

# Effect of Unrelated Comorbid Conditions on Hypertension Management

Barbara J. Turner, MD, MSED; Christopher S. Hollenbeak, PhD; Mark Weiner, MD; Thomas Ten Have, PhD; and Simon S.K. Tang, MPH

**Background:** Quality-of-care assessment at a single visit can be affected by whether a patient's comorbid conditions are related or unrelated to a specific measure.

**Objective:** To examine the association of unrelated comorbid conditions with treatment of uncontrolled hypertension in primary care visits.

**Design:** Examination of a database derived from electronic medical records collected during routine care of a cohort of primary care patients.

**Setting:** 6 primary care practices in Philadelphia, Pennsylvania.

**Patients:** 15 459 patients with uncontrolled hypertension who made 70 557 visits to 200 clinicians from January 2004 through December 2006.

**Measurements:** Intensification of any antihypertensive treatment before the next visit was assessed. Patient and clinician information were obtained from electronic medical records and administrative data. Unrelated comorbid conditions included 28 conditions, such as arthritis and emphysema, whereas related comorbid conditions included vascular diseases. Generalized estimating equation logistic

regression models were used to adjust for patient, health care, and provider characteristics and for clustering. Variation in the effect of unrelated comorbid conditions was examined at the visit, patient, and provider level.

**Results:** At study visits, patients had a mean of 2.2 (SD, 1.8) unrelated comorbid conditions. The adjusted odds of treatment intensification decreased with the number of unrelated comorbid conditions, from 0.85 (95% CI, 0.80 to 0.90) for 1 to 0.59 (CI, 0.51 to 0.69) for 7 or more versus none. The relationship between treatment intensification and unrelated comorbid conditions persisted at the visit, patient, and provider levels ( $P < 0.001$ ).

**Limitations:** The reasons for not intensifying treatments are unknown. The recorded blood pressure may be inaccurate. Physicians may vary in their recording of comorbid conditions.

**Conclusion:** Patients with more unrelated comorbid conditions were less likely to have uncontrolled hypertension addressed at a visit. The effect of different types of comorbid conditions on meeting quality-of-care measures merits further investigation.

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For author affiliations, see end of text.

Several studies have reported that overall quality of care is superior for patients with multiple comorbid conditions (1). However, these studies do not examine the effect of different types of comorbid conditions on achieving quality-of-care goals. Piette and Kerr (2) hypothesized that unrelated (discordant) comorbid conditions that do not share the same pathogenesis or management plan might compromise measured quality of care. For example, a patient with symptomatic osteoarthritis, gastroesophageal reflux, and emphysema might be less likely to have elevated blood pressure addressed than a patient who has a condition that is related to hypertension, such as coronary artery disease or peripheral vascular disease. The negative effect of unrelated comorbid conditions on hypertension care may be overcome in time if these patients see their physician more frequently; however, some quality-of-care measures, including the federal Physician Quality Reporting Initiative, assess quality at only 1 visit or within a time frame that may include only 1 visit (3).

Concern about unrelated comorbid conditions was first raised a decade ago by Redelmeier and colleagues (4), who found that patients with specific chronic diseases were less likely to have unrelated disorders addressed. That study evaluated the effect of single unrelated conditions only. Experts in quality-of-care measures have endorsed research into the effect of multiple comorbid conditions (5). For this project, we distinguished whether comorbid conditions were unrelated or related to vascular diseases and examined the effect of the number of these conditions on meeting a process-of-care measure: intensification of treatment for uncontrolled hypertension. We hypothesized that providers would be less likely to intensify antihypertensive treatment for patients with unrelated comorbid conditions than for those with related comorbid conditions. We predicted that patients who received care from related specialists (nephrologists or cardiologists) would be less likely to receive treatment intensification because the primary care provider might defer this care to the specialist. Conversely, we predicted that care from specialists managing unrelated conditions (such as pulmonary or gastroenterologic conditions) would allow the primary care provider to be more attentive to managing uncontrolled hypertension.

## METHODS

The study did not follow a protocol but was designed to address an a priori hypothesis raised by several groups of experts concerning the negative effect of unrelated comorbid conditions on achieving quality-of-care goals (2, 5). To

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Conversion of graphics into slides

test this hypothesis, we used intensification of antihypertensive treatment for uncontrolled blood pressure as an example of a quality-of-care measure. The final analysis plan was accomplished by an iterative process. The University of Pennsylvania institutional review board approved the use of the database for our research via an expedited review procedure.

### Study Sample

Our database includes patients 18 years of age or older treated from 1 January 2003 through 30 December 2006 in 6 primary care practices affiliated with an academic medical center in Philadelphia, Pennsylvania. All practices use the Epic Hyperspace electronic medical record (Epic Systems Corporation, Verona, Wisconsin), which allows tracking of demographic characteristics, physiologic measures, clinical diagnoses, smoking history, laboratory data, visit attendance data, prescribed medications, and insurance information. At each visit, office staff enters patient characteristics and validates insurance and medical assistants record vital signs. The provider enters all other clinical data into the electronic medical record, including coded diagnoses at the visit's conclusion. The provider also enters each prescription into the medical record and either gives a paper copy to the patient or has it called in or faxed to the pharmacy. For each visit, we linked provider sex, race, and training level from certification and departmental sources, as well as specialist visits.

Because the guidelines for defining hypertension were updated in 2003 (6), we limited our analysis to 2004 to 2006. Patients with hypertension were defined by the diagnosis of hypertension (International Classification of Diseases, Ninth Revision, Clinical Modification, codes 401.xx-404.xx) and use of an antihypertensive medication; the diagnosis of hypertension and elevated blood pressure; or elevated blood pressure at 2 or more visits. Patients met the first 2 of these definitions on more than 80% of visits. Uncontrolled hypertension was defined as systolic blood pressure of 130 mm Hg or greater or diastolic blood pressure of 80 mm Hg or greater for patients with diabetes or chronic renal insufficiency, and systolic blood pressure of 140 mm Hg or greater or diastolic blood pressure of 90 mm Hg or greater for nondiabetic patients (6).

### Antihypertensive Treatment

Antihypertensive medications were standardized to their generic form whenever possible and categorized by strength. Combination antihypertensive drugs were examined as their components. We excluded prescriptions written as "prn" or "as needed" or for an alternative indication, such as stage fright or edema. Each prescription's duration in days was calculated from the number of prescribed pills divided by the number of daily pills according to the directions, and the result was multiplied by the number of refills. The duration was recalculated from the start of each new prescription. A medication was judged as inactive when all refills were expended or a stop date was recorded.

#### Context

Little is known about the quality of care received by patients with multiple unrelated conditions.

#### Contribution

This study examined the electronic medical records of 15 459 patients who were seen at 6 primary care practices with uncontrolled hypertension. Most patients had 2 or more comorbid conditions that were not related to hypertension, such as arthritis, gastroesophageal reflux, or thyroid disease. At clinic visits, the odds that treatment for uncontrolled hypertension would be intensified decreased as the number of unrelated comorbid conditions increased.

#### Caution

Electronic medical record data may be inaccurate or incomplete.

#### Implication

Patients with multiple unrelated conditions are less likely to have uncontrolled hypertension addressed at a clinic visit.

—The Editors

### Outcome Variable

Our outcome was treatment intensification for uncontrolled hypertension before the next visit by adding a new drug; increasing the dose of an existing drug; or renewing use of a drug for which the prescription had expired more than 1 month ago. We allowed a 30-day lapse for expired prescriptions because patients often have leftover drugs to take before they run out. We also specified a second outcome variable that looked only at treatment intensification on the day of the patient visit.

### Classification of Comorbid Conditions

We identified each patient's comorbid conditions from coded diagnoses entered by providers in visits during the study time frame. The Elixhauser severity measure (7) is predictive of mortality and does not assess temporality of conditions (8) but was valuable as the first step in our identification of unrelated chronic conditions. From the 31 Elixhauser categories, we identified 19 unrelated comorbid conditions after combining 3 cancer groups and 2 anemia groups. We excluded obesity and used patients' body weights in our analyses. We then added 10 unrelated conditions that occurred in more than 5% of our study sample's visits and would likely require ongoing care, resulting in a total of 28 unrelated comorbid conditions (Appendix Table 1, available at [www.annals.org](http://www.annals.org)). To be counted, an unrelated comorbid condition had to be diagnosed at least twice in the study time frame; it was counted from the first visit in which it was noted. Related comorbid conditions included 3 types of vascular diseases: coronary artery disease, peripheral vascular disease, and cerebrovascular dis-

ease. Two other conditions associated with increased risk for vascular disease were diabetes (International Classification of Diseases, Ninth Revision, Clinical Modification, codes 250.xx at 2 visits or hemoglobin A<sub>1c</sub> level  $\geq 7\%$ ) and renal insufficiency (creatinine level  $\geq 152.5$   $\mu\text{mol/L}$  [ $\geq 2$  mg/dL]).

### Other Covariates

Socioeconomic status variables included age, sex, race, insurance type, and median household annual income (established by linking the patient's home ZIP code to 2000 U.S. census tract data, available at [www.census.gov](http://www.census.gov)). On the basis of our earlier research on patient nonadherence to medical care (9), we examined the proportion of primary care visits that were kept. We created a variable for time from 1 visit until the next and for total number of visits by a patient in the study time frame.

We created categories for both systolic and diastolic blood pressures at the current and previous visits according to the current standard (6). The antihypertensive regimen was characterized by the number of currently prescribed (active) antihypertensive drugs at the start of the visit. We categorized weight by quartiles for women and men separately and grouped these quartiles for analysis.

Provider characteristics included sex, race, and type (attending, resident, nonphysician). We examined provider workload (in quartiles) based on the maximum annual arrived patient visits, the mean number of sessions per week, or the mean number of arrived visits per session. We use the first of these measures because it was significantly associated with the outcome. We also created indicators for specialist care within the study time frame, categorized as related (cardiology and nephrology) or unrelated (such as rheumatology or dermatology). We did not retain date of service for specialty visits. We excluded visits for which key data elements, such as race, income, weight, or visit diagnoses (Figure 1), were missing. We created indicators for when smoking was not reported (43.5% of visits) and for unknown insurance type (0.5% of visits).

### Statistical Analysis

We used population-averaged logistic models to examine the unadjusted and adjusted associations of unrelated comorbid conditions with treatment intensification for uncontrolled hypertension. These included main effects for the dummy variables for comorbid conditions, continuous time, interaction terms between time and the comorbid condition variables, and terms adjusted for patient and provider variables in Table 1.

Using generalized estimating equations, we adjusted for correlations due to clustering at the patient level with an exchangeable working correlation structure. To examine the bias of the parameter estimates (10), we compared our results with those of a generalized estimating equations model that adjusted for clustering by provider and to a parametric random-effects model that adjusted for cluster-

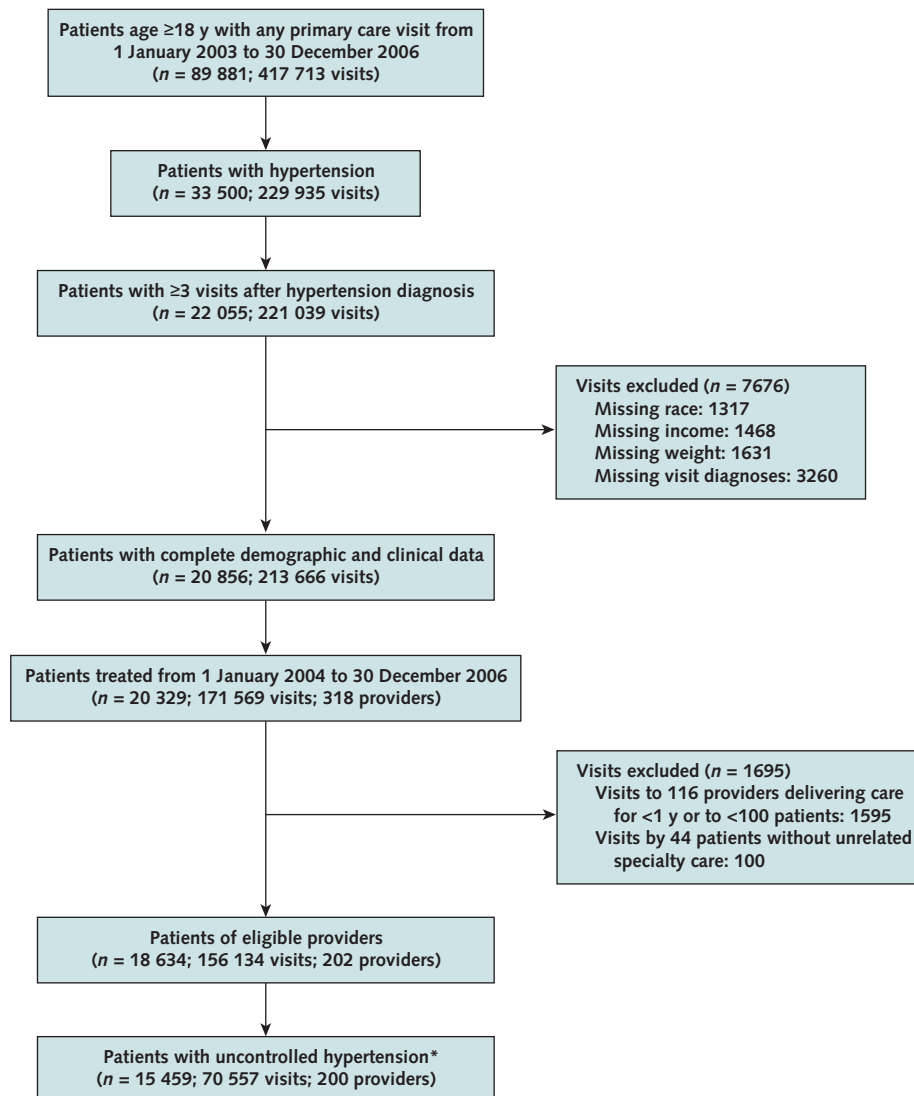
ing at the physician and patient levels. We did not report these models because they did not differ substantively from the reported model that adjusted for clustering by patient. Model misspecification in terms of correlation structure is accommodated by the sandwich estimator for the variances of parameter estimates (10). We report adjusted odds ratios for all analyses but recognize that these may overestimate the relative risks because the outcome rate is only 30%.

Following the strategy of Localio and colleagues (11) to adjust for cluster-level confounding (by physician) when examining patient-level effects, we performed a sensitivity analysis by replacing the dummy variables for unrelated comorbid conditions with 3 variables developed to examine the effect of unrelated comorbid conditions at the visit, patient, and provider levels. First, a visit-level variable was created by subtracting the accumulated comorbid condition count from the maximum accumulated comorbid condition level for all of a patient's visits. Second, we examined the difference of the maximum accumulated comorbid condition count for a given patient from the average of the maximum comorbid condition counts for all of a given provider's patients. Finally, for each provider, we calculated the average of the maximum comorbid conditions across all of the provider's patients. These 3 variables help account for patient- and provider-level confounding when evaluating associations between changes in visit-level comorbid conditions and treatment intensification. To make the interpretation more straightforward, we examined the continuous accumulated number of comorbid conditions rather than the categorical version we examined in the primary analysis.

To evaluate whether the effect of comorbid conditions differed for physicians with varying workloads, we fit 4 models for each quartile of physician workload. We also estimated a model that specifies the outcome variable as intensification on the day of the visit to explore any differences with the outcome as defined above. Finally, we excluded patient visits if a related specialist had provided care during the study time frame. This enabled us to evaluate the effect of unrelated comorbid conditions among primary care patients who only received additional care from unrelated specialists. All statistical analyses were performed by using Stata software, version 9 (Stata, College Station, Texas).

### Role of the Funding Source

This study was funded by a grant from Pfizer to the University of Pennsylvania. Authors from the University of Pennsylvania and Penn State College of Medicine conducted all analyses and wrote the manuscript. One author is a Pfizer employee, but he did not have direct access to study data. This author contributed to the study design and reviewed the manuscript. Pfizer had no role in the decision to submit the manuscript for publication.

**Figure 1. Study flow diagram.**

\*82% of patients had  $\geq 1$  hypertension diagnosis and a prescribed antihypertensive medication, 83% had  $\geq 1$  hypertension diagnosis and elevated blood pressure, and 92% had  $\geq 2$  elevated blood pressure readings at separate visits.

## RESULTS

The analysis file includes patients 18 years of age or older who were seen at least 3 times after the diagnosis of hypertension (**Figure 1**). Of 171 569 visits by 20 329 patients to 318 providers from January 2004 through December 2006, we excluded 15 395 visits by 1595 patients to 116 providers who delivered care for less than 1 year or had fewer than 100 patients, as well as 44 patients (100 visits) without unrelated specialty care. Of the remaining 18 634 patients, 15 459 (83.0%) had uncontrolled hypertension during at least 1 visit.

At 70 557 study visits of patients with uncontrolled hypertension, providers intensified antihypertensive treatment in 31% of patients. The mean number of unrelated

comorbid conditions at study visits was 2.2 (SD, 1.8), whereas only 17% of study visits had none (**Table 1**). At least 1 related comorbid condition was present at 14% of study visits and diabetes was diagnosed at more than 40% of visits. More than one half of study visits were by female and black patients (**Table 2**). More than one third of patients had both elevated systolic and diastolic blood pressures at the index visit, and nearly 70% received antihypertensive medication at that time. Most of the 200 providers were white, and more than half were women. Attending physicians saw three quarters of study visits.

Both before and after adjustment (**Table 3**), unrelated comorbid conditions showed a strong negative association with intensification of antihypertensive treatment. Com-



**Table 1. Unrelated and Related Comorbid Conditions Reported at Visits**

Variable	Patients, n (%)	Visits, n (%)
<b>Total</b>	15 459 (100)	70 557 (100)
<b>Number of unrelated comorbid conditions*</b>		
0	786 (5.1)	12 074 (17.1)
1	2035 (13.2)	16 655 (23.6)
2	2816 (18.2)	15 334 (21.7)
3	2827 (18.3)	11 472 (16.2)
4	2507 (16.2)	7097 (10.1)
5	1751 (11.3)	3909 (5.5)
6	1215 (7.9)	1900 (2.7)
≥7	1522 (9.8)	1803 (2.6)
<b>Related comorbid conditions</b>		
Single vascular disease†	2300 (14.9)	7998 (11.3)
Multiple vascular diseases†	873 (5.6)	1927 (2.7)
Diabetes	4943 (32.0)	31 533 (44.7)
Chronic renal insufficiency	999 (6.5)	6969 (9.9)

\* Appendix Table 2 (available at [www.annals.org](http://www.annals.org)) lists unrelated comorbid conditions.

† Includes coronary artery disease, cerebrovascular disease, and peripheral vascular disease.

pared with that for no comorbid conditions, the adjusted odds of treatment intensification increased from 15% for 1 unrelated comorbid condition to 41% for 7 or more unrelated comorbid conditions. This effect plateaus above 4 unrelated comorbid conditions (Figure 2). Conversely, the adjusted odds of treatment intensification was increased for related comorbid conditions. For the 2 conditions with a lower target for blood pressure control, diabetes was negatively associated with intensification, whereas chronic renal insufficiency showed no effect.

We performed sensitivity analyses to examine the effect of unrelated comorbid conditions in separate models at the visit, patient, and provider levels by using a continuous specification for the number of unrelated comorbid conditions. Each additional unrelated comorbid condition was associated with a 4% (95% CI, 2% to 6%) reduction in the adjusted odds of treatment intensification in the analysis at the visit level, whereas the reduction was 10% (CI, 8% to 11%) at the physician level and 12% (CI, 8% to 16%) at the provider level.

In our final model, visits to providers with the highest quartile of workload were associated with significantly lower adjusted odds of treatment intensification (adjusted odds ratio, 0.61 [CI, 0.57 to 0.65]) (Appendix Table 1, available at [www.annals.org](http://www.annals.org)). We specified fully adjusted models for each level of the provider workload variable to examine whether the negative effect of unrelated comorbid conditions is stronger for the busiest providers. In this series of models, the adjusted odds for each additional unrelated comorbid condition (as a continuous measure) decreased by 7% to 9% ( $P < 0.001$ ) at all levels of provider workload.

The effect of unrelated comorbid conditions was similar in a model that specified the outcome as treatment intensification on the same day (occurring for 75% of study visits), with adjusted odds ratios ranging from 0.82 (CI, 0.77 to 0.87) for 1 unrelated comorbid condition to 0.56 (CI, 0.48 to 0.66) for 7 or more unrelated comorbid conditions versus none.

Treatment intensification was more likely to occur when the patient's blood pressure was elevated at the previous visit (adjusted odds ratio, 1.31 for stage 1 hypertension and 1.62 for stage 2 hypertension;  $P < 0.001$ ) or when both systolic and diastolic blood pressures were elevated at the current visit than when only the diastolic blood pressure was elevated (adjusted odds ratio, 2.08 [CI, 1.97 to 2.19]) (Appendix Table 1, available at [www.annals.org](http://www.annals.org)). Care from a related specialist, such as a cardiologist or nephrologist, was associated with significantly higher adjusted odds of treatment intensification. The adjusted odds ratio for 1 related specialist versus none was 1.10 (CI, 1.05 to 1.16); the ratio was higher for care from 2 related specialists versus none (adjusted odds ratio, 1.52 [CI, 1.36 to 1.70]) (Appendix Table 1, available at [www.annals.org](http://www.annals.org)). Conversely, care from 3 unrelated specialists, such as gastroenterologists and orthopedists, was associated with 12% lower adjusted odds of treatment intensification ( $P < 0.001$ ) (Appendix Table 1, available at [www.annals.org](http://www.annals.org)). Among the 46 563 visits of patients without care from a related specialist, the negative association between unrelated comorbid conditions and treatment intensification persisted, ranging from 0.83 (CI, 0.77 to 0.88) for 1 unrelated comorbid condition to 0.51 (CI, 0.40 to 0.65) for 7 or more unrelated comorbid conditions (data not shown).

Unrelated comorbid conditions with the strongest negative association ( $P < 0.001$ ) with treatment intensification after adjustment for patient characteristics were cancer, chronic rhinitis or sinusitis, depression or anxiety, diarrhea or constipation, emphysema or asthma, gastroesophageal reflux or gastritis, headache, nonrheumatoid arthritis, and thyroid disorder (Appendix Table 2, available at [www.annals.org](http://www.annals.org)).

## DISCUSSION

Among more than 70 000 primary care visits of patients with uncontrolled hypertension, having more unrelated comorbid conditions showed a strong negative association with antihypertensive treatment intensification by the provider. Approximately 60% of patients in our study visits had 2 or more unrelated comorbid conditions. As the number of unrelated comorbid conditions increased from 2 to 7 or more, the reduction in the adjusted odds of treatment intensification increased progressively from 28% to 41%. Unfortunately, most studies of the quality of hypertension care consider only related comorbid conditions (12) and do not account for the effect of unrelated comorbid condi-

Table 2. Patient and Provider Characteristics

Characteristic	Patients	Visits	Providers
<b>Total, n</b>	15 459	70 557	—
<b>Patient</b>			
Mean age (SD), y	59.6 (14.9)	61.9 (14.7)	—
Sex, n (%)			
Female	9357 (60.5)	44 656 (64.3)	—
Male	6102 (39.5)	25 901 (35.8)	—
Race, n (%)			
Black	7960 (51.5)	41 163 (58.3)	—
Other	7499 (48.5)	29 394 (41.7)	—
Median household income, n (%)*			
<\$25 000	3002 (19.4)	15 962 (22.6)	—
\$25 000–\$34 999	4459 (28.8)	22 205 (31.4)	—
\$35 000–\$69 999	6212 (40.2)	26 235 (37.1)	—
≥\$70 000	1784 (11.5)	6141 (8.7)	—
Insurance type, n (%)†			
Commercial	10 703 (69.2)	47 782 (67.7)	—
Medicaid	2502 (16.2)	13 624 (19.3)	—
Medicare	5508 (35.6)	29 687 (42.0)	—
Self-pay	273 (1.8)	976 (1.4)	—
Unknown	74 (0.5)	250 (0.4)	—
Cigarette smoking, n (%)			
No	6483 (42.0)	31 815 (45.1)	—
Current	1639 (10.6)	8031 (11.4)	—
Not recorded	7337 (47.5)	30 711 (43.5)	—
Maximum body weight, by quartiles, n (%)			
Men ≤83 kg, women ≤70 kg	3758 (24.3)	15 439 (21.9)	—
Men 84–94 kg, women 71–83 kg	3860 (25.0)	16 974 (24.1)	—
Men 95–109 kg, women 84–99 kg	3876 (25.1)	17 956 (25.4)	—
Men ≥110 kg, women ≥100 kg	3965 (25.6)	20 188 (28.6)	—
Blood pressure at last visit, n (%)‡			
Normal	8575 (55.5)	29 991 (42.5)	—
Stage 1 hypertension	6124 (39.8)	35 869 (50.8)	—
Stage 2 hypertension	1307 (8.5)	8231 (11.7)	—
Systolic/diastolic blood pressure at current visit, n (%)‡			
Normal/high	2819 (18.2)	10 831 (15.4)	—
High/normal	7145 (46.2)	32 236 (45.7)	—
High/high	5495 (35.5)	27 490 (39.0)	—
Number of antihypertensive drugs at index visit, n (%)			
0	6635 (42.9)	21 938 (31.1)	—
1	4003 (25.9)	18 469 (26.1)	—
2	3087 (20.0)	17 281 (24.5)	—
3	1294 (8.4)	9256 (13.1)	—
≥4	440 (2.8)	3613 (5.1)	—
Adherence to scheduled primary care visits by quartile, n (%)			
<3 visits	902 (5.8)	4050 (5.7)	—
First (0–60%)	3344 (21.6)	21 122 (18.3)	—
Second (61–73%)	3829 (24.7)	19 260 (27.2)	—
Third (74–84%)	3748 (24.2)	16 606 (28.0)	—
Fourth (85–100%)	3636 (23.5)	13 569 (20.8)	—
Mean time until next visit (SD), mo	3.0 (3.4)	2.5 (2.8)	—
Mean time since last visit (SD), mo	3.9 (4.4)	3.0 (3.3)	—
<b>Provider</b>			
Race, n (%)			
White	11 244 (72.7)	49 554 (70.2)	151
Black	2536 (16.4)	12 877 (18.2)	11
Other (Asian or Latino)	1573 (10.2)	7739 (11.0)	38
Sex, n (%)			
Female	7017 (45.4)	31 857 (45.2)	109
Male	8442 (54.6)	38 700 (54.9)	91
Type, n (%)			
Attending	11 730 (75.9)	54 603 (77.4)	80
Resident	1906 (12.3)	7844 (11.1)	109
Nurse practitioner or physician's assistant	1823 (11.8)	8110 (11.5)	11

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Table 2—Continued

Characteristic	Patients	Visits	Providers
Workload: annual arrived patient visits by quartile, <i>n</i> (%)			
100–1186	4232 (27.4)	18 162 (25.7)	149
1187–1834	3939 (25.4)	16 953 (24.0)	30
1535–3745	3457 (22.4)	16 132 (22.9)	13
3746–4948	3831 (24.8)	19 310 (27.4)	8
Care from related specialists, <i>n</i> (%)§			
1	3835 (24.9)	20 724 (29.3)	–
2	474 (3.1)	3270 (4.6)	–
Care from unrelated specialists, <i>n</i> (%)§			
1	6230 (40.3)	24 779 (35.1)	–
2	3702 (23.9)	15 665 (22.2)	–
3	2359 (15.3)	11 666 (16.5)	–
4	1394 (9.0)	7386 (10.5)	–
≥5	802 (5.2)	4891 (6.9)	–

\* Based on residence ZIP code.

† Patients can have more than 1 insurance type.

‡ Blood pressure categories according to the seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (6).

§ Categories are the number of different types of specialists visited.

tions in the context of a busy visit that also has numerous preventive care mandates (13). A decade ago, Redelmeier and colleagues (4) found that emphysema was associated with a physician not treating hyperlipidemia. Our study advances that work by considering the overall burden of unrelated comorbid conditions.

Treatment intensification was more likely to occur at visits of patients with related (vascular) comorbid conditions, such as coronary artery disease. Despite an increased risk for vascular disease, diabetic patients were less likely to have treatment intensification (14). This poor performance is probably driven by limited adoption of the recommended standard of less than 130/80 mm Hg for blood pressure control in patients with diabetes (6).

Of the 28 unrelated comorbid conditions in our analysis, nonrheumatoid arthritis showed one of the strongest

negative associations with treatment intensification. Arthritis is a costly disease that often greatly compromises patient function and productivity (15) and requires substantial provider effort to manage. The provider may be in a quandary about whether to attend to the patient's arthritic needs or take care of conditions that are evaluated by quality measures. Durso (16) recently acknowledged that clinical care guidelines do not prioritize care for multiple medical conditions.

Several quality-of-care studies that used process measures similar to ours report that patients with multiple comorbid conditions receive better quality of care (1, 17); however, as an editorialist noted (18), they did not distinguish unrelated from related comorbid conditions. On the other hand, we strongly endorse the approach used in these studies of examining quality of care over time and not at a

Table 3. Associations of Comorbid Conditions with Treatment Intensification

Variable	Unadjusted Odds Ratio (95% CI)	P Value	Adjusted Odds Ratio (95% CI)*	P Value
<b>Number of unrelated comorbid conditions†</b>				
1	0.83 (0.79–0.88)	<0.001	0.85 (0.80–0.90)	<0.001
2	0.69 (0.66–0.74)	<0.001	0.72 (0.68–0.76)	<0.001
3	0.69 (0.64–0.73)	<0.001	0.72 (0.67–0.77)	<0.001
4	0.60 (0.56–0.65)	<0.001	0.65 (0.60–0.70)	<0.001
5	0.61 (0.55–0.67)	<0.001	0.62 (0.56–0.68)	<0.001
6	0.57 (0.51–0.65)	<0.001	0.60 (0.53–0.69)	<0.001
≥7	0.55 (0.48–0.63)	<0.001	0.59 (0.51–0.69)	<0.001
<b>Related comorbid conditions‡</b>				
Single vascular disease	1.04 (0.89–1.22)	0.61	1.14 (1.06–1.22)	<0.001
Multiple vascular diseases	1.03 (0.88–1.20)	0.73	1.16 (1.02–1.33)	0.022
Chronic renal insufficiency	1.06 (0.99–1.14)	0.091	0.95 (0.88–1.03)	0.23
Diabetes	0.74 (0.71–0.77)	<0.001	0.67 (0.64–0.70)	<0.001

\* Adjusted for all variables in Table 2.

† See Appendix Table 2 (available at [www.annals.org](http://www.annals.org)) for a list of these conditions.

‡ The reference groups, in descending order, were no unrelated comorbid conditions; no vascular disease, including coronary artery disease, cerebrovascular disease, or peripheral vascular disease; no chronic renal insufficiency; and no diabetes.

single visit. Evaluating care over time may equalize the playing field, because patients with multiple comorbid conditions seem to be more adherent to recommended care (19) and have more health care visits. However, the negative effect of unrelated comorbid conditions in our analysis persisted after adjustment for the number of patients' visits.

Kerr and colleagues (20) have suggested that hypertension care should be evaluated only when poor control persists after several visits. Appropriately, providers in our study were more likely to intensify treatment when the patient's blood pressure was high at the previous visit or when both systolic and diastolic blood pressures were elevated at the current visit. We judged the need to intensify treatment as being the same for patients with only slightly elevated blood pressures as for those with severely elevated pressures. Hayward (21) has argued that such cut-point measures must account for medication burden (as we did) and for the adverse consequences of diastolic hypotension. Vasan and colleagues (22) found that treating a slightly elevated blood pressure or other slightly abnormal cardiovascular risk factor yields minor reductions in cardiovascular disease. Therefore, cut-point quality measures may be particularly inappropriate for patients with other extenuating circumstances, such as multiple unrelated comorbid conditions.

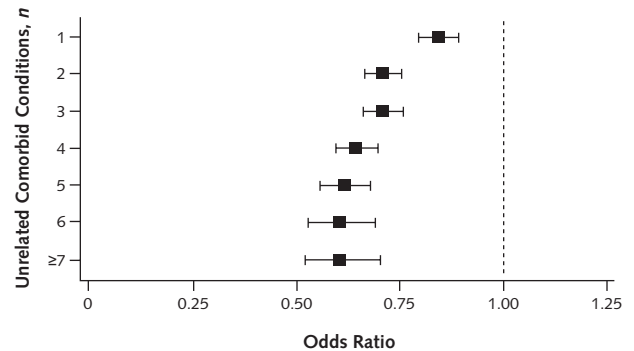
Approximately 30% of our cohort was not treated for hypertension before the index visit. In an elderly cohort with hypertension, treatment for noncardiovascular comorbid conditions was associated with more than a 40% reduction in the adjusted odds of having any antihypertensive medication (23). However, some of this apparent undertreatment might have occurred in patients with significantly reduced life expectancy due to unrelated comorbid conditions, such as end-stage cancer or severe emphysema. Such patients should be excluded from assessment of cardiovascular quality of care.

Contrary to our hypotheses, care from related specialists, such as cardiologists, was associated with a higher likelihood that the primary care provider would intensify antihypertensive treatment, whereas intensification was less likely when patients received care from unrelated specialists, such as rheumatologists. These findings suggest that specialist care does not relieve the primary care provider of the need to treat uncontrolled hypertension.

Our analysis was complicated by clustering of visits within patient, patients within provider, and providers within the study settings. A sensitivity analysis revealed that the negative effect of unrelated comorbid conditions persists at the patient and provider levels, suggesting that the effect is not due to specific patients or providers. In addition, we found that the negative association of unrelated comorbid conditions persisted across varying physician workload levels.

Our study has limitations. First, we examined a process-of-care measure, treatment of uncontrolled hypertension (24), instead of actual blood pressure control, which

**Figure 2. Adjusted association of unrelated comorbid conditions with management of uncontrolled hypertension.**



Data are adjusted for all variables in Table 2.

can be influenced by many patient, provider, and health care attributes (25). Second, our information on comorbid conditions comes from diagnoses entered by providers, whose thoroughness in recording diagnoses may systematically vary. Third, we could not judge whether failure to intensify treatment was clinically justifiable, such as in the case of patient nonadherence. This is unlikely to account for many instances in which treatment was not intensified because physicians generally do not assess adherence even when blood pressure is elevated (26). Fourth, prescribed medications in our electronic record may not be accurate, even though recording prescriptions is mandatory. However, a Veterans Administration study found that current antihypertensive drugs were omitted in fewer than 2% of its electronic medical records (27). Fifth, we did not examine the subsequent effect on blood pressure of failing to intensify treatment. However, other researchers (28) have found that the blood pressure was statistically significantly higher when patients did not have the "expected" number of treatment intensifications for uncontrolled hypertension over 1 year. Finally, to identify unrelated comorbid conditions that are more likely to be chronic, we considered only conditions that were recorded among the coded diagnoses for at least 2 visits.

Nearly a decade ago, Berlowitz and colleagues (29) reported that adjustment for case mix often changed the assessment of a physician's quality of care for hypertension. Our study should add weight to arguments that clinical complexity, as reflected by unrelated comorbid conditions, should be considered when evaluating quality of care (5). As more practices adopt electronic medical records, collecting data on unrelated comorbid conditions for quality-of-care assessment will become more feasible. At a minimum, our findings should raise awareness that physicians' care of hypertension may be affected when their patients have other competing clinical issues to address.



From the University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania; Penn State College of Medicine, Hershey, Pennsylvania; and Pfizer, New York, New York.

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**Requests for Single Reprints:** Barbara J. Turner, MD, MEd, University of Pennsylvania School of Medicine, 1123 Blockley Hall, 423 Guardian Drive, Philadelphia, PA 19104-6021; e-mail, [btturner@mail.med.upenn.edu](mailto:btturner@mail.med.upenn.edu).

Current author addresses and author contributions are available at [www.annals.org](http://www.annals.org).

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**Current Author Addresses:** Dr. Turner: University of Pennsylvania School of Medicine, 1123 Blockley Hall, 423 Guardian Drive, Philadelphia, PA 19104-6021.

Dr. Hollenbeak: Department of Public Health Sciences, Penn State College of Medicine, 600 Centerview Drive, A210, Hershey, PA 17033.

Dr. Ten Have: Center for Clinical Epidemiology and Biostatistics, University of Pennsylvania School of Medicine, Blockley Hall, 6th Floor, 423 Guardian Drive, Philadelphia, PA 19104-6021.

Dr. Weiner: University of Pennsylvania School of Medicine, 1116 Blockley Hall, 423 Guardian Drive, Philadelphia, PA 19104-6021.

Mr. Tang: Pfizer, 235 East 42nd Street, New York, NY 10017.

**Author Contributions:** Conception and design: B.J. Turner, M. Weiner, S.S.K. Tang.

Analysis and interpretation of the data: B.J. Turner, C.S. Hollenbeak, M. Weiner, T. Ten Have.

Drafting of the article: B.J. Turner, C.S. Hollenbeak.

Critical revision of the article for important intellectual content: B.J. Turner, C.S. Hollenbeak, M. Weiner, T. Ten Have, S.S.K. Tang.

Final approval of the article: B.J. Turner, C.S. Hollenbeak, M. Weiner, T. Ten Have, S.S.K. Tang.

Provision of study materials or patients: B.J. Turner.

Statistical expertise: B.J. Turner, C.S. Hollenbeak, T. Ten Have.

Obtaining of funding: B.J. Turner, S.S.K. Tang.

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**Appendix Table 1. Association of Patient and Provider Factors with Treatment Intensification for Uncontrolled Hypertension in the Final Model\***

Variable	Adjusted Odds Ratio (95% CI)	P Value
<b>Number of unrelated comorbid conditions</b>		
1	0.85 (0.80–0.90)	<0.001
2	0.72 (0.68–0.76)	<0.001
3	0.72 (0.67–0.77)	<0.001
4	0.65 (0.60–0.70)	<0.001
5	0.62 (0.56–0.68)	<0.001
6	0.60 (0.53–0.69)	<0.001
≥7	0.59 (0.51–0.69)	<0.001
<b>Related comorbid conditions</b>		
Single vascular disease	1.14 (1.06–1.22)	<0.001
Multiple vascular diseases	1.17 (1.02–1.33)	0.022
Diabetes	0.67 (0.64–0.70)	<0.001
Chronic renal insufficiency	0.95 (0.88–1.03)	0.23
<b>Age (per year)</b>	1.01 (1.01–1.01)	<0.001
<b>Women</b>	1.06 (1.01–1.11)	0.021
<b>Race</b>		
Black	1.16 (1.09–1.24)	<0.001
Other	1.12 (1.02–1.24)	0.016
<b>Median household income in residence ZIP code</b>		
<\$25 000	1.08 (0.98–1.19)	0.117
\$25 000–\$35 000	1.07 (0.98–1.18)	0.120
>\$35 000–\$75 000	1.03 (0.95–1.11)	0.44
<b>Insurance type</b>		
Medicaid	1.03 (0.97–1.09)	0.37
Medicare	0.93 (0.88–0.98)	0.010
Self-pay	1.12 (0.95–1.31)	0.185
Unknown	0.93 (0.86–1.01)	0.073
<b>Maximum body weight (quartiles)</b>		
Second	1.13 (1.06–1.20)	<0.001
Third	1.18 (1.10–1.25)	<0.001
Fourth	1.22 (1.14–1.31)	<0.001
<b>Smoking status</b>		
Current	1.05 (0.98–1.13)	0.138
Not reported	0.93 (0.89–0.98)	0.003
<b>Months until next visit</b>	1.02 (1.02–1.03)	<0.001
<b>Number of patient visits in study time frame</b>		
4–5	0.86 (0.82–0.90)	<0.001
6–9	0.77 (0.73–0.81)	<0.001
>10	0.69 (0.64–0.75)	<0.001
<b>Blood pressure at previous visit</b>		
Stage 1 hypertension	1.31 (1.26–1.35)	<0.001
Stage 2 hypertension	1.62 (1.54–1.71)	<0.001
<b>Systolic/diastolic blood pressure at current visit</b>		
High/normal	1.30 (1.23–1.38)	<0.001
High/high	2.08 (1.97–2.19)	<0.001
<b>Number of antihypertensive medications at start of visit</b>		
1	0.86 (0.82–0.90)	<0.001
2	0.64 (0.61–0.67)	<0.001
3	0.52 (0.49–0.56)	<0.001
≥4	0.42 (0.38–0.47)	<0.001

**Appendix Table 1—Continued**

Variable	Adjusted Odds Ratio (95% CI)	P Value
<b>Patient adherence to scheduled visits (quartiles)</b>		
Second	0.94 (0.89–0.98)	0.011
Third	0.86 (0.81–0.91)	<0.001
Fourth	0.88 (0.83–0.94)	<0.001
Few visits	0.81 (0.73–0.90)	<0.001
<b>Provider type</b>		
Resident	1.16 (1.08–1.24)	<0.001
Nurse practitioner or physician's assistant	0.70 (0.64–0.76)	<0.001
<b>Female provider</b>		
	1.11 (1.06–1.16)	<0.001
<b>Provider race</b>		
Black	0.85 (0.79–0.90)	<0.001
Other	0.95 (0.88–1.02)	0.150
<b>Provider workload (quartiles of annual arrived visits)</b>		
Second	0.88 (0.82–0.93)	<0.001
Third	1.04 (0.97–1.10)	0.29
Fourth	0.61 (0.57–0.65)	<0.001
<b>Care from related specialists†</b>		
1	1.10 (1.05–1.16)	<0.001
2	1.52 (1.36–1.70)	<0.001
<b>Care from unrelated specialists†</b>		
2	0.92 (0.87–0.97)	0.001
3	0.88 (0.82–0.93)	<0.001
4	0.88 (0.81–0.94)	0.001
≥5	0.88 (0.80–0.96)	0.007

\* The reference groups that correspond to each variable were as follows, in descending order: no unrelated comorbid conditions, no vascular disease, no diabetes, no chronic renal insufficiency, men, white race, median household income >\$75 000, commercial insurance, lowest quartile of weight, nonsmoker, 1–3 patient visits, normal blood pressure at previous visit, high diastolic blood pressure only at current visit, no active antihypertensive medication at the start of visit, lowest quartile of patient adherence to scheduled visits, attending provider, male provider, white provider, lowest quartile of provider workload, no related specialty care, and 1 unrelated specialist.

† Categories are the number of different types of specialists visited.

**Appendix Table 2. Adjusted Association of Unrelated Comorbid Conditions with Intensification of Antihypertensive Medication at Visits**

Unrelated Comorbid Condition	Adjusted Odds Ratio (95% CI)*	P Value
AIDS or HIV infection	0.88 (0.70–1.11)	0.28
Alcoholism	1.09 (0.94–1.27)	0.23
Anemia	0.96 (0.90–1.01)	0.107
Cancer	0.87 (0.81–0.92)	<0.001
Chronic rhinitis and sinusitis†	0.76 (0.72–0.79)	<0.001
Coagulopathy	0.84 (0.70–0.99)	0.039
Collagen vascular disease†	0.82 (0.71–0.97)	0.020
Depression or anxiety†	0.80 (0.75–0.85)	<0.001
Diarrhea or constipation†	0.80 (0.76–0.85)	<0.001
Drug abuse	0.94 (0.78–1.12)	0.48
Electrolyte and fluid abnormality	0.89 (0.83–0.96)	0.001
Emphysema or asthma	0.80 (0.75–0.85)	<0.001
Gastroesophageal reflux disease or gastritis†	0.80 (0.76–0.83)	<0.001
Headache†	0.85 (0.80–0.90)	<0.001
Hemophilia†	0.86 (0.71–1.06)	0.134
Liver dysfunction	0.91 (0.82–1.00)	0.042
Nonrheumatoid arthritis	0.79 (0.76–0.83)	<0.001
Other neurologic disorders	1.20 (0.87–1.67)	0.26
Paraplegia	0.99 (0.80–1.23)	0.94
Peptic ulcer disease	0.77 (0.64–0.94)	0.010
Psychosis	0.74 (0.59–0.92)	0.008
Pulmonary circulation disorders	0.94 (0.84–1.06)	0.31
Rheumatoid arthritis	0.89 (0.79–0.99)	0.030
Seizures†	0.82 (0.69–0.98)	0.031
Thrombocytopenia or thrombocytosis†	0.90 (0.74–1.09)	0.28
Thyroid disorder†	0.85 (0.79–0.91)	<0.001
Weight loss	1.58 (0.98–2.54)	0.062

\* Adjusted for patient sex, age, and race.

† This condition was added to the Elixhauser severity measure; anxiety was added to the Elixhauser depression category (7).