, whereas for quality of life and processes of care, a higher score represented a better outcome; some studies required recoding of quality-of-

Table 2. Summary Statistics

Characteristic	Number of Studies				
	Asthma (n = 27)	Congestive Heart Failure (n = 21)	Depression (n = 33)	Diabetes (n = 31)	Total (n = 112)
Year of publication					
1993-1998	14	8	9	11	42
1999-2003	13	13	24	20	70
Setting					
Inpatient	0	4	1	0	5
Outpatient	27	17	32	31	107
Follow-up time					
0-6 mo	10	16	19	7	52
7-12 mo	14	5	12	14	45
>12 mo	3	0	2	10	15
Jadad quality score					
0	3	3	4	9	19
1-2	15	10	15	17	57
3	9	8	14	5	36
4+	0	0	0	0	0
Sample size at follow-up					
0-100	14	4	7	6	31
101-200	8	10	13	8	39
200+	5	7	13	17	42
Number of interventions					
1	23	4	13	12	52
2	4	13	7	9	33
3	0	2	8	9	19
4	0	2	5	1	8
Type of intervention					
Delivery system design	3	19	19	19	60
Self-management support	24	19	20	17	80
Decision support	2	4	20	12	38
Clinical information systems	2	1	7	9	19
Community resources	0	0	1	3	4
Health care organization	0	1	4	1	6

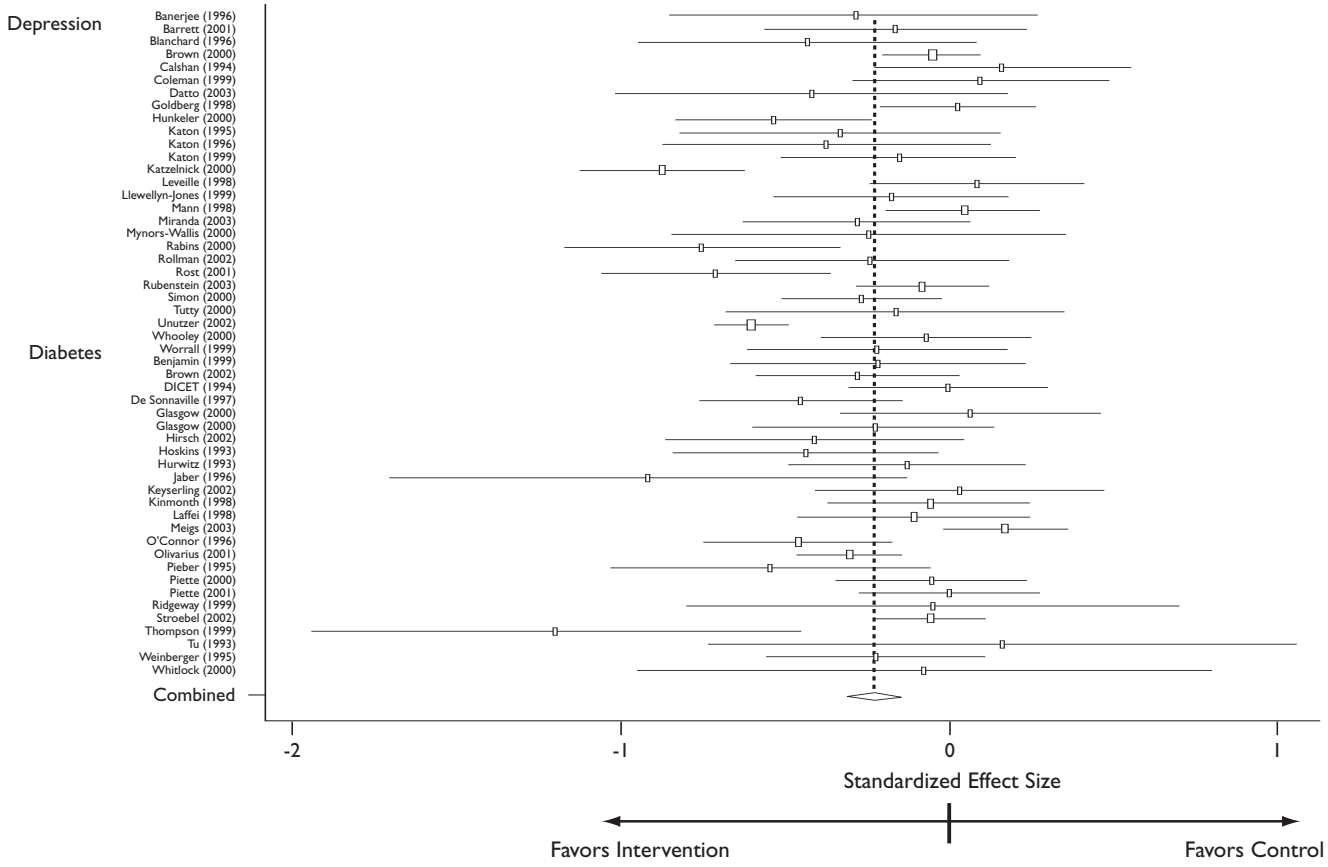
life measures for consistency. For example, if a study used the St. George's Respiratory Questionnaire as a measure of quality of life (0-100, with higher scores indicating poorer quality of life), we recoded the variables so that higher scores represented better quality of life. We excluded studies that did not provide sufficient statistics for data abstraction if our efforts to contact the study's authors for additional data were unsuccessful.

Statistical Analysis

We conducted all analyses using the Stata statistical software package (version 8.0, Stata Corporation, College Station, Tex).[42-47] For each study, effect sizes were calculated for the intervention group relative to the comparison group at follow-up. If outcomes were measured on a continuous scale, we computed Hedges *g,* the standardized effect size, with an adjustment to correct for small-sample bias.[48] For each intervention-control comparison of a dichotomous outcome, we calculated the risk ratio and its standard deviation.[49] Effect sizes were estimated for each type of outcome variable using random-effects models (incorporating both between-study and within-study variance[50]), first pooled across conditions and then stratified by condition. A priori, we deemed pooled estimates based on fewer than 5 studies to be unreliable for statistical hypothesis testing, as noted in the results. To check for publication bias (which may result from the nonpublication of small negative studies), we visually assessed funnel plots for asymmetry and used the regression asymmetry test.[51]

We used a multivariate approach to independently assess the effect of each CCM element on the estimated pooled effect size, after adjusting for the presence of the other elements if the study's intervention contained more than 1 element. To do this, we fit random-effects meta-regression models[52] for each of the 4 types of outcomes. The only covariates included in these regressions were a constant term and 6 indicator variables equal to unity if the intervention included that particular CCM element, zero otherwise.[53] Some of the CCM elements were imple-

Figure 2. Forest Plot of Studies Reporting Data on Clinical Outcomes as Continuous Variables



mented in too few studies for a pooled estimate to be computed, so we labeled those situations as "not estimable" in the results. All statistical hypothesis tests were carried out at the 2-sided .05 level of confidence.

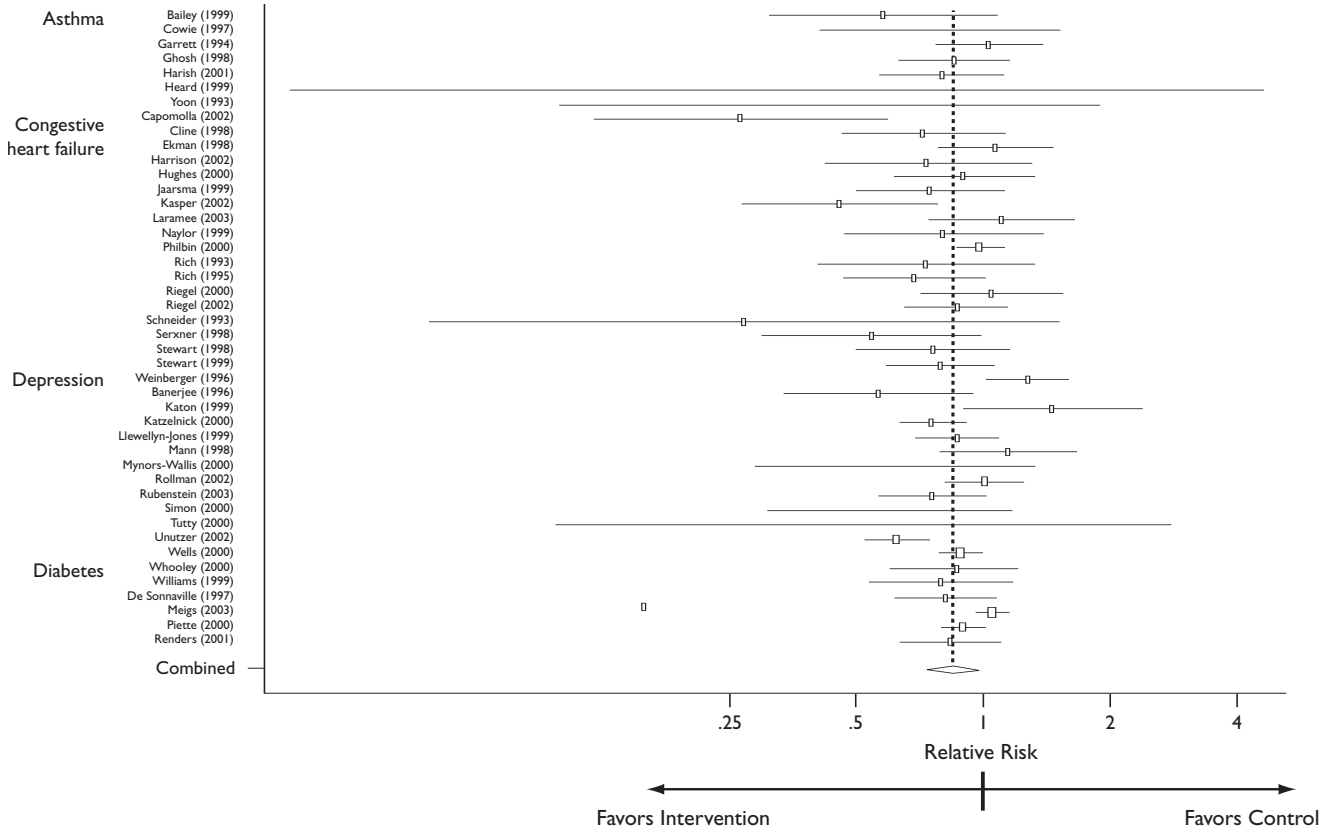
The degree of between-study heterogeneity was assessed by the chi-square test for heterogeneity based on the Cochran Q test.[54] We also calculated the heterogeneity statistic I^2, which is independent of the number of studies and the effect-size metric, and can be interpreted as the proportion of total variation in the estimated treatment effect that is due to between-study heterogeneity rather than chance.[55] We fit random-effects meta-regression models[52] to determine whether study-level variables explained the heterogeneity in the treatment effects, including in these models the following study-level variables: indicators for CCM element, indicators for type of chronic illness, duration of follow-up, inpatient or outpatient setting, and Jadad quality score.

In post hoc meta-regression analyses, we included variables to determine whether synergies were associated with the use of more CCM elements. The first specification included an ordinal variable for the number of CCM elements in the intervention. The second specification examined only the subset of studies that included delivery system design (the most frequently studied CCM component) in the intervention. Studies that incorporated delivery system design plus any additional CCM elements were compared with studies that incorporated delivery system design only. The third specification was similar but examined only the subset of studies that included self-management support (the second most frequently studied CCM component).

Sensitivity Analysis

We used the Jadad scale to assess the quality of studies in our sample.[56] Each study received from 0 to 5 points (with higher scores representing higher methodological quality), depending on whether it was described as randomized or double blind, if the randomization sequence or blinding procedure was appropriate, and if it provided detailed information on withdrawals and dropouts. Because studies of low methodological quality have been found to overestimate treatment benefit,[57] we conducted a sensitivity analysis by re-estimating pooled effects and refitting meta-regression models using only the 36 studies with a Jadad quality score of 3 or higher.

Figure 3. Forest Plot of Studies Reporting Data on Clinical Outcomes as Dichotomous Variables



RESULTS

Identification, Distribution, and Quality of Evidence

Figure 1 illustrates the flow of literature from the original sources to final acceptance for our review. We identified 1345 abstracts of studies published between January 1993 and June 2003. On the basis of screening the abstracts, we excluded 1041 abstracts and requested 304 articles for detailed review. Of these, we excluded an additional 192 articles. The **Evidence Table**, available at http://www.rand.org/health/icice, provides a list of references for the 112 studies included, as well as further details on each of these studies. Any given study could contribute data on 1 or more outcomes of interest, so we report sample sizes for the stratified analyses in the tables below.

Summary statistics for the sample of studies are provided in **Table 2.** Of the 112 studies in our analysis, 93 studies (83%) were described as randomized. Only 36 studies (32%) scored a 3 on the Jadad scale, and none scored higher than 3. The primary limitation of these studies was the lack of double blinding, but double blinding is rarely possible in studies of organizational interventions. Almost half of the studies (46%) contained only 1 CCM element in the intervention. The most common CCM elements contained in the interventions were self-management support (n = 80), delivery system design (n = 60), and decision support (n = 38). The 2 most common elements, self-management support and delivery system design, were frequently bundled together with at least 1 other element (64% [51/80] and 83% [50/60], respectively). Only 8 studies included 4 CCM elements in the intervention. Most interventions were carried out in the outpatient setting, but 4 congestive heart failure studies and 1 depression study tested inpatient interventions.

Overall Results

We first examined the overall effectiveness of interventions with 1 or more CCM elements. Overall, the interventions led to statistically significant improvements in each of the 4 outcomes of interest. In particular, for the 52 studies that reported clinical outcomes as continuous variables (depression and diabetes only), there was a statistically significant pooled effect size of –0.23 in favor of the intervention (95% confidence interval [CI] = –0.31, –0.15; $P < .001$ for whether the reduction was less than 0; see **Figure 2**). The 46 studies that reported clinical outcomes as dichotomous variables yielded a statistically significant pooled relative risk of 0.84 in favor of the intervention (95% CI = 0.78, 0.90; $P < .001$ for whether the relative risk was less than 1; see

Figure 4. Forest Plot of Studies Reporting Data on Quality of Life

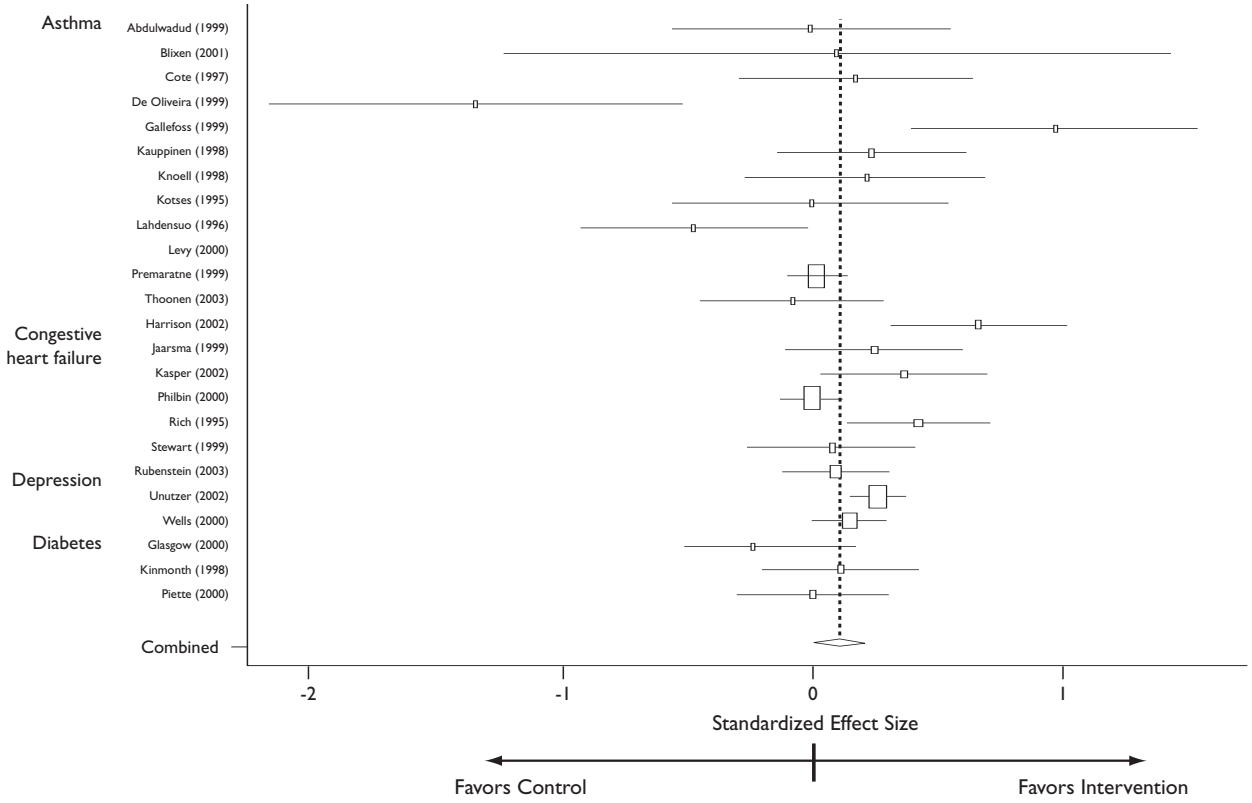


Figure 3). The overall effect on quality-of-life outcomes, based on data from 24 studies, was statistically significant and favored the intervention (0.11; 95% CI = 0.02, 0.21; $P = .023$; see **Figure 4**). Finally, 32 studies contributed data on process outcomes of interest for a pooled relative risk of 1.19 (95% CI = 1.10, 1.28; $P < .001$; see **Figure 5**).

The overall effects were pooled across conditions. To enhance the clinical interpretation of our findings, we report the condition-specific pooled effect sizes in **Table 3.** Across conditions, the interventions had consistent effects on clinical outcomes and processes. With respect to quality of life, however, the asthma studies showed equivocal results, despite an adequate number of studies.

The pooled effect size (–0.19) for the diabetes studies reporting continuous data on HbA_{1c} indicates a lower HbA_{1c} value in the intervention group at follow-up compared with the control group. Assuming a range of standard deviation values from 1.56 to 2.47 (the interquartile range for the studies in our sample), this effect size is equivalent to a reduction in HbA_{1c} of 0.30% to 0.47%. The positive effect size reported for the congestive heart failure studies (0.28) indicates a higher quality-of-life scale score in the intervention group compared with the control group and is equivalent to an increase of 5.6-6.7 points on the Chronic Heart Failure Questionnaire.

We assessed publication bias along 2 dimensions: outcome measure and condition. Based on funnel plot inspection and the regression asymmetry test, evidence of publication bias was apparent for the congestive heart failure studies (all outcomes) and the asthma studies with dichotomous data on the clinical outcome.

Relative Effectiveness of Chronic Care Model Elements

In the meta-regression analyses, we found that 4 elements of the CCM (delivery system design, self-management support, decision support, and clinical information systems) were associated with better outcomes and processes, after adjusting for the presence of other elements if the intervention contained more than 1 element (**Table 4**). Our sample had too few studies that implemented the community resources and health care organization elements to judge the relative effectiveness of those 2 elements. The statistically significant effects observed for delivery system design and self-management support could be attributed to both the larger number of studies and the larger estimated effects. Decision support improved

process significantly, but not outcomes. We observed no statistically significant effects for clinical information systems, perhaps due to the smaller number of studies. We also noted that no single element of the CCM was essential to improved outcomes (**Appendix**, available at http://www.rand.org/health/icice).

Evidence of substantial between-study heterogeneity was noted for the analyses of continuous clinical outcomes (I^2 = 78%; Cochran's χ^2 test for homogeneity Q = 230.4, df = 51, P < .001); dichotomous clinical outcomes (I^2 = 67%; Q =135.19, df = 45, P < .001); quality of life (I^2 = 75%, Q = 92.81; df = 23; P < .001); and processes (I^2 = 90%; Q = 311.59, df = 31, P < .001). These I^2 values indicate that more than two thirds of the variation in the estimated treatment effects may be attributable to between-study heterogeneity. We fit random-effects meta-regression models to identify potential explanations for this variation, but the study-level variables we considered—indicators for type of chronic illness, indicators for CCM element, duration of follow-up, inpatient or outpatient setting, and Jadad quality score—did not appreciably reduce the unexplained variance.

Synergistic Effects

In our random-effects meta-regression analyses, the number of CCM elements incorporated in the study intervention was not associated with better outcomes, with P values ranging from 0.38 to 0.81. Only 2 CCM domains, delivery system design and self-management support, were represented in enough studies for a meaningful comparison of interventions consisting of that element alone versus that element in conjunction with other elements. In our data, these comparisons were never statistically significant, with P values ranging from 0.13 to 0.61.

Sensitivity Analysis

We re-fit the meta-regression models to the subset of studies (n = 36) that scored a 3 on the Jadad scale.[57] This sensitivity analysis yielded results that were qualitatively similar to the main analysis (**Appendix Tables 6** and **7**, available at http://www.rand.org/health/icice). The pooled effect sizes were generally larger (favoring the intervention), with larger confidence intervals.

DISCUSSION

Interventions that incorporated 1 or more elements of the CCM had beneficial effects on clinical outcomes and processes of care for patients, and the results were consistent across a variety of chronic illnesses. Although our estimates of pooled effect size were small to moderate,[58] they also are broadly consistent with those reported in prior meta-analyses.[22,28,35,40] Interventions directed at diabetes care, for example, led to a 0.30%-0.47% reduction in HbA_{1c}. Managed care organizations may realize benefits from even smaller reductions in mean population values for continuous risk factors such

Figure 5. Forest Plot of Studies Reporting Data on Processes of Care

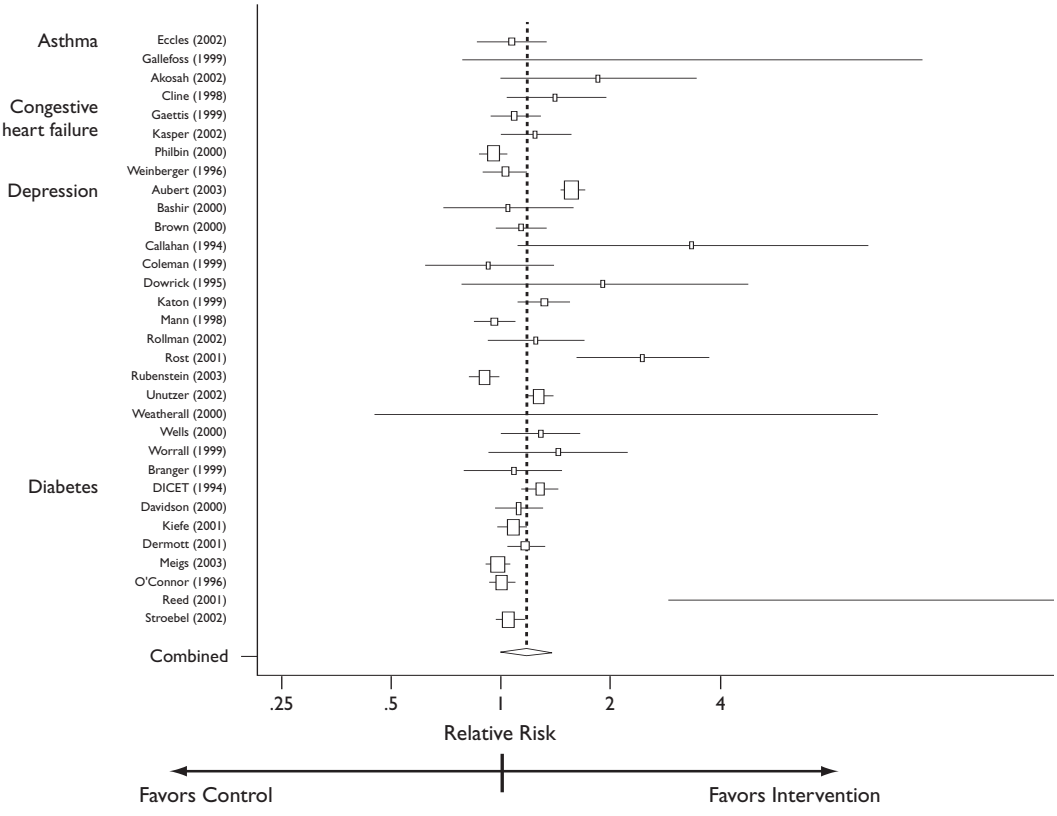


Table 3. Pooled Estimates by Condition

	Clinical Outcome							
	Continuous Variable* (Lower Is Better)		Dichotomous Variable (Lower Is Better)		Quality of Life (Higher Is Better)		Process of Care (Higher Is Better)	
Chronic Condition	Effect Size (95% CI)	No.	Relative Risk (95% CI)	No.	Effect Size (95% CI)	No.	Relative Risk (95% CI)	No.
Overall	–0.23 (–0.31, –0.15)	52	0.84 (0.78, 0.90)	46	0.11 (0.02, 0.21)	24	1.19 (1.10, 1.28)	32
Asthma			0.82 (0.69, 0.98)	9	0.01 (–0.19, 0.20)	12	1.61 (0.56, 4.64)	2†
Congestive heart failure			0.81 (0.71, 0.92)	19	0.28 (0.06, 0.51)	6	1.13 (1.00, 1.28)	6
Depression	–0.25 (–0.37, –0.13)	27	0.83 (0.74, 0.93)	14	0.18 (0.08, 0.28)	3†	1.28 (1.11, 1.48)	15
Diabetes	–0.19 (–0.29, –0.10)	25	0.92 (0.81, 1.05)	4†	–0.02 (–0.20, 0.17)	3†	1.10 (1.01, 1.19)	9

CI indicates confidence interval.
*Includes data only on studies related to depression and diabetes.
†Pooled estimates based on fewer than 5 studies should be interpreted with caution.

Table 4. Pooled Estimates by Chronic Care Model Element

	Clinical Outcome							
	Continuous Variable* (Lower Is Better)		Dichotomous Variable (Lower Is Better)		Quality of Life (Higher Is Better)		Process of Care (Higher Is Better)	
Element Present	Effect Size (95% CI)	No.	Relative Risk (95% CI)	No.	Effect Size (95% CI)	No.	Relative Risk (95% CI)	No.
Delivery system design	–0.21 (–0.40, –0.02)	33	0.77 (0.62, 0.96)	30	0.33 (–0.10, 0.76)	12	1.16 (1.01, 1.34)	21
Self-management support	–0.22 (–0.38, –0.05)	35	0.81 (0.66, 0.99)	36	–0.03 (–0.25, 0.19)	22	1.31 (1.00, 1.71)	15
Decision support	–0.14 (–0.33, 0.05)	24	0.87 (0.69, 1.09)	17	0.04 (–0.36, 0.45)	7	1.29 (1.08, 1.54)	18
Clinical information systems	–0.06 (–0.27, 0.15)	13	0.83 (0.64, 1.07)	10	–0.28 (–1.08, 0.51)	2†	1.08 (0.91, 1.28)	9
Community resources	–0.11 (–0.41, 0.19)	4†	NE	0	NE	1	NE	0
Health care organization	–0.02 (–0.33, 0.29)	4†	0.82 (0.56, 1.20)	3†	–0.38 (–1.26, 0.49)	3†	0.88 (0.67, 1.16)	5

CI indicates confidence interval; NE, not estimable.
*Includes data only on studies related to depression and diabetes.
†Pooled estimates based on fewer than 5 studies should be interpreted with caution.

as lipid levels and HbA_{1c}. For example, the European Prospective Investigation of Cancer and Nutrition (EPIC-Norfolk) estimated that a population reduction of 0.2% in HbA_{1c} could reduce the prevalence of men with high HbA_{1c} levels (5%-6.9%) from 79% to 57% and reduce excess mortality by 10%.[59] We found that interventions directed at congestive heart failure led to a 5.6- to 6.7-point improvement in the Chronic Heart Failure Questionnaire, slightly less than the 7- to 9-point difference that is regarded as a minimal clinically important difference on that scale.[60]

The evidence was mixed for quality of life, with the asthma and diabetes studies showing no benefit. It has been well established that condition-specific quality-of-life scales are more sensitive to changes in clinical status than are generic measures of quality of life. Most of the studies included in our meta-analyses used condition-specific quality of life scales (see the Evidence Table, available at http://www.rand.org/health/icice). For some conditions, one might reasonably expect disease-specific interventions to have a more direct effect on clinical outcomes and processes of care than on quality

of life. Improvements in diabetes care, for example, are focused on preventing long-term microvascular complications beyond the end point of the studies we examined,[61] with less focus on improving short-term quality of life. We speculate that our meta-analyses might have yielded different results, for example, had we used a quality-of-life measure that is more sensitive to the short-term benefits of improved glycemic control.[62,63]

The CCM elements most responsible for these benefits could not be determined from the data. Effects appeared to be somewhat stronger for delivery system design and self-management support, although decision support had significant beneficial effects on processes. The other elements of the CCM may be critical infrastructure for providing high-quality chronic care but are more difficult to test scientifically. For example, leadership support may be necessary to promote and sustain higher quality, but randomizing managed care organizations to receive changes in leadership support is clearly infeasible. It is no wonder that these elements have not had many scientific trials. The fact that such linkages are hard to study scientifically does not mean they are unimportant. Instead, they are supported by common sense and reports from successful organizations.

The CCM has been promoted as a unified package. Evidence that interventions with multiple components do better than interventions with single components[64] has been interpreted as supporting synergistic effects in which the whole is bigger than the sum of the parts. Some components of the model, such as building an electronic patient registry, may facilitate other components and reduce their costs. We found that single interventions were quite successful. In post hoc analyses, we attempted to identify whether there may be some advantage to having more components, but that advantage was never statistically significant and does not appear to be more than additive.

One limitation of our work is that the studies in our sample only incorporated elements of the CCM and were not designed to test the entire CCM package.[11,13,14] The RAND/University of California–Berkeley Improving Chronic Illness Care Evaluation (ICICE) is nearing completion, and it is the first independent and controlled evaluation of the effects of implementing the CCM as a whole. Organizations signed up for the Institute of Healthcare Improvement's Collaboratives to improve care for specific conditions[65] and worked together to learn about the CCM and about how to make organizational changes to improve quality of care. The design of the ICICE has been published,[66] and results from the evaluation are posted at http://www.rand.org/health/ICICE/ as they become available. Despite the large scale of the evaluation—24 organizations with both intervention and control sites, and 12 organizations with intervention sites only—the number of participating organizations was too small to determine which components of the CCM were most critical to success. The organizations' characteristics and what they did differed in many ways, many times more than the number that could be studied statistically.

A second limitation is that the use of meta-analytic methods necessarily forces what are likely complex, multivariate interventions into a narrow linear framework. In this meta-analysis we aggregated results across conditions and across interventions. We attempted to investigate the sources of variation between studies, but we were unable to explain much of it. We also were unable to assess interactions between CCM element and type of chronic illness. For example, a clinical information systems intervention featuring physician reminders may be particularly effective for improving care for one type of chronic illness but not for other types, and a pooled analysis would not identify the interaction. A related limitation is that we were unable to assess the intensity of implementation in the study interventions.[17,67] Perhaps the interventions we studied were successful because doing trials requires energy and commitment to the intervention concept. This energy may be an important component of initial success that is hard to transfer. If there is significant variation in the intensity of implementation of these elements across studies, simplified comparisons based on the presence or absence of these elements may mask important between-study differences. In addition, we focused our data collection on selected outcomes. We needed to do so in order to aggregate across studies, recognizing that interventions may have had different effects on other outcomes and processes of care. However, the outcomes we selected were reported in a large number of studies and likely reflect outcomes of interest to managed care organizations. A final limitation is that we used an unconventional search strategy by relying on prior meta-analyses as the primary substrate for identifying our sample of studies. Doing so may have introduced unpredictable biases, but we also systematically searched the MEDLINE database and the Chronic Care Bibliography[41] to identify more recently published studies.

Despite these limitations, our meta-analysis shows that interventions that contain 1 or more elements of the CCM can improve outcomes and processes for several chronic illnesses of interest to managed care organizations. How to transfer the gains from these efficacy studies into the chaotic real world of healthcare is a different but equally important issue.

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