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Defining Patient Complexity From the Primary Care Physician's Perspective

A Cohort Study

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Background: Patients with complex health needs are increasingly the focus of health system redesign.

Objective: To characterize complex patients, as defined by their primary care physicians (PCPs), and to compare this definition with other commonly used algorithms.

Design: Cohort study.

Setting: 1 hospital-based practice, 4 community health centers, and 7 private practices in a primary care network in the United States.

Participants: 40 physicians who reviewed a random sample of 120 of their own patients.

Measurements: After excluding patients for whom they were not directly responsible, PCPs indicated which of their patients they considered complex. These patients were characterized, independent predictors of complexity were identified, and PCP-defined complexity was compared with 3 comorbidity-based methods (Charlson score, Higashi score, and a proprietary Centers for Medicare & Medicaid Services algorithm).

Results: Physicians identified 1126 of their 4302 eligible patients (26.2%) as complex and assigned a mean of 2.2 domains of complexity per patient (median, 2.0 [interquartile range, 1 to 3]). Mental health and substance use were identified as major issues in younger complex patients, whereas medical decision making and care coordination predominated in older patients ($P < 0.001$ for trends by decade). Major independent predictors of PCP-defined complexity ($P < 0.001$) included age (probability of complexity increased from 14.8% to 19.8% with age increasing from 55 to 65 years), poorly controlled diabetes (from 12.7% to 47.6% if hemoglobin A_{1c} level $\geq$9%), use of antipsychotics (from 12.7% to 31.8%), alcohol-related diagnoses (from 12.9% to 27.4%), and inadequate insurance (from 12.5% to 19.2%). Classification agreement for complex patients ranged from 26.2% to 56.0% when PCP assignment was compared with each of the other methods.

Limitation: Results may not be generalizable to other primary care settings.

Conclusion: Primary care physicians identified approximately one quarter of their patients as complex. Medical, social, and behavioral factors all contributed to PCP-defined complexity. Physician-defined complexity had only modest agreement with 3 comorbidity-based algorithms.

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Life-saving advances in medical care, improved disease prevention practices, and an aging population have all increased the medical complexity of patients who receive primary care in the United States (1). Recent estimates (2) indicate that more than 75 million persons in the United States have 2 or more concurrent chronic conditions. Approximately 65% of total health care expenditures are directed toward the 25% of patients with multiple chronic conditions, including 80% of Medicare spending on the subset of patients with 4 or more chronic diseases (1, 3). Given the central role of the primary care system in managing and coordinating patient care, a clearer understanding of the attributes that contribute to complexity may help in redesigning our health system to meet the changing health care needs of our population (4).

Although several methods are already used to identify patients with increased health care needs, no definition of patient complexity has been widely established (5–8). Most complexity measures are based on the number of chronic conditions or medications and may also include data on previous health care costs and use of resources (9–12). However, patient complexity is probably a multifaceted concept not fully captured by the number or type of medical conditions or by previous health care costs. For example, caring for an adherent and insured patient with 5 well-controlled comorbid conditions may be relatively straightforward, whereas management of another patient with fewer conditions may present a considerable challenge because of psychosocial or nonmedical factors.

We hypothesized that primary care physicians (PCPs) have a unique perspective on what defines complexity beyond medical comorbidity or previous resource use. Our goals were to empirically define a set of complex patients on the basis of physician review of their own primary care patient panels, characterize these complex patients (in

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Context

Understanding factors that contribute to the complexity of a patient's health care needs is essential to well-designed health care systems. Measures of complexity exist, but their correspondence to physician assessment is undefined.

Contribution

Researchers asked 40 primary care physicians to rate the complexity of 120 of their own patients and to document the characteristics associated with complexity. Over one quarter of patients were defined as complex. Social and behavioral factors contributed to physician assessment of complexity. Physician assessment differed substantially from 3 often-used comorbidity measures.

Implication

Patient complexity is multidimensional and is not adequately captured in measures that focus only on comorbid conditions.

—The Editors

terms of complexity domains and compared with noncomplex patients), identify independent predictors of PCP-defined patient complexity by using electronically available variables, and assess the correlation of PCP-defined complexity with other commonly used approaches.

METHODS

Procedure for Defining Complex Patients

Primary care physicians were recruited from the Massachusetts General Primary Care Practice-Based Research Network, which comprises 12 primary care practices (4 community health centers, 1 hospital-based practice, and 7 private offices) and 141 attending PCPs. A convenience sample of 41 attending PCPs was recruited from 9 of 12 practices, 40 of whom agreed to participate. All 3 practice settings were represented, with the proportion of participating PCPs from each practice setting ranging from 25.0% to 34.8%. Physician participants and nonparticipants did not significantly differ in demographic characteristics or clinical productivity (**Appendix Table 1**, available at www.annals.org).

Study participants reviewed a list of 120 randomly selected patients from their panels and indicated which patients they considered complex by using a Web-based survey tool developed for this study and linked to our system's electronic medical record. Patients seen in our primary care network in the previous 3 years were linked to specific PCPs by using a validated algorithm (13). Because our goal was to assess patient complexity as defined by physicians, PCPs were not provided with a specific definition of patient complexity. Rather, they were asked to indicate "in their view" which of their patients were complex. Physicians reviewed their lists between March and May 2009 and were paid a $250 participation stipend.

Once a patient was identified as complex, PCPs were further asked to indicate which factors influenced this designation by choosing from a list of 5 complexity domains, which were developed from previously published concepts (14) and modified on the basis of feedback from a PCP advisory group in our institution by using hypothetical patient examples. With this approach, we defined 5 patient complexity domains (**Table 1**).

Comparison of PCP-Defined Complexity With Other Methods

We hypothesized that some apparently complex patients (such as those with multiple diagnoses) are relatively straightforward for a PCP to manage, whereas other apparently noncomplex patients (such as younger patients with no comorbid conditions) require substantial management efforts because of nonmedical issues. To investigate this hypothesis, we compared our PCP-defined complexity method with 3 separate methods for identifying complex patients: the Charlson score (10, 12), a predictor of future mortality based on patient age and a weighted algorithm of 16 diagnoses associated with subsequent mortality (including cerebrovascular disease, dementia, and congestive heart

Table 1. **Identifying Patient Complexity***

Complexity Domain	Definition
Medical decision making	The cognitive effort required to evaluate and understand the clinical processes and make the appropriate therapeutic decisions
Coordination of care	The work involved in overseeing and coordinating elements of care involving other providers, and the responsibility for making sure that the medical system is working for the patient
Patient's personal characteristics	The individual behaviors of the patient that increase the challenge of providing effective care (such as suboptimal adherence to medications or scheduled appointments)
Patient's diagnosed mental health issues	Psychiatric disorders distinct from the patient's characteristics that increase the complexity of care (including substance abuse)
Patient's socioeconomic circumstance	Influences outside of the medical sphere that increase the complexity of managing the patient (such as patient home or work responsibilities that interfere with self-management or patient inability to afford prescribed medications)

* Instructions given to participating physicians: "I am writing to ask you to participate in the MGH [Massachusetts General Hospital] Patient Complexity Project, an IRB [institutional review board]–approved study to understand patient complexity from the PCP's [primary care physician's] perspective. The study involves asking you to review a list of your own patients to indicate which ones, in your view, are complex. For those patients deemed complex, you are further asked to indicate which domain(s) of complexity are primarily involved."

Table 2. **Physician and Patient Characteristics for Overall Cohort and by Tertile of Patient Panel Complexity**

Variable	All Physicians (*n* = 40)	Patient Panel Complexity			*P* Value*
		Top Tertile (*n* = 14)	Middle Tertile (*n* = 14)	Bottom Tertile (*n* = 12)	
Complex patients, *n/N (%)*	1126/4302 (26.2)	597/1374 (43.5)	343/1568 (21.9)	186/1360 (13.7)	<0.001
PCP characteristics					
Mean age (SD), *y*	46.0 (8.8)	50.3 (9.6)	44.3 (7.5)	43.1 (8.1)	0.054
Women, %	57.5	64.3	50.0	58.3	0.76
Mean time since graduation (SD), *y*	17.6 (8.9)	21.7 (10.2)	16.1 (7.4)	14.4 (7.5)	0.052
Mean time on staff (SD), *y*	13.5 (7.7)	17.9 (7.1)	11.6 (7.7)	10.4 (6.6)	0.010
Mean outpatient visits in the previous year (SD), *n*	1620.4 (876.8)	1649.2 (795.6)	1595.1 (949.5)	1616.1 (953.9)	0.92
Mean FTEs in the previous year (SD), *n*	0.51 (0.24)	0.51 (0.20)	0.52 (0.26)	0.51 (0.26)	0.91
Mean panel size (SD), *n*	744.9 (314.9)	704.5 (253.5)	716.9 (373.4)	824.6 (317.5)	0.29
Practice type, %					0.088
Community health center	40.0	57.1	42.9	16.7	
Hospital-based	25.0	14.3	21.4	41.7	
Office-based	35.0	28.6	35.7	41.7	
Mean complexity domains per complex patient (SD), *n*	2.2 (1.2)	2.2 (1.3)	2.2 (1.2)	2.2 (1.1)	0.90
Prevalence of complexity domains among complex patients, %					
Medical decision making	62.4	66.2	57.4	59.7	0.106
Patient's personal characteristics	54.4	51.9	58.3	54.8	0.49
Coordination of care	39.6	41.4	36.4	39.8	0.70
Mental health issues	33.7	34.0	32.9	33.9	0.97
Patient's socioeconomic circumstances	30.6	38.6	32.7	32.8	0.28
Patient characteristics					
Mean age (SD), *y*	50.9 (16.4)	53.2 (16.8)	50.9 (16.4)	48.7 (15.8)	<0.001
Women, %	61.6	61.9	61.3	61.5	0.80
Nonwhite, %	23.7	25.1	23.2	22.9	0.170
Insurance status, %					<0.001
Commercial health insurance	67.9	61.8	68.2	73.7	
Government insurance	29.5	35.9	29.1	23.5	
Uninsured	2.6	2.3	2.7	2.8	
Median household income, $†	58 081	53 784	58 374	62 514	<0.001
Did not graduate high school, %†	16.0	19.0	15.6	13.2	<0.001
Mean clinic visits (SD), *n*	7.4 (6.0)	8.6 (6.6)	7.5 (6.0)	6.2 (5.0)	<0.001
Mean PCP visits (SD), *n*	5.9 (5.2)	7.0 (5.7)	5.7 (5.2)	5.1 (4.4)	<0.001

FTE = full-time equivalent; PCP = primary care physician.
* Top vs. bottom tertile.
† Based on census block data; 533 patients had no census information.

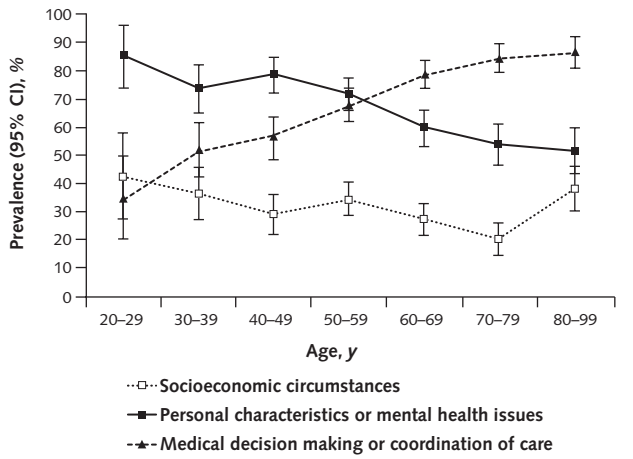
failure); Higashi and colleagues' method (9), which is based on a count of 9 common chronic conditions (atrial fibrillation, chronic obstructive pulmonary disease, coronary artery disease, depression, diabetes, heart failure, hypertension, osteoarthritis, and stroke); and a commercial severity adjustment tool used by the Centers for Medicare & Medicaid Services (CMS) that incorporates patient age, diagnoses, and incurred costs to model future hospitalization risk. Because our broader goal was to identify individual patients rather than describe patient populations, we dichotomized the 3 algorithms to define a binary set of complex versus noncomplex patients. We used Charlson score thresholds of 1 or more and 2 or more conditions and a Higashi score threshold of 2 or more conditions because these thresholds gave a relatively similar proportion of complex patients as our PCP method. We used a threshold relative risk of 3 or greater in the CMS tool because our institution applies this threshold to identify high-risk patients for case-management referral.

Statistical Analysis

We compared characteristics of PCP-designated complex versus noncomplex patients by using chi-square or *t* tests as appropriate. The characteristics of PCPs who reported the highest versus the lowest proportion of complex patients (by tertile) were also compared. Physician variables included age, sex, years since medical school graduation, years in practice at our institution, and measures of outpatient clinical activity in the study year (such as clinical sessions per week, size of patient panel, and number of annual patient visits). We compared PCP-defined complexity with each of the other patient-classification methods by determining percentage of agreement among patients identified as complex. To examine variability in complexity designation by PCP, we also calculated percentage of agreement per PCP.

Patient-related variables were derived from clinical data available from electronic data sources over the 3 years preceding the study. Sources of data included registration

Figure. **Prevalence (95% CI) of complexity domains among 1126 PCP-defined complex patients, by patient age.**



$P < 0.001$ for trends by decade. PCP = primary care physician.

records (patient demographic characteristics), appointment scheduling (annual visits and "no-show" missed appointments), billing information, laboratory tests, and prescribed medications (**Appendix**, available at www.annals.org). Median household income and high school graduation rates were derived from census block group data and represent neighborhood-level markers of socioeconomic status.

We constructed a multivariate logistic regression model to identify independent predictors of PCP-defined patient complexity, after accounting for confounding by physician by including a fixed effect for physician in all models (using the PROC Logistic command in SAS, version 9.2 [SAS Institute, Cary, North Carolina]). Covariates were selected on the basis of clinical judgment, and associations were noted in univariate analyses. Model fit was assessed by using the Hosmer–Lemeshow goodness-of-fit test, and we checked for collinearity by using the variance inflation factor. No problems with lack of fit or collinearity were detected. For these models, we report the change in predicted probability of PCP-defined complexity for each model variable when other model variables are held constant (using mean cohort values). For age, we report the change in predicted probability for being defined as complex with age change from 55 to 65 years. For the other continuous variables, we report the change in predicted probability of PCP-defined complexity by using the mean values for the complex and noncomplex populations. All analyses were performed by using SAS. The Massachusetts General Hospital Institutional Review Board approved our study.

Role of the Funding Source

Funding for this study was provided by a Systems Improvement Grant from Partners Community Healthcare, Inc., and by the Massachusetts General Hospital Primary Care Operations Improvement Program. The funding sources had no role in the design, data collection, analysis, interpretation, implementation, or conduct of the study; the drafting, revision, or approval of the manuscript; or the decision to submit the manuscript for publication.

RESULTS

Primary Data Collection

The 40 participating physicians represented 9 primary care practices within our network, with 16 PCPs from community health centers, 10 from hospital-based practices, and 14 from office-based practices. Of the initial 4800 patients listed, 322 (6.7%) were excluded by PCPs as "not my patient" and 176 (3.7%) were skipped, leaving 4302 patients for analysis. Among the 7 PCPs with skipped patients, skipped and nonskipped patients were clinically similar; and these 7 PCPs did not significantly differ from the 33 PCPs with no skipped patients in terms of PCP demographic characteristics or clinical productivity.

More than one quarter of patients (1126 [26.2%]) were defined as complex by their PCPs, with variation between PCPs (SD, 15.4%; range, 1.7% to 70.0%). Physicians who practiced in community health centers reported a higher proportion of complex patients than those in the other 2 practice settings (29.7% vs. 23.9%; $P < 0.001$) (**Appendix Table 2**, available at www.annals.org). Overall, PCPs who reported the highest proportion of complex patients were older, had graduated medical school longer ago, and had been on staff for more years (**Table 2**).

Table 3. **Characteristics of PCP-Defined Complex Versus Noncomplex Patients**

Characteristic	Complex Patients (n = 1126)	Noncomplex Patients (n = 3176)	P Value
Mean age (SD), *y*	60.0 (16.3)	47.7 (15.2)	<0.001
Women, %	65.5	60.1	0.001
Nonwhite, %	22.9	24.0	0.48
Insurance status, %			<0.001
Commercial health insurance	42.4	77.0	
Government insurance	55.3	20.3	
Uninsured	2.3	2.7	
Median household income, $*	53 159	59 934	<0.001
Did not graduate high school, %*	18.3	15.2	<0.001
Mean clinic visits (SD), *n*	11.3 (7.7)	6.1 (4.5)	<0.001
Mean PCP visits (SD), *n*	9.3 (6.9)	4.7 (3.8)	<0.001
Mean prescribed medications (SD), *n*	14.8 (9.7)	6.8 (5.6)	<0.001
"No-show" rate >25%, %†	10.0	8.0	0.054
Mean providers seen (SD), *n*	2.9 (2.1)	2.0 (1.4)	<0.001

PCP = primary care physician.
* Based on census block data; 533 patients had no census information.
† Rate calculated as [missed appointments/(missed + arrived appointments)] among patients with ≥3 missed or arrived appointments in the past 3 y; data are missing for 577 patients with <3 missed or arrived appointments in the past 3 y.

Domains of Complexity

Among the 1126 complex patients, PCPs identified a mean of 2.2 contributing domains per patient (median, 2.0 [interquartile range, 1 to 3]). The most prevalent domain was medical decision making (62.4% of complex patients), followed by the patient's personal characteristics (54.4%), coordination of care (39.6%), the patient's diagnosed mental health issues (33.7%), and his or her socioeconomic circumstances (30.6%). Fifteen complex patients (1.3%) were not assigned any domain. The prevalence of the domains varied by age, with patient personal characteristics and socioeconomic issues predominating in younger patients and medical decision making and care coordination predominating in older patients ($P < 0.001$ for trends by decade) (**Figure**). The prevalence of each assigned complexity domain did not significantly differ between PCPs in the highest versus the lowest tertile of patient panel complexity (**Table 2**).

Characteristics of Complex Versus Noncomplex Patients

Complex patients were more likely to be underinsured and to live in census blocks with lower median income and high school graduation rates. Overall, complex patients made more visits, had more missed appointments, and saw more providers than noncomplex patients (**Table 3**).

Because the prevalence of the complexity domains differed by patient age (**Figure**), we also explored the associations of patient characteristics with age. We found that several factors were associated with complexity in younger patients but not in older patients, including female sex, nonwhite race or ethnicity, a positive urine test result for alcohol or drug abuse, a diagnosis of alcohol-related problems or hepatitis C, and prescription of smoking cessation agents (**Appendix Table 3**, available at www.annals.org).

In a multivariate regression model, major independent predictors of PCP-defined complexity included increased age, poorly controlled diabetes (hemoglobin A_{1c} [HbA_{1c}] level ≥9%), prescription of antipsychotics, alcohol-related diagnoses, and inadequate insurance. For each variable, we calculated the change in predicted probability of PCP-defined complexity for 2 values of the variable (holding all other variables in the model constant). The predicted probability of PCP-defined complexity increased from 14.8% to 19.8% as patient age increased from 55 to 65 years ($P < 0.001$), 12.7% to 47.6% as HbA_{1c} changed from less than 9% to 9% or greater ($P < 0.001$), 12.7% to 31.8% if the patient received antipsychotics ($P < 0.001$), 12.9% to 27.4% ($P < 0.001$) if the patient received an alcohol-related diagnosis, and 12.5% to 19.2% ($P < 0.001$) if the patient was inadequately insured.

In addition to these variables, patient complexity was independently associated with more annual clinic visits (predicted probability increase with increase from 6 to 11 visits per year, 12.6% to 14.4%; $P = 0.002$), more prescribed medications (increase from 7 to 15, 11.5% to 19.8%; $P < 0.001$), need for psychotherapy (12.5% to 19.2%; $P < 0.001$), and diagnosis of atrial fibrillation (12.8% to 23.8%; $P < 0.001$).

Table 4. **Comparison of PCP-Defined Classification of Patient Complexity With Other Methods**

Complexity Measure	Patients Considered Complex by PCP (n = 1126)	Patients Considered Noncomplex by PCP (n = 3176)
Charlson score, *n (%)*		
Threshold of 2		
Score ≥2	295 (26.2)	277 (8.7)
Score <2	831 (73.8)	2899 (91.3)
Threshold of 1		
Score ≥1	510 (45.3)	693 (21.8)
Score <1	616 (54.7)	2483 (78.2)
Higashi method, *n (%)*		
Score ≥2	631 (56.0)	508 (16.0)
Score <2	495 (44.0)	2668 (84.0)
CMS tool, *n (%)**		
RR ≥3	311 (28.9)	154 (5.5)
RR <3	766 (71.1)	2640 (94.5)

CMS = Centers for Medicare & Medicaid Services; PCP = primary care physician; RR = relative risk.
* This tool was applied to only 3871 patients; 431 could not be classified because of lack of billing data.

Contrast Between PCP-Defined Complexity and Other Measures of Complexity

The overall agreement between PCP-defined complexity and other patient classification methods derived from clinically available data sources was modest, ranging from 69.6% (95% CI, 68.2% to 71.0%) to 76.2% (CI, 74.9% to 77.6%). **Appendix Figures 1** to **4** (available at www.annals.org) show agreement results per PCP. The concordance of PCP designations of complexity with each of the other methods was low, ranging from 26.2% (CI, 23.6% to 28.9%) to 56.0% (CI, 53.1% to 58.9%), whereas the concordance of designations of noncomplexity was higher, ranging from 78.2% (CI, 76.7% to 79.6%) to 94.5% (CI, 93.6% to 95.3%) (**Table 4**).

Many patients were discordantly classified. For example, nearly one half (48%) of patients with a Charlson score of 2 or greater were not deemed complex by their PCPs, whereas 16% of PCP-identified noncomplex patients had 2 or more of the comorbid conditions used by Higashi and colleagues' method. Most of the PCP-identified complex patients (766 of 1077 [71%]) were not considered high risk per the CMS model; conversely, a few PCP-identified noncomplex patients (154 of 2794 [6%]) were considered high risk for hospitalization by CMS. The CMS algorithm could not classify 431 patients; these missing patients were younger and less complex than the CMS-classified patients.

We conducted exploratory analyses to compare the characteristics of patients identified as complex by their PCP versus by each of the other classification methods (**Table 5**), as well as those of patients who were discor-

Table 5. **Differences in Characteristics, Diagnostic Procedures, Laboratory Test Results, and Health System Encounters in the Past 3 Years Among Patients Considered Complex by PCPs Versus by Other Methods**

Variable	Considered Complex by PCP (*n* = 1126)	Charlson Score ≥2 (*n* = 572)	Charlson Score ≥1 (*n* = 1203)	Higashi Score ≥2 (*n* = 1139)	CMS RR ≥3 (*n* = 465)
Patient characteristics					
Mean age (SD), %	60.0 (16.3)	63.6 (14.7)	56.9 (17.0)	64.5 (13.9)	65.2 (14.5)
Women, %	65.5	64.5	65.5	57.6	55.3
Nonwhite, %	22.9	15.6	23.7	19.2	19.6
Insurance status, %					
Commercial	42.4	45.5	55.1	39.6	30.1
Government	55.3	53.3	42.9	59.4	67.7
Uninsured	2.3	1.2	2.0	1.1	2.2
Mean clinic visits (SD), *n*	11.3 (7.7)	10.7 (7.6)	9.8 (7.1)	11.8 (7.4)	14.2 (8.7)
Mean prescribed medications (SD), *n*	14.8 (9.7)	14.4 (9.8)	12.7 (9.1)	15.3 (9.1)	19.3 (10.5)
Laboratory results, %					
HbA_{1c} level >9%	6.3	7.2	5.2	7.2	8.8
Creatinine level >0.14 μmol/L (>2.5 mg/dL)	2.8	3.5	2.0	2.7	5.4
Clinical encounters, %					
Emergency department visit	41.5	38.3	34.0	43.6	61.3
Psychotherapy	18.1	12.1	12.3	15.7	23.9
Diagnoses, %					
Bipolar disease	4.5	1.8	2.2	3.5	7.1
Alcohol-related	4.4	3.3	2.8	4.4	6.0
Atrial fibrillation	10.5	11.7	7.7	14.2	15.3
Medications, %					
Selective serotonin reuptake inhibitors	35.1	29.0	28.8	37.7	38.9
Benzodiazepines	36.8	30.9	28.6	33.6	39.4
Antipsychotics	9.3	4.0	4.3	7.4	12.3

CMS = Centers for Medicare & Medicaid Services; HbA_{1c} = hemoglobin A_{1c}; PCP = primary care physician; RR = relative risk.

dantly classified by their PCP versus each of the other classification methods (**Appendix Table 4**, available at www.annals.org). These comparisons demonstrated numerous patient-level differences among the methods. The comparison of discordantly classified patients particularly underscored the influence of mental health problems, specific medication prescriptions, lack of disease control, and insurance status on PCP-defined complexity.

DISCUSSION

The complex patient has been described as "one for whom clinical decision-making and required care processes are not routine or standard" (15). This qualitative definition has been difficult to translate into quantitative terms, with most predictive models relying on measures of comorbidity or on predictors of future health care costs or complications. We empirically defined a cohort of complex patients by having physicians review a random sample of their own patient panels. Here, we operationalize the definition of physician-defined patient complexity and describe the characteristics of these physician-defined complex patients in detail.

To our knowledge, no other studies have quantitatively defined patient complexity from a PCP's perspective. Our results provide insight into what PCPs experience as complex. We found that the prevalence of physician-defined complex patients varied among physicians in the same care network, with more experienced and longer-serving physicians having more complex patient panels; patients were deemed complex on the basis of more than a simple count or weighting of comorbid conditions; and, conversely, many patients with multiple comorbid conditions were not rated as complex by their PCPs. This discrepancy between PCP-defined complexity and complexity derived from widely used comorbidity scales suggests that diagnoses do not sufficiently capture the challenges faced by PCPs in their work day. Our results emphasize the role of patient psychosocial issues and underscore the potential importance of incorporating individualized measures of disease severity. For example, we found that poor glycemic control is a strong independent predictor of complexity beyond a diagnosis of diabetes, which suggests that elevated HbA_{1c} levels reflect a complex interplay among disease severity, medical treatment, and patient self-management behaviors (16). Factors that moderate chronic disease management, such as lack of adequate insurance, alcohol-related problems, and prescriptions for anxiety and other mental health issues, were all associated with increased complexity.

Our findings demonstrate that population-level electronic health data can be used to characterize physician-defined complex patients. Using these electronic data sources, we found that complex patients had more frequent visits, more high-cost procedures, and more need for psy-

chotherapy than noncomplex patients. In addition, certain variables associated with complexity were specific to younger patients (such as alcohol use), which underscores the age-related variability in contributors to patient complexity.

The passage of the Patient Protection and Affordable Care Act could bring an additional 32 million currently uninsured Americans into the primary care system (17) at a time when primary care is in a period of crisis. Fewer medical school graduates are entering the field, and many PCPs are leaving clinical practice, citing decreased job satisfaction and other work-related stressors (18, 19). In surveys of PCPs, higher overall patient complexity has been associated with decreased job satisfaction (20, 21). Of note, the most experienced PCPs in our system reported the highest prevalence of complex patients, which suggests that the practice of primary care may become increasingly burdensome as a PCP's closed patient panel ages. Redesign efforts that increase practice-level support for PCP-defined complex patients may represent a strategy for improving PCP recruitment and retention (22).

With the advent and increasing adoption of electronic health records, clinical performance measurement, and population management, primary care is undergoing substantial change (23). Attention and investment are increasingly being devoted to transforming the system of primary care delivery in the United States, including a growing number of demonstration projects that use the patient-centered medical home and non–visit-based care strategies (24). Previous studies (6, 9) have shown that complex patients often achieve better care quality due to increased visit frequency. Our data provide some quantitative evidence that caring for complex patients in primary care may require a team approach, especially given the effects of alcohol use, mental health disorders and treatment, insurance status, and visit frequency on PCP-defined patient complexity. To the extent that the PCP definition reflects the management challenges experienced in primary care, efforts to redesign care may require investing targeted resources and creating effective care teams designed to more effectively manage our most complex and costly patients.

Our study has limitations. We primarily used electronically available patient data for our analyses. In contrast to epidemiologic studies that use carefully phenotyped cohorts, this pragmatic approach offers greater generalizability for applications within health care systems but is limited by missing and unverified data. Because we did not have access to individual-level educational and financial information, we relied on the surrogate approach of census group data, which may result in some misclassification. In addition, we chose to dichotomize the 3 comorbidity algorithms, which facilitated comparison to the PCP-defined complexity designations at the expense of a potential loss of information.

Our patient complexity designations were collected from PCPs in practices within a single health care system and thus may not be generalizable to other systems and patient populations. A PCP's perception of patient complexity may be influenced by provider characteristics and the availability of practice resources and allied team members to collaborate in the care of challenging patients. Applying this approach in different practice settings and care systems may provide further insight into the system-level factors that influence PCP perception of patient complexity. In the absence of a gold standard for defining patient complexity, our results must be interpreted as a PCP perspective on complexity. In addition, because each physician in our study had both a unique mix of patients and (probably) a unique interpretation of patient complexity, our results by necessity reflect the average interpretation of the group. Future work is needed to prospectively investigate the differences in clinically meaningful outcomes between a PCP-derived predictive model and other available predictive tools.

Our results demonstrate that in the primary care setting, physician-defined patient complexity reflects a wide range of medical, social, and behavioral factors that seem distinct from other measures of comorbidity and case-mix adjustment. An untested hypothesis that bears further investigation is whether this approach to identifying complex patients may be useful in guiding primary care system redesign efforts to both improve care and contain costs.

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Appendix

Data were obtained from our network's electronic clinical data repository for the 3-year period of 2005 to 2007. For the purpose of our exploratory analysis, we excluded variables that were significant in univariate analyses but did not have at least 4% prevalence in 1 or more of the 4 comparison groups (complex or noncomplex patients aged <60 or ≥60 years). Variables were created from the following sources:

1. Administrative database: We used registration data to assign insurance status and self-reported race or ethnicity and sex.

2. Outpatient scheduling database: We used our network's patient scheduling system database to identify all visits, all visits to the patient's PCP, and missed ("no-show") appointments.

3. Current Procedure Terminology (CPT) codes: We used CPT codes obtained from billing data to create diagnostic and visit categories.

Diagnostic procedure categories included echocardiography (CPT code 93307), electrocardiography (codes 93000, 93005, 93010, 93225, 93226, and 93227), myocardial perfusion scanning (codes 78465, 78478, and 78480), pulmonary function testing (codes 94150, 94375, and 94720), magnetic resonance imaging (codes 70544, 70549, 70551, 70553, 72141, 72148, 72158, 73221, and 74183), computed tomography (codes 70450, 70491, 70496, 70498, 71250, 71260, 71275, 72125, 72191, 72192, 72193, 72194, 73701, 74150, 74160, 74170, 74175, and 76375), and duplex ultrasonography (codes 93880, 93970, 93971, and 93975).

Visit categories included comprehensive office outpatient visit (CPT codes 99205, 99215, and 99245), emergency department evaluation (codes 99282 to 99285), home health services (Healthcare Common Procedure Coding System codes G0179 and G0180), and psychiatric or psychotherapy visit (CPT codes 90801, 90804, 90805, 90806, 90807, 90853, and 90862).

4. Outpatient International Classification of Diseases, Ninth Revision (ICD-9), and diagnosis-related group (DRG) codes: We grouped ICD-9 and DRG codes into the following categories: abdominal pain (ICD-9 codes 789.00 and 789.07), acute or chronic kidney disease (ICD-9 codes 070.54, 070.51, 584.9, and 585.X), alcohol-related diagnoses (ICD-9 305.X, 424.5, 535.3, and 571.X; DRG codes 521 and 750), anxiety (ICD-9 codes 300.0 and 309.0 to 309.4), atrial fibrillation (ICD-9 code 427.31), bipolar disease (ICD-9 codes 296.4 to 296.7), hepatitis C infection (ICD-9 codes 070.51 and 070.54), and neck pain (ICD-9 codes 707.8, 707.9, and 723.1).

5. Laboratory results: We identified patients with any HbA_{1c} level greater than 9.0%, prothrombin time (international normalized ratio) greater than 3.5, serum creatinine level greater than 0.14 μmol/L (>2.5 mg/dL), serum albumin level less than 3.0 g/L, blood alcohol result greater than 1000 mg/L, and any positive result on urine toxicology screening (including any one of cocaine, opiates, tetrahydrocannabinol or cannabinoids, barbiturates, benzodiazepines, amphetamines, phencyclidine, or their derivatives).

6. Medications: We grouped medicines listed in the electronic medical record into the following treatment categories: benzodiazepines, opiate analgesics, selective serotonin reuptake inhibitors, antipsychotics, and medications prescribed for smoking cessation (including nicotine replacement, varenicline, and bupropion sustained-release).

We excluded measurement of antinuclear antibody titers, arterial catheterization, pulmonary function studies, fluoroscopically guided needle biopsy, injection of transforaminal or intravertebral anesthetic agents, nerve conduction studies, albumin level less than 3.0 g/L or serum creatinine level greater than 0.14 μmol/L (>2.5 mg/dL), and diagnosis of ascites.

Appendix Table 1. Characteristics of Participating Versus Nonparticipating PCPs From 9 Primary Care Practices

Characteristic	Participating PCPs (n = 40)	Nonparticipating PCPs (n = 84)	*P* Value
Mean age (SD), *y*	46.0 (8.8)	47.4 (9.2)	0.44
Women, %	57.5	50.0	0.43
Mean time since graduation, *y*	17.6 (8.9)	20.4 (15.4)	0.20
Mean time on staff, *y*	13.5 (7.7)	14.3 (10.0)	0.67
Mean outpatient visits in previous year (SD), *n*	1620.4 (876.8)	1734.3 (863.8)	0.50
Mean FTEs in previous year (SD), *n*	0.51 (0.24)	0.52 (0.26)	0.81
Mean panel size (SD), *n*	744.9 (314.9)	780.4 (398.1)	0.62

FTE = full-time equivalent; PCP = primary care physician.

Appendix Table 2. Physician and Patient Characteristics, by Practice Setting

Variable	Community Health Center (n = 16)	Hospital-Based (n = 10)	Office-Based (n = 14)	*P* Value		
				Overall	Community Health Center vs. Other	Hospital- vs. Office-Based
Complex patients, *n/N (%)*	500/1686 (29.7)	248/1103 (22.5)	378/1513 (25.0)	<0.001	<0.001	0.14
PCP characteristics						
Mean age (SD), *y*	43.1 (7.7)	48.3 (7.0)	47.8 (10.7)	0.23	0.086	0.89
Women, %	56.3	60.0	57.1	0.98	0.90	0.89
Mean time since graduation (SD), *y*	14.3 (6.9)	20.3 (6.6)	19.4 (11.4)	0.156	0.054	0.81
Mean time on staff (SD), *y*	11.0 (7.1)	16.7 (5.9)	13.9 (9.0)	0.182	0.103	0.40
Mean outpatient visits in previous year (SD), *n*	2008.0 (1013.4)	841.2 (325.9)	1733.9 (618.1)	0.002	0.020	<0.001
Mean FTEs in previous year (SD), *n*	0.62 (0.25)	0.29 (0.11)	0.55 (0.18)	0.001	0.019	<0.001
Mean panel size (SD), *n*	788.4 (305.5)	442.8 (196.6)	910.9 (246.7)	<0.001	0.48	<0.001
Mean complexity domains per complex patient (SD), *n*	2.1 (1.2)	2.3 (1.2)	2.3 (1.1)	0.001	<0.001	0.47
Prevalence of complexity domains among complex patients, %						
Medical decision making	48.2	76.2	72.2	<0.001	<0.001	0.27
Patient's personal characteristics	58.8	45.2	54.5	0.002	0.007	0.022
Coordination of care	31.2	42.7	48.7	<0.001	<0.001	0.145
Mental health issues	36.2	35.5	29.1	0.070	0.107	0.093
Patient's socioeconomic circumstances	32.0	28.2	30.2	0.56	0.35	0.60
Patient characteristics						
Mean age (SD), *y*	48.2 (16.7)	54.0 (15.7)	51.7 (16.3)	<0.001	<0.001	<0.001
Women, %	61.1	58.3	64.4	0.005	0.62	0.001
Nonwhite, %	37.9	17.1	12.6	<0.001	<0.001	0.001
Insurance status, %				<0.001	<0.001	0.024
Commercial health insurance	59.3	71.4	75.0			
Government insurance	35.9	27.8	23.6			
Uninsured	4.9	0.8	1.4			
Median household income, $*	42 982	67 412	67 308	<0.001	<0.001	0.93
Did not graduate high school, %*	25.2	10.7	10.1	<0.001	<0.001	0.107
Mean clinic visits (SD), *n*	8.5 (6.7)	6.7 (5.3)	6.8 (5.3)	<0.001	<0.001	0.68
Mean PCP visits (SD), *n*	6.3 (5.7)	6.3 (5.0)	5.2 (4.7)	<0.001	<0.001	<0.001

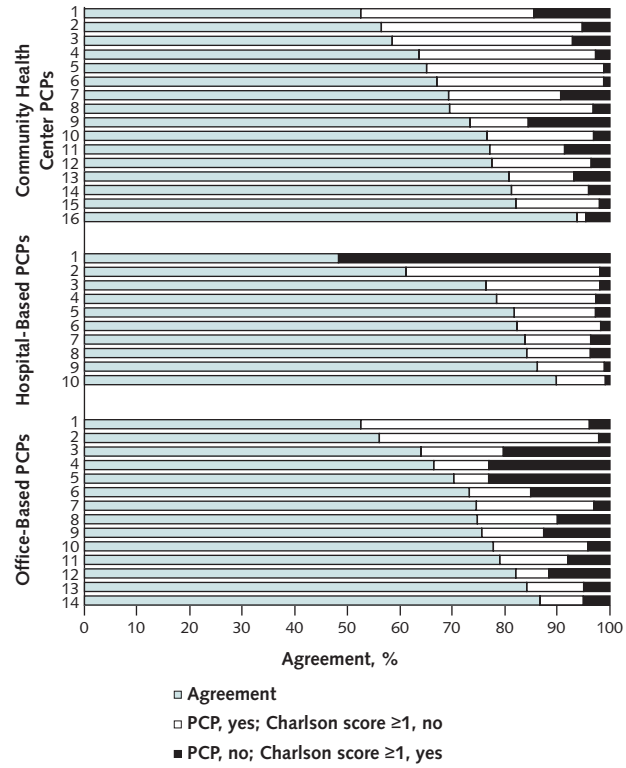
FTE = full-time equivalent; PCP = primary care physician.
* Based on census block data; 533 patients had no census information.

Appendix Table 3. **Differences in Patient Characteristics, Diagnostic Procedures, Laboratory Test Results, and Health System Encounters in Previous 3 Years Between PCP-Defined Complex and Noncomplex Patients, by Age**

Variable	All (n = 4302)			Age <60 y (n = 2988)			Age ≥60 y (n = 1314)		
	Complex (n = 1126)	Noncomplex (n = 3176)	*P* Value	Complex (n = 550)	Noncomplex (n = 2438)	*P* Value	Complex (n = 576)	Noncomplex (n = 738)	*P* Value
Patient characteristics									
Mean age (SD), *y*	60.0 (16.3)	47.7 (15.2)	<0.001	46.2 (9.6)	41.2 (10.0)	<0.001	73.1 (8.8)	69.3 (7.8)	<0.001
Women, %	65.5	60.1	0.001	68.9	60.9	<0.001	62.3	57.6	0.082
Nonwhite, %	22.9	24.0	0.48	31.5	26.7	0.024	14.8	14.9	0.94
Insurance status, %			<0.001			<0.001			<0.001
Commercial health insurance	42.4	77.0		64.6	87.8		21.2	41.1	
Government insurance	55.3	20.3		31.1	8.8		78.5	58.5	
Uninsured	2.3	2.7		4.4	3.4		0.4	0.4	
Median household income, $*	53 159	59 934	<0.001	50 284	59 206	<0.001	55 783	62 149	<0.001
Did not graduate high school, %*	18.3	15.2	<0.001	21.3	15.8	<0.001	15.6	13.1	<0.001
Mean clinic visits (SD), *n*	11.3 (7.7)	6.1 (4.5)	<0.001	10.8 (8.1)	5.5 (4.2)	<0.001	11.9 (7.2)	7.9 (4.9)	<0.001
Mean PCP visits (SD), *n*	9.3 (6.9)	4.7 (3.8)	<0.001	8.4 (7.1)	4.1 (3.4)	<0.001	10.1 (6.6)	6.7 (4.3)	<0.001
Mean prescribed medications (SD), *n*	14.8 (9.7)	6.8 (5.6)	<0.001	13.7 (9.9)	6.1 (5.2)	<0.001	15.9 (9.4)	9.2 (6.1)	<0.001
"No-show" rate >25%, %†	10.0	8.0	0.054	14.7	9.9	0.002	5.6	2.6	0.008
Mean providers seen (SD), *n*	2.9 (2.1)	2.0 (1.4)	<0.001	2.9 (2.1)	2.0 (1.4)	<0.001	2.9 (2.1)	2.1 (1.5)	<0.001
Diagnostic procedures, %									
Electrocardiography	61.5	31.3	<0.001	48.2	23.3	<0.001	74.1	57.7	<0.001
Computed tomography	43.2	18.6	<0.001	37.3	15.0	<0.001	48.8	30.2	<0.001
Magnetic resonance imaging	25.4	9.9	<0.001	25.1	8.9	<0.001	25.7	13.4	<0.001
Echocardiography	21.1	6.1	<0.001	11.1	3.8	<0.001	74.1	57.7	<0.001
Duplex ultrasonography	17.7	5.0	<0.001	8.7	3.4	<0.001	26.2	10.2	<0.001
Myocardial perfusion scanning	14.5	5.2	<0.001	8.7	2.8	<0.001	20.0	13.3	0.001
Laboratory results, %									
HbA_{1c} level >9%	6.3	0.7	<0.001	7.1	0.4	<0.001	5.6	1.8	<0.001
Positive result on drug abuse or ethanol urine test	3.4	0.9	<0.001	6.6	1.2	<0.001	0.4	0.3	0.80
Albumin level <3 g/L	5.6	0.9	<0.001	3.8	0.6	<0.001	7.3	1.9	<0.001
International normalized ratio >3.5	6.7	0.9	<0.001	2.6	0.3	<0.001	10.6	2.9	<0.001
Creatinine level >0.14 μmol/L (>2.5 mg/dL)	2.8	0.3	<0.001	1.8	0.1	<0.001	3.7	0.8	<0.001
Clinical encounters in previous year, %									
Primary care visit billed as complex	66.1	35.6	<0.001	59.3	31.5	<0.001	72.6	48.9	<0.001
Emergency department visit	41.5	18.6	<0.001	38.4	17.9	<0.001	44.4	20.9	<0.001
Psychotherapy	18.1	7.4	<0.001	25.5	8.6	<0.001	11.1	3.7	<0.001
Physical therapy	27.0	11.2	<0.001	21.1	9.6	<0.001	32.6	16.3	<0.001
Home health services	11.0	1.3	<0.001	3.3	0.4	<0.001	18.4	4.2	<0.001
Diagnoses, %									
Abdominal pain	31.8	18.1	<0.001	34.9	18.7	<0.001	28.8	16.1	<0.001
Anxiety	26.2	13.9	<0.001	32.4	14.3	<0.001	20.3	12.6	<0.001
Neck pain	17.0	9.0	<0.001	21.3	9.6	<0.001	12.9	6.8	<0.001
Type 2 diabetes	16.3	2.4	<0.001	11.5	1.4	<0.001	20.8	6.0	<0.001
Bipolar disease	4.5	1.0	<0.001	6.7	1.2	<0.001	2.4	0.3	<0.001
Alcohol-related	4.4	1.5	<0.001	5.8	1.4	<0.001	3.1	1.8	0.106
Hepatitis C	2.5	0.8	<0.001	4.0	0.8	<0.001	1.0	0.5	0.30
Kidney disease	7.9	0.7	<0.001	3.3	0.2	<0.001	12.3	2.4	<0.001
Atrial fibrillation	10.5	1.8	<0.001	2.9	0.8	<0.001	17.7	5.3	<0.001
Medications, %									
Narcotics	37.7	20.9	<0.001	43.1	21.3	<0.001	32.6	19.7	<0.001
Selective serotonin reuptake inhibitors	35.1	17.7	<0.001	40.4	17.9	<0.001	30.0	17.1	<0.001
Benzodiazepines	36.8	17.4	<0.001	38.7	16.0	<0.001	34.9	22.1	<0.001
Smoking cessation agents	10.8	4.9	<0.001	15.6	5.2	<0.001	6.3	4.2	0.094
Antipsychotics	9.3	1.4	<0.001	13.5	1.6	<0.001	5.4	0.8	<0.001

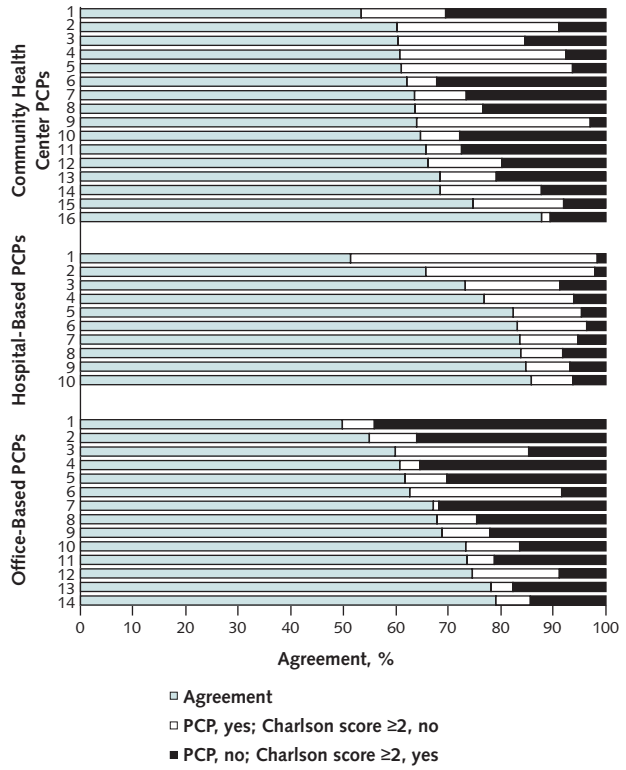
HbA_{1c} = hemoglobin A_{1c}; PCP = primary care physician.
* Based on census block data; 533 patients had no census information.
† Rate calculated as [missed appointments/(missed + arrived appointments)] among patients with ≥3 missed or arrived appointments in the past 3 y; data are missing for 577 patients with <3 missed or arrived appointments in the past 3 y.

Appendix Figure 1. **Agreement between PCP-defined complexity and Charlson score (threshold score of 1) for each PCP, grouped by practice type.**



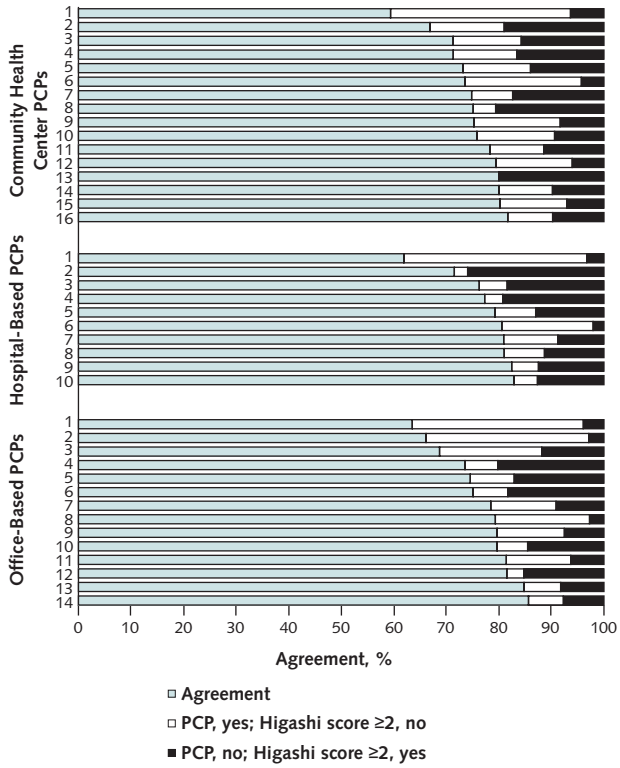
PCP = primary care physician.

Appendix Figure 2. **Agreement between PCP-defined complexity and Charlson score (threshold score of 2) for each PCP, grouped by practice type.**



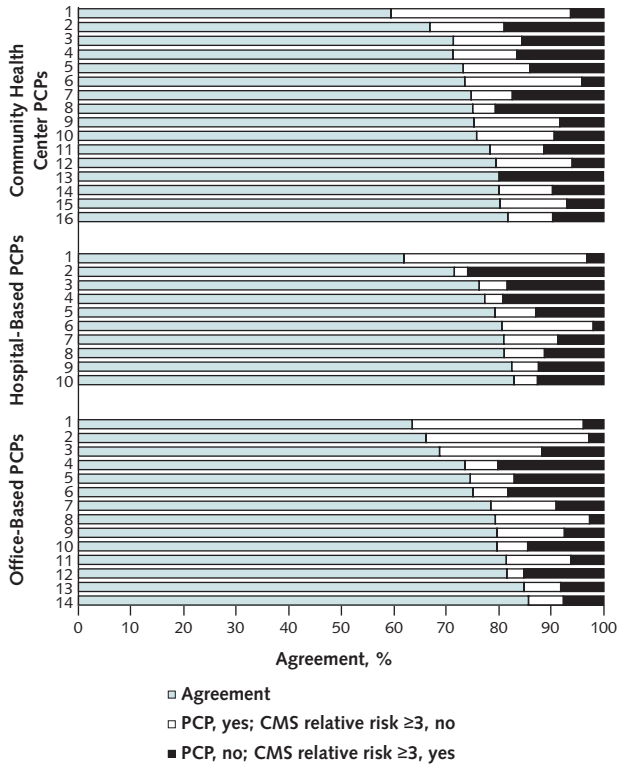
PCP = primary care physician.

Appendix Figure 3. **Agreement between PCP-defined complexity and Higashi score (threshold score of 2) for each PCP, grouped by practice type.**



PCP = primary care physician.

Appendix Figure 4. **Agreement between PCP-defined complexity and CMS hospitalization risk algorithm (threshold relative risk of 3) for each PCP.**



CMS = Centers for Medicare & Medicaid Services; PCP = primary care physician.

Appendix Table 4. **Differences in Patient Characteristics, Diagnostic Procedures, Laboratory Test Results, and Health System Encounters Over 3 Years Among Patients With Noncongruent PCP and Comorbidity Algorithm Classifications**

Characteristic	PCP-Defined Complex Patients With a Charlson Score <2 (*n* = 831)	PCP-Defined Noncomplex Patients With a Charlson Score ≥2 (*n* = 277)	*P* Value	PCP-Defined Complex Patients With a Charlson Score <1 (*n* = 616)	PCP-Defined Noncomplex Patients With a Charlson Score ≥1 (*n* = 693)	*P* Value	PCP-Defined Complex Patients With a Higashi Score <2 (*n* = 495)	PCP-Defined Noncomplex Patients With a Higashi Score ≥2 (*n* = 508)	*P* Value	PCP-Defined Complex Patients With a CMS RR <3* (*n* = 766)	PCP-Defined Noncomplex Patients With a CMS RR ≥3* (*n* = 154)	*P* Value
Patient characteristics												
Mean age (SD), *y*	57.4 (16.3)	59.8 (14.6)	0.036	57.8 (16.2)	52.8 (16.4)	<0.001	51.8 (15.2)	62.3 (13.3)	<0.001	58.2 (16.4)	65.0 (14.8)	<0.001
Women, %	66.4	66.1	0.91	65.1	65.1	0.99	70.5	52.6	<0.001	67.5	46.1	<0.001
Nonwhite, %	24.8	13.4	<0.001	21.7	23.2	0.52	27.1	18.7	0.002	23.6	17.5	0.099
Insurance status, %			<0.001			<0.001			<0.001			0.161
Commercial health insurance	46.9	62.5		46.3	68.0		58.6	52.0		49.4	40.9	
Government insurance	50.4	36.5		50.5	29.4		37.2	46.7		49.0	57.1	
Uninsured	2.7	1.1		3.3	2.6		4.2	1.4		1.7	2.0	
Mean clinic visits (SD), *n*	10.9 (7.5)	8.6 (6.2)	<0.001	10.5 (7.3)	7.9 (5.5)	<0.001	8.4 (6.2)	9.5 (5.8)	0.003	10.0 (6.4)	11.6 (7.2)	0.008
Mean prescribed medications (SD), *n*	13.8 (9.1)	10.8 (7.2)	<0.001	13.0 (8.7)	9.6 (6.6)	<0.001	10.6 (7.6)	11.8 (6.6)	0.010	12.4 (7.4)	14.2 (7.2)	0.007
Laboratory results, %												
HbA_{1c} level >9%	4.6	2.9	0.22	3.4	1.9	0.082	1.2	3.4	0.024	4.4	3.9	0.76
Creatinine level >0.14 μmol/L (>2.5 mg/dL)	1.7	1.1	0.48	2.0	0.7	0.050	1.0	1.0	1.00	1.2	2.6	0.172
Clinical encounters, %												
Emergency department visit	38.5	26.0	<0.001	36.0	23.7	<0.001	27.1	32.3	0.071	32.6	51.3	<0.001
Psychotherapy	19.1	8.7	<0.001	18.7	8.5	<0.001	17.4	12.0	0.016	15.5	20.1	0.159
Diagnoses, %												
Bipolar disease	5.3	1.1	0.003	6.2	2.0	<0.001	3.4	1.2	0.017	3.0	3.9	0.56
Alcohol-related	4.8	3.3	0.27	4.6	1.7	0.003	2.8	2.8	0.94	3.5	3.9	0.82
Atrial fibrillation	7.9	5.4	0.162	8.0	3.3	<0.001	1.0	9.7	<0.001	6.9	5.8	0.63
Medications, %												
Selective serotonin reuptake inhibitors	35.1	22.7	<0.001	33.8	22.9	<0.001	27.1	33.1	0.038	32.8	32.5	0.94
Benzodiazepines	36.7	24.6	<0.001	35.6	21.5	<0.001	34.3	27.4	0.017	34.9	32.5	0.57
Antipsychotics	10.5	1.8	<0.001	10.9	2.0	<0.001	7.7	3.4	0.003	6.8	7.1	0.87

CMS = Centers for Medicare & Medicaid Services; HbA_{1c} = hemoglobin A_{1c}; PCP = primary care physician; RR = relative risk.
* A total of 431 patients could not be classified by this tool because of lack of billing data.