Does Diabetes Care Differ by Type of Chronic Comorbidity?

An evaluation of the Piette and Kerr framework

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OBJECTIVE—To evaluate the relationship between diabetes care and types of comorbidity, classified by the degree to which their treatment is concordant with that for diabetes.

RESEARCH DESIGN AND METHODS—Retrospective cohort study (fiscal year [FY] 2001 to FY 2004) of 42,826 veterans with new-onset diabetes in FY 2003. Veterans were classified into five chronic comorbid illness groups (CCIGs): none, concordant only, discordant only, both concordant and discordant, and dominant. Five diabetes-related care measures were assessed in FY 2004 (guideline-consistent testing and treatment goals for HbA_{1c} and LDL cholesterol and diabetes-related outpatient visits). Analyses included logistic regressions adjusting for age, race, sex, marital status, priority code, and interaction between CCIGs and visit frequency.

RESULTS—Only 20% of patients had no comorbidities. Mean number of visits per year ranged from 7.8 (no CCIG) to 17.5 (dominant CCIG). In unadjusted analyses, presence of any illness was associated with equivalent or better care. In the fully adjusted model, we found interaction between CCIG and visit frequency. When visits were <7 per year, the odds of meeting the goal of HbA_{1c} <8% were similar in the concordant (odds ratio 0.96 [95% CI 0.83–1.11]) and lower in the discordant (0.90 [0.81–0.99]) groups compared with the no comorbidity group. Among patients with >24 visits per year, these odds were insignificant. Dominant CCIG was associated with substantially reduced care for glycemic control for all visit categories and for lipid management at all but the highest visit category.

CONCLUSIONS—Our study indicates that diabetes care varies by types of comorbidity. Concordant illnesses result in similar or better care, regardless of visit frequency. Discordant illnesses are associated with diminished care: an effect that decreases as visit frequency increases.

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Comorbid illnesses among patients may complicate care by competing for time, attention, or other resources (1–5). This is particularly applicable for patients with chronic illnesses, such as diabetes. As a consequence, the quality of diabetes care might be compromised unless additional resources are made available to compensate.

Comorbid illnesses are common among patients with diabetes. In 2004, 88.6% of people with diabetes who responded to the Medical Expenditure Panel Survey reported having at least one additional chronic illness, while close to 15% reported having four or more, illustrating how common comorbidity is among the diabetic population (2). The prevalence of both diabetes and comorbid illness is likely to increase as the U.S. population ages.

Despite a high level of comorbidity among diabetic patients, the literature studying the effect of comorbidity on diabetes care predominantly focuses on a single coexisting condition, such as a mental illness (6–9). On the other hand, researchers accounting for all concurrent morbidity have applied aggregate morbidity counts or one-dimensional scores (10,11). Both approaches fail to reveal the true impact of multiple comorbid illnesses because not all illnesses are likely to have the same impact. Measuring patient complexity still poses a challenge to both clinicians and researchers, as described in a recent article (12).

Piette and Kerr (13) have proposed a novel theoretical framework as a way to categorize the effect of comorbidity on patients with diabetes and other chronic illnesses. The Piette and Kerr framework groups comorbid illnesses as concordant illnesses (illnesses that overlap with diabetes in their pathogenesis and management plans [e.g., cardiovascular diseases]), discordant illnesses (illnesses with unrelated pathogenesis or management plans [e.g., mental health illnesses and musculoskeletal disorders]), and dominant illnesses (illnesses whose severity eclipses all other illness management plans [e.g., end-stage kidney and liver diseases and metastatic cancer]). The framework hypothesizes that effects differ depending on the nature of comorbid illness (13–15). The presence of a discordant illness may draw resources away from diabetes management and result in compromised diabetes care, the presence of a concordant illness may result in similar or better diabetes care, and the presence of a dominant illness may result in substantially worse diabetes care. The primary purpose of this study was to evaluate the relationship between diabetes care and different types of comorbid illnesses,

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classified by the degree to which their treatment is concordant with that for diabetes as described by Piette and Kerr (13). We hypothesized that having concordant illnesses would be associated with similar or better diabetes care outcomes, having discordant illnesses would be associated with worse diabetes care outcomes, and the presence of dominant illnesses would lead to substantially worse diabetes care outcomes.

RESEARCH DESIGN AND METHODS

Data source

This study used data from the Diabetes Epidemiology Cohort (DEpiC), an administrative research database created by merging matched data files from the Veterans Health Administration (VHA) and Centers for Medicare and Medicaid Services (CMS). The DEpiC database identifies all VHA users with diabetes using a validated approach of having two or more diabetes-related ICD-9-CM codes (250.xx, 357.2, 362.0, and 366.41) from both inpatient and outpatient visits or any prescription for antiglycemic medication using a 24-month window (16).

Study cohort

A retrospective cohort study design was used to study patients with incident diabetes in the DEpiC database. The study observation period extended from fiscal year (FY) 2001 to FY 2004. The incident diabetes cohort was composed of patients with new-onset diabetes in FY 2003. We chose to study patients with incident diabetes over those with prevalent diabetes because the former tend to be more homogenous with respect to diabetes duration and management needs/demands.

We identified patients with incident diabetes in the baseline year (FY 2003) by excluding those with diabetes-related codes and/or medications in a 2-year look-back period (FY 2001 to FY 2002). Comorbidities were identified using a minimum of two codes during the look-back and baseline years. Data on number of laboratory tests performed were obtained from both VHA and CMS files, which allowed for enumeration of tests' frequency and consistency. However, the VHA Decision Support System files were the only source for laboratory test results. Study outcomes were assessed in the follow-up year (FY 2004).

From the DEpiC database, we identified 51,043 patients who were VHA system users throughout the study period (FY 2001 to FY 2004) and had new-onset diabetes in the baseline year (FY 2003). Patients enrolled in Medicare HMO plans (n = 6,581) (whose clinical data are not reported to CMS) were excluded. Patients with less than three visits in the baseline year (n = 1,636) were also excluded to reduce potential underassessment of comorbid illnesses. After the above exclusions, there were 42,826 patients with incident diabetes in the analysis cohort. Data were available on visits and testing for HbA_{1c} and LDL cholesterol (LDL-C) for all 42,826 patients. However, results for HbA_{1c} and LDL-C tests were available only for those patients who underwent laboratory testing in the VHA system. This reduced the cohort size to 39,516 and 39,332 when analyzing the intermediate measures HbA_{1c} <8% and LDL-C <130 mg/dL, respectively.

Study variables

Outcome variables. Our study assessed five diabetes-related care measures (three process measures and two intermediate [or treatment goal] measures) that were based on the Diabetes Quality Improvement Project (DQIP) measures (17). The process measures included a test for HbA_{1c} at least once every 6 months, a diabetes-related visit at least once every 6 months, and a test for LDL-C at least once a year. We used the last test result in FY 2004 from a subset of patients who underwent laboratory testing in the VHA system to assess two intermediate measures (or treatment goals): HbA_{1c} <8% and LDL-C <130 mg/dL.

Independent variable. Selection of relevant chronic comorbid illnesses and their subsequent grouping into chronic comorbid illness groups (CCIGs) was done using a nominative group process informed by VHA–Department of Defense diabetes guidelines and opinions of field experts from multiple VHA centers (both internal and external to our study team). We categorized patients using a comprehensive list of 53 chronic illnesses into the five CCIGs: none, concordant only, discordant only, both concordant and discordant, and dominant. Patients with no illness other than diabetes belonged to the none CCIG group. Presence of a dominant illness was given priority over other illnesses for CCIG classification. See the Supplementary Data for a listing of chronic comorbid illnesses used for CCIG categorization. We built on our team's prior work for compilation of the ICD-9-CM code list (18). The variable CCIG was our main independent variable.

Covariates. We included health care use and additional sociodemographic variables available in the database as covariates. Face-to-face (F2F) visit frequency was used to measure overall and diabetes-related visits. F2F visits refer to in-person visits to a medical professional with decision-making capacity in either the Medicare or VHA outpatient services that were identified using the current procedural terminology codes for visits as outlined in the health care effectiveness data and information set measures (the Supplementary Data lists current procedural terminology codes used to define F2F visits). The visits were classified as being diabetes related if they were assigned a diabetes-specific ICD-9-CM code within the given visit. Total F2F visits were categorized as <7, 7–12, 13–24, and >24 visits per year.

Sociodemographic variables included age categories of <55, 55–64, 65–74, and >75 years; sex; race/ethnicity divided into white, African American, Hispanic, and other; marital status of married or not married; and VHA priority code of low income, severely disabled, moderately disabled, and copay. The VHA priority code is derived from VHA enrollment group assignment based on assessment of an individual's income and service-connected disability.

Statistical analyses

First, we cross-tabulated study covariates with CCIGs and diabetes-related care measures to describe their bivariate associations and to identify potential confounders. Second, we tabulated the levels at which patients met care guidelines across the CCIGs in the overall cohort and within each F2F visit frequency stratum. Third, logistic regression modeling was used to test for association between CCIGs and diabetes care, sequentially without (model 1) and with (model 2) sociodemographic variables (age, sex, race, marital status, and VHA priority code). Model 3 added visit frequency to model 2. In model 4, we tested for interaction between CCIGs and F2F visit frequency to determine the effect of visit frequency on the strength of association between CCIGs and diabetes care. We assigned each veteran to a parent facility where he or she had the most outpatient encounters. We then used this information to adjust for the effects of clustering by VHA facility. Patients belonging to the none CCIG group

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were used as the reference category in all our logistic regression models. We report odds ratios (ORs) and their 95% CIs. Analyses were conducted using SAS version 9.2 (SAS Institute Inc., Cary, NC). Models accounting for clustering by facility were built using PROC GENMOD, and the CONTRAST option was used to generate ORs for the interaction terms.

RESULTS—Only 20% of the 42,826 patients were free of chronic comorbid illnesses. Patients with concordant illnesses constituted ~13% of the study cohort, 30.13% had discordant illnesses, and 25.15% had both concordant and discordant illnesses. Approximately 12% of patients were diagnosed with a dominant illness (Table 1).

All covariates were significantly associated with type of comorbidity ($P < 0.001$). Diabetic patients with either no comorbidities or those with discordant illnesses were more likely to be younger, female, and nonwhite (Table 1). The concordant group had the highest levels of married (66.7%), poverty (38.4%), and copay (28.4%). The discordant group had the lowest levels in all these categories (56.1, 31.4, and 12.6%). A service-connected disability, as measured by the VHA priority code, was more prevalent among patients with discordant and dominant illnesses. F2F visits increased as comorbidities increased. The annual F2F visits ranged from mean (SD) 7.85 (6.6) for the CCIG with no illnesses to 17.48 (15.05) for the CCIGs with both concordant and discordant illnesses and 17.29 (15.5) for the dominant CCIG. (Table 1)

All study covariates showed statistically significant bivariate associations with study outcomes and were entered into the multivariable logistic regression models. Table 2 displays the unadjusted proportions of patients who met diabetes-related care guidelines and treatment goals by CCIGs and visit frequency. Approximately 44% were tested for HbA_{1c} once every 6 months in FY 2004. Three out of four (71%) patients met the HbA_{1c} goal of <8%. The LDL-C measures were met at a higher rate (LDL-C testing 77.2% and LDL-C <130 mg/dL 60.7%). A total of 58% of the study cohort had a diabetes-related visit once every 6 months as recommended. For all the diabetes care measures, the proportion of patients meeting them increased as F2F visits increased. Comparing across CCIGs, the highest proportions were almost always observed in either the none or the concordant CCIG and the lowest in the dominant CCIG.

Table 3 presents results from three sequential main effects models built to assess the association between CCIGs and the five study outcomes (unadjusted, adjusted for sociodemographic covariates, and then further adjusted for F2F visit

Table 1—*Characteristics of veterans with incident diabetes in FY 2003*

	CCIG					
Characteristic	None (*n* = 8,544)	Concordant only (*n* = 5,612)	Discordant only (*n* = 12,902)	Both (*n* = 10,772)	Dominant (*n* = 4,996)	Overall (*n* = 42,826)
Age (years)						
<55	27.31	12.01	38.51	17.57	14.31	24.71
55–64	32.58	22.65	30.89	21.22	18.45	26.27
65–74	26.44	34.84	18.93	30.20	28.56	26.47
>75	13.67	30.51	11.66	31.01	38.67	22.55
Sex						
Male	95.66	98.33	94.82	97.73	97.02	96.44
Female	4.34	1.67	5.18	2.27	2.98	3.56
Race						
White	63.47	79.81	67.44	81.93	78.54	73.21
African American	14.17	11.33	18.11	12.18	15.13	14.60
Other	18.75	7.15	11.32	4.34	3.70	9.61
Hispanic	3.60	1.71	3.14	1.55	2.62	2.58
Marital status						
Married	62.06	66.66	56.06	64.61	61.97	61.49
Not married	37.37	32.88	43.50	35.06	37.75	38.09
Missing	0.57	0.46	0.44	0.32	0.28	0.42
VHA priority code						
Low income	35.60	38.03	31.36	35.47	33.77	34.39
Severe disabled	14.72	14.42	34.70	28.45	32.49	26.23
Moderately disabled	26.03	18.85	20.73	16.95	16.77	20.13
Copay	22.51	28.40	12.59	18.91	16.59	18.70
Missing	1.14	0.30	0.62	0.21	0.38	0.55
Total F2F visits (in FY 2004)						
<7	51.67	29.78	27.15	15.87	21.18	28.85
7–12	32.78	34.60	32.33	28.17	23.38	30.63
13–24	13.46	28.23	26.94	35.85	34.15	27.50
>24	2.08	7.39	13.58	20.11	21.30	13.02
Total F2F visits, mean (SD)	7.85 (6.6)	11.66 (8.4)	14.95 (19.1)	17.48 (15.1)	17.29 (15.5)	14.01 (15.0)
Diabetes-related F2F visits, mean (SD)	2.74 (2.2)	3.00 (2.6)	3.08 (2.7)	3.36 (3.28)	2.71 (3.2)	3.03 (2.8)

Data are percentages unless otherwise indicated. All patient characteristics were significantly associated with CCIG groups in bivariate analysis.

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Table 2—*Veterans with incident diabetes in FY 2003 who met recommended diabetes-related care measures in FY 2004 by CCIGs and visit frequency*

Diabetes-related care measure*	CCIG	Total annual F2F visits				Total
		<7	7–12	13–24	>24	
Process measures						
HbA_{1c} testing (at least once every 6 months)	None	36.99	50.23	52.43	58.43	43.86
	Concordant	38.78	49.38	53.09	54.22	47.63
	Discordant	33.11	45.50	50.26	51.77	44.27
	Both	31.99	46.51	49.27	49.12	45.72
	Dominant	22.02	35.62	40.80	40.79	35.61
LDL-C testing (at least once a year)	None	71.33	79.76	82.70	84.83	75.90
	Concordant	72.23	84.55	85.54	89.16	81.50
	Discordant	67.11	78.28	81.19	79.91	76.25
	Both	66.08	81.11	83.97	85.64	80.66
	Dominant	50.57	69.95	76.32	79.23	70.00
Diabetes-related F2F visit (at least once every 6 months)	None	51.37	69.51	70.96	74.72	60.44
	Concordant	51.23	62.00	62.25	62.17	58.87
	Discordant	44.90	63.92	66.74	65.81	59.77
	Both	39.18	59.56	62.30	62.93	57.98
	Dominant	22.59	47.52	53.22	53.10	45.38
Intermediate measures						
Treatment goal for HbA_{1c} (HbA_{1c} <8%)†	None	69.63	77.86	76.59	76.25	73.33
	Concordant	69.49	76.97	76.58	76.44	74.45
	Discordant	66.72	74.49	75.50	74.90	72.65
	Both	61.12	72.18	70.96	72.32	69.91
	Dominant	44.97	63.72	66.17	65.20	60.67
Treatment goal for LDL-C (LDL-C <130 mg/dL)†	None	54.56	61.43	65.56	67.09	58.46
	Concordant	59.68	70.06	73.53	74.71	68.04
	Discordant	50.13	58.53	60.81	60.39	57.05
	Both	52.99	66.41	70.35	71.38	66.44
	Dominant	38.89	53.68	61.55	62.02	54.73

Data are percentages. *CCIG variable was significantly associated with all outcome variables within every F2F visit frequency stratum in bivariate analysis. All *P* values were <0.0001. †Excluded patients tested for HbA_{1c} (n = 3,310) and LDL-C (n = 3,494) outside of the VHA and covered by Medicare for whom test results were not available.

frequency). Results from the unadjusted models (model 1) showed that comorbidity type was associated with odds of meeting diabetes guidelines and goals. Increased odds were seen among the concordant and the both concordant and discordant CCIGs. Discordant and dominant groups were associated with similar and lower odds, respectively, for meeting diabetes guidelines and goals compared with the no comorbidity group. For example, patients with concordant (OR 1.17 [95% CI 1.09–1.25]) illness had 17% higher odds for getting tested for HbA_{1c} as per guideline compared with those with no comorbidity, and patients with both concordant and discordant comorbidities had 8% higher odds. The dominant group had 29% lower odds of meeting the guideline. This trend was seen for two other outcomes—LDL-C testing and LDL-C treatment goal. Model 2 additionally controlled for sociodemographic variables, and the results were similar to model 1. The initial models showed a pattern of improved or similar diabetes care among patients with either concordant, discordant, or both concordant and discordant illnesses, contrary to the study hypotheses.

However, after adjusting for differences in F2F visit frequency, model 3 results supported the study hypotheses. For all study outcomes, patients in the concordant illness group had similar or increased likelihood of meeting recommended diabetes care measures compared with those with no illnesses. Those with discordant and dominant illnesses reported statistically significant lower likelihood of meeting recommended diabetes-related care measures compared to those with no illnesses. The magnitude of reduction in odds ranged between 10–21% for discordant CCIG and 32–54% for dominant CCIG. The complete set of results for model 3 is provided in Supplementary Table 1.

Table 4 presents results from model 4, which included all covariates from model 3 along with an additional interaction term between CCIGs and F2F visit frequency. The interaction term was significant for four out of five outcomes (HbA_{1c} goal, LDL-C goal, LDL-C testing, and diabetes-related visits), indicating that the association between CCIGs and study outcomes was modified by visit frequency.

Presence of concordant illnesses was associated with similar odds for HbA_{1c}-related measures regardless of visit frequency and increased odds for LDL-C–related measures only at lower visit frequency (<24 visits). Presence of discordant illnesses resulted in lower odds for HbA_{1c}-related measures when annual visit frequency was ≤12 and for LDL-C–related measures when there were <7 annual visits. Presence of dominant illnesses was associated with significantly lower odds for HbA_{1c}-related measures regardless of visit frequency and LDL-C–related measures when number of visits made in a year

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Table 3—*Results from logistic regression models assessing the effect of CCIGs on diabetes-related care measures*

		Diabetes-related care measures met				
		Process			Intermediate	
Model	CCIG (reference: none)	HbA_{1c} testing (at least once every 6 months)	LDL-C testing (at least once a year)	Diabetes-related F2F visit (at least once every 6 months)	Treatment goal for HbA_{1c} <8%§	Treatment goal for LDL-C <130 mg/dL§
Model 1*	Concordant	**1.17 (1.09–1.25)**	**1.40 (1.24–1.57)**	0.93 (0.87–1.00)	1.06 (0.96–1.17)	**1.50 (1.37–1.66)**
	Discordant	1.02 (0.97–1.07)	1.02 (0.94–1.10)	0.97 (0.92–1.02)	0.96 (0.90–1.03)	0.94 (0.89–1.01)
	Both	**1.08 (1.01–1.15)**	**1.32 (1.20–1.46)**	**0.90 (0.84–0.96)**	**0.84 (0.77–0.92)**	**1.40 (1.29–1.51)**
	Dominant	**0.71 (0.66–0.76)**	**0.74 (0.65–0.84)**	**0.54 (0.51–0.58)**	**0.56 (0.50–0.62)**	**0.86 (0.78–0.94)**
Model 2†	Concordant	**1.16 (1.08–1.24)**	**1.32 (1.18–1.47)**	0.99 (0.92–1.06)	1.01 (0.92–1.11)	**1.39 (1.27–1.52)**
	Discordant	1.04 (0.99–1.10)	1.07 (0.98–1.16)	0.98 (0.94–1.03)	1.01 (0.94–1.09)	1.00 (0.94–1.07)
	Both	**1.09 (1.03–1.17)**	**1.29 (1.17–1.42)**	0.96 (0.91–1.03)	**0.83 (0.76–0.91)**	**1.34 (1.24–1.45)**
	Dominant	**0.74 (0.69–0.80)**	**0.73 (0.65–0.82)**	**0.60 (0.56–0.64)**	**0.57 (0.52–0.63)**	**0.82 (0.75–0.90)**
Model 3††	Concordant	1.01 (0.94–1.08)	1.13 (1.00–1.27)	0.83 (0.77–0.89)	0.92 (0.84–1.02)	**1.25 (1.14–1.38)**
	Discordant	**0.88 (0.83–0.93)**	**0.87 (0.80–0.95)**	**0.79 (0.75–0.83)**	**0.90 (0.83–0.97)**	**0.87 (0.81–0.94)**
	Both	**0.86 (0.80–0.91)**	0.96 (0.85–1.07)	**0.70 (0.66–0.75)**	**0.70 (0.64–0.78)**	1.10 (1.01–1.20)
	Dominant	**0.59 (0.55–0.64)**	**0.56 (0.49–0.65)**	**0.46 (0.42–0.49)**	**0.50 (0.45–0.55)**	**0.68 (0.62–0.76)**

Data are OR (95% CI). Bold type indicates statistical significance. *Model 1: Unadjusted model. †Model 2: Added sociodemographic covariates age-groups, sex, race, marital status, and VHA priority code to the model. ††Model 3: Added covariate total visit frequency (F2F visits) to the model. All covariates were significant independent predictors for all diabetes care measures. §Excluded patients tested for HbA_{1c} (n = 3,310) and LDL-C (n = 3,494) outside of the VHA and covered by Medicare for whom test results were not available.

were ≤24. For all illness groups, the odds for having diabetes-related F2F visits as recommended were significantly lower than those with no illnesses, regardless of visit frequency.

Using results from LDL-C treatment goal measure (LDL-C level <130 mg/dL) as a specific illustration, among patients who had more than seven visits per year, having concordant illnesses significantly increased the odds (OR 1.16 [95% CI 1.01–1.33]) of meeting the goal compared with patients with no comorbidity. The odds were significantly lower for patients with discordant (0.87 [0.79–0.96]) and dominant (0.52 [0.45–0.61]) illnesses.

As visit frequency increased to 7–12 annual visits, those with concordant illnesses had significantly higher odds of meeting the LDL-C goal (OR 1.38 [95% CI 1.20–1.60]). Those with both concordant and discordant illnesses also had higher odds (1.21 [1.06–1.38]). Those with discordant illnesses had lower odds (0.95 [0.85–1.07]), but the findings were not significant. Those with dominant illnesses had lower odds (0.72 [0.61–0.86]). These results were similar among patients with 13–24 annual visits.

Finally, among patients making >24 annual visits, there were no statistically significant differences among the five CCIGs in the odds for attaining the LDL-C treatment goal.

CONCLUSIONS—In the initial analysis, our study found that an increasing burden of comorbidity was associated with increased visit frequency and higher levels of receiving recommended diabetes care regardless of type of CCIG. However, after adjustment for visit frequency, the results supported the study hypotheses that having concordant illnesses was associated with similar or better diabetes care, having discordant illnesses was associated with decreased diabetes care, and the presence of dominant illnesses resulted in markedly decreased diabetes care. This difference was more pronounced among patients who made less frequent visits.

There are some studies that report a similar relationship between comorbidity type and receipt of guideline-concordant care, for example, a study by Sales et al. (19) among postacute myocardial infarction patients and a Lagu et al. (20) study among hypertensive patients. Krein et al. (21) showed that chronic pain affected hypertension care in diabetes. Our findings support the underlying premise of the competing demands framework proposed by Piette and Kerr (13) among veterans with new-onset diabetes. Health care resources are finite, and diabetic patients burdened with additional discordant or dominant illness may not be able to receive all the care they need to address both their diabetes and nondiabetes needs (13,22).

However, the phenomenon of competing demands was not consistent. As visit frequency increased, differences in diabetes care became less pronounced. Health care systems' ability to compensate in this way will depend on availability of resources, including subspecialty care and care coordination. Physicians' capacity will depend on how well they manage visit time to address multiple illnesses. Finally, patients' ability to compensate may depend on access to health care, availability of a caregiver, and how they prioritize their self-care (13–15,22–24). Such compensatory mechanisms are a likely explanation for the association between increased comorbidity burden and a seemingly paradoxical improvement in quality of care that has been reported in several studies (11,25–28).

Few other studies report a similar interaction between type of comorbidity and visit frequency when examining quality of care. Kodl et al. (29) reported that among veterans, when visit frequency was not accounted for, presence of a mental health diagnosis was associated with either increased or similar likelihood of colorectal cancer screening. However, after adjusting for visit frequency, presence of a mental health diagnosis increases risk of not receiving colorectal cancer screening. Along similar lines, Fenton et al. (30) demonstrated substandard preventive care for diabetes among HMO-enrolled

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Table 4—Results from logistic regression models assessing the effect of interaction between CCIGs and visit frequency on diabetes-related care measures

	CCIG (reference: none)	Model 4† Total F2F visits per year <7	7–12	13–24	>24
Process measures					
HbA_{1c} testing (at least once every 6 months)	Concordant	1.09 (0.97–1.22)	0.97 (0.86–1.09)	1.03 (0.89–1.19)	0.87 (0.59–1.30)
	Discordant	**0.87 (0.80–0.95)**	**0.84 (0.76–0.93)**	0.95 (0.82–1.10)	0.81 (0.56–1.15)
	Both	**0.84 (0.74–0.95)**	**0.88 (0.79–0.98)**	0.90 (0.79–1.03)	0.72 (0.50–1.02)
	Dominant	**0.55 (0.47–0.65)**	**0.58 (0.51–0.67)**	**0.65 (0.56–0.76)**	**0.52 (0.36–0.73)**
LDL-C testing (at least once a year)	Concordant	1.01 (0.87–1.18)	**1.35 (1.14–1.59)**	1.18 (0.92–1.51)	1.40 (0.82–2.39)
	Discordant	**0.85 (0.77–0.95)**	0.97 (0.85–1.11)	0.97 (0.78–1.20)	0.78 (0.51–1.19)
	Both	**0.80 (0.69–0.92)**	1.09 (0.94–1.28)	1.08 (0.85–1.39)	1.07 (0.72–1.59)
	Dominant	**0.44 (0.38–0.51)**	**0.61 (0.50–0.75)**	**0.68 (0.53–0.87)**	0.68 (0.43–1.08)
Diabetes-related F2F visit (at least once every 6 months)	Concordant	1.06 (0.95–1.18)	**0.76 (0.67–0.86)**	**0.72 (0.61–0.85)**	**0.62 (0.41–0.95)**
	Discordant	**0.79 (0.73–0.86)**	**0.77 (0.70–0.85)**	**0.83 (0.71–0.96)**	**0.65 (0.46–0.90)**
	Both	**0.67 (0.59–0.76)**	**0.69 (0.62–0.77)**	**0.73 (0.63–0.84)**	**0.62 (0.45–0.84)**
	Dominant	**0.34 (0.29–0.40)**	**0.45 (0.40–0.51)**	**0.51 (0.44–0.60)**	**0.42 (0.31–0.58)**
Intermediate measures					
Treatment goal for HbA_{1c} (HbA_{1c} <8%)§	Concordant	0.96 (0.83–1.11)	0.91 (0.78–1.06)	0.96 (0.80–1.16)	1.01 (0.64–1.58)
	Discordant	**0.90 (0.81–0.99)**	**0.86 (0.77–0.97)**	1.02 (0.85–1.21)	1.03 (0.69–1.54)
	Both	**0.68 (0.58–0.80)**	**0.73 (0.63–0.83)**	**0.75 (0.63–0.89)**	0.84 (0.58–1.22)
	Dominant	**0.38 (0.32–0.45)**	**0.52 (0.44–0.62)**	**0.61 (0.51–0.75)**	**0.60 (0.40–0.88)**
Treatment goal for LDL-C (LDL-C <130 mg/dL)§	Concordant	**1.16 (1.01–1.33)**	**1.38 (1.20–1.60)**	**1.32 (1.10–1.59)**	1.31 (0.88–1.95)
	Discordant	**0.87 (0.79–0.96)**	0.95 (0.85–1.07)	0.88 (0.75–1.03)	0.85 (0.61–1.19)
	Both	0.92 (0.81–1.04)	**1.21 (1.06–1.38)**	1.19 (0.99–1.42)	1.21 (0.88–1.66)
	Dominant	**0.52 (0.45–0.61)**	**0.72 (0.61–0.86)**	**0.81 (0.67–0.99)**	0.77 (0.54–1.11)

Data are OR (95% CI). Bold type indicates statistical significance. †Model 4: Added the interaction term between CCIGs and visit frequency (CCIG × F2F visits) to model 3. The interaction term (CCIG × F2F visits) was significant for all diabetes care measures, except for HbA_{1c} testing. §Excluded patients tested for HbA_{1c} (n = 3,310) and LDL-C (n = 3,494) outside of the VHA and covered by Medicare for whom test results were not available.

patients who made either infrequent outpatient visits (less than eight per year) or more frequent but low-priority visits.

We identified two studies of patients with diabetes that were based on the competing demands framework proposed by Piette and Kerr (13) and whose results fail to support the framework's hypotheses. Woodard et al. (31) studied the effect of concordant and discordant illnesses on quality care among all veterans with diabetes. They concluded that complexity of comorbidity was associated with superior care, regardless of comorbidity type. Their results remained unchanged after accounting for visit frequency. The difference between their study and ours is that their sample included patients with prevalent as well as incident diabetes, used different comorbid illnesses to determine CCIGs, and used the relative risk score from the diagnostic cost groups (DxCG) as an illness burden indicator. DxCG is correlated with both comorbidity type and visit frequency, and its inclusion might modify the effect of the other variables. Bayliss et al. (32) used a population of prevalent diabetes patients to study the pre- and posteffect of three discordant incident conditions (cancer, depression, and exacerbation of chronic obstructive pulmonary disease) on intermediary outcomes (HbA_{1c}, LDL-C, and blood pressure) and reported no short-term or long-term effects on study outcomes.

Our implementation of the Piette and Kerr (13) framework can refine the assessment of comorbidities when evaluating diabetes care. In studies examining pay for performance, for example, comorbidities were measured in aggregate for risk-adjustment purposes, whereas our findings indicate that different types of comorbidities have different effects. It can also be used to evaluate the adequacy of the compensatory response across health care systems: adequate compensation should attenuate the adverse effect of discordant comorbidities. It might also help in identifying system factors that favor adequate compensation, such as better care coordination. Additional applications might include evaluating whether diabetes care quality measures need tailoring for certain illness groups.

Our study has several strengths. First, we used a large population-based study cohort to evaluate the Piette and Kerr (13) framework. Second, we used a comprehensive list of 53 comorbid illnesses. Third, we evaluated five CCIG groups, including those with dominant illnesses. Fourth, the VHA population is known to have higher prevalence of comorbidity, which enabled us to successfully contrast the patterns of study outcomes across the various CCIGs, which might not be possible in populations with low prevalence of comorbidity. Fifth, use of a longitudinal

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study design preserved temporality between the exposure and outcome.

Our study has several limitations. First, the study results are not generalizable to the U.S. population or other populations because the VHA population is predominantly male and has a high prevalence of comorbidity. Second, we did not have access to laboratory results from Medicare. Data from private insurance was also unavailable. Third, the inclusion criteria in the baseline year (FY 2003) biased the study to those with at least three or more F2F visits. Fourth, our study cohort was drawn from an administrative database that does not include any patient-reported data on resources available for self-care of diabetes management; health care access barriers; knowledge, attitudes, beliefs, and perceptions on diabetes care; quality of patient-physician interaction; and other factors that are known to have an impact on our study outcomes. Fifth, when classifying comorbid illnesses, we looked for presence or absence of comorbid illnesses only; we did not account for their severity. Sixth, we classified all patients into broad CCIGs but did not assess the relative burden of illnesses within each CCIG.

Further research is required to extend this study's findings. One such area is the impact of type of visits (primary or specialty) on diabetes care. In addition, this study is limited to understanding the impact of the framework on diabetes care for those with new-onset diabetes. We feel that further analysis will be required to determine whether these findings will apply to those with prevalent diabetes as well.

Comorbidity type affected diabetes care. Discordant illnesses were associated with decreased diabetes care, possibly as a result of competition for time, attention, or other limited resources. Concordant illnesses, on the other hand, were associated with either similar or better care, probably because their management is congruent with that for diabetes. Dominant illnesses were associated with significant decrease in diabetes care that may be appropriate given their poor prognoses. In addition, the effect of competing demands was greater at the lower end of the visit frequency spectrum. This suggests the need for better care coordination within health care systems to improve diabetes care among patients with comorbidities. The Piette and Kerr (13) framework, based on the competing demands model, can be used as a tool to compare diabetes care across health care systems and providers, to identify patient groups who might be receiving over- and undertreatment and design specific interventions to improve their care, and to design appropriate performance measures based on evidence-based benefits while accounting for individuals' comorbidity type and life expectancy.

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S.R.P. researched data, contributed to discussion, and wrote the manuscript. M.R. researched data, contributed to discussion, and reviewed and edited the manuscript. B.G.F., C.-L.T., D.R.M., C.L.C., and L.M.P. contributed to discussion and reviewed and edited the manuscript. E.A.K. reviewed and edited the manuscript. L.M.P. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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