Supplementary Online Content

Goodwin JS, Li S, Kuo Y-F. Association of the work schedules of hospitalists with patient outcomes of hospitalization. *JAMA Intern Med*. Published online November 25, 2019. doi:10.1001/jamainternmed.2019.5193

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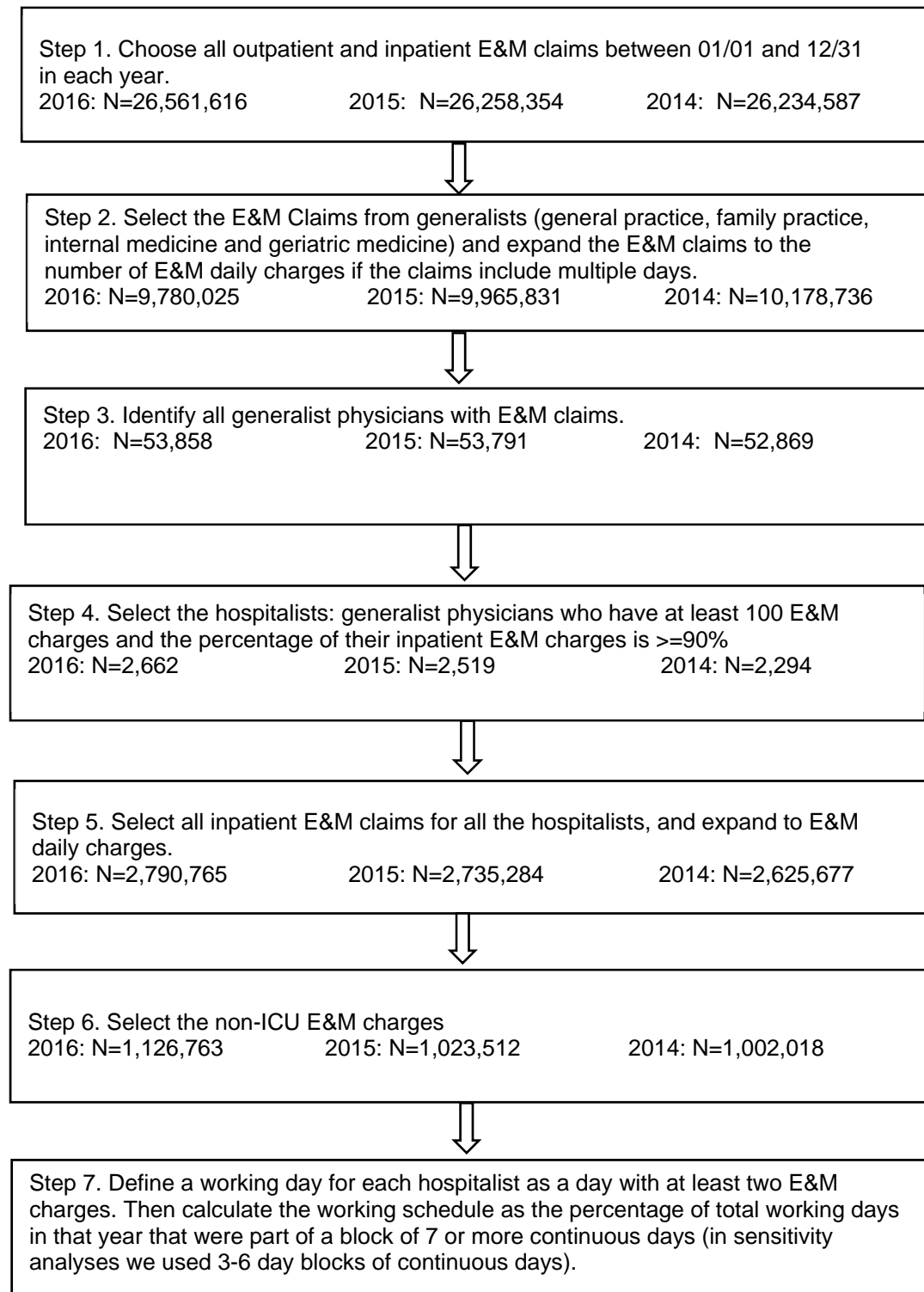**eReferences.**

This supplementary material has been provided by the authors to give readers additional information about their work.
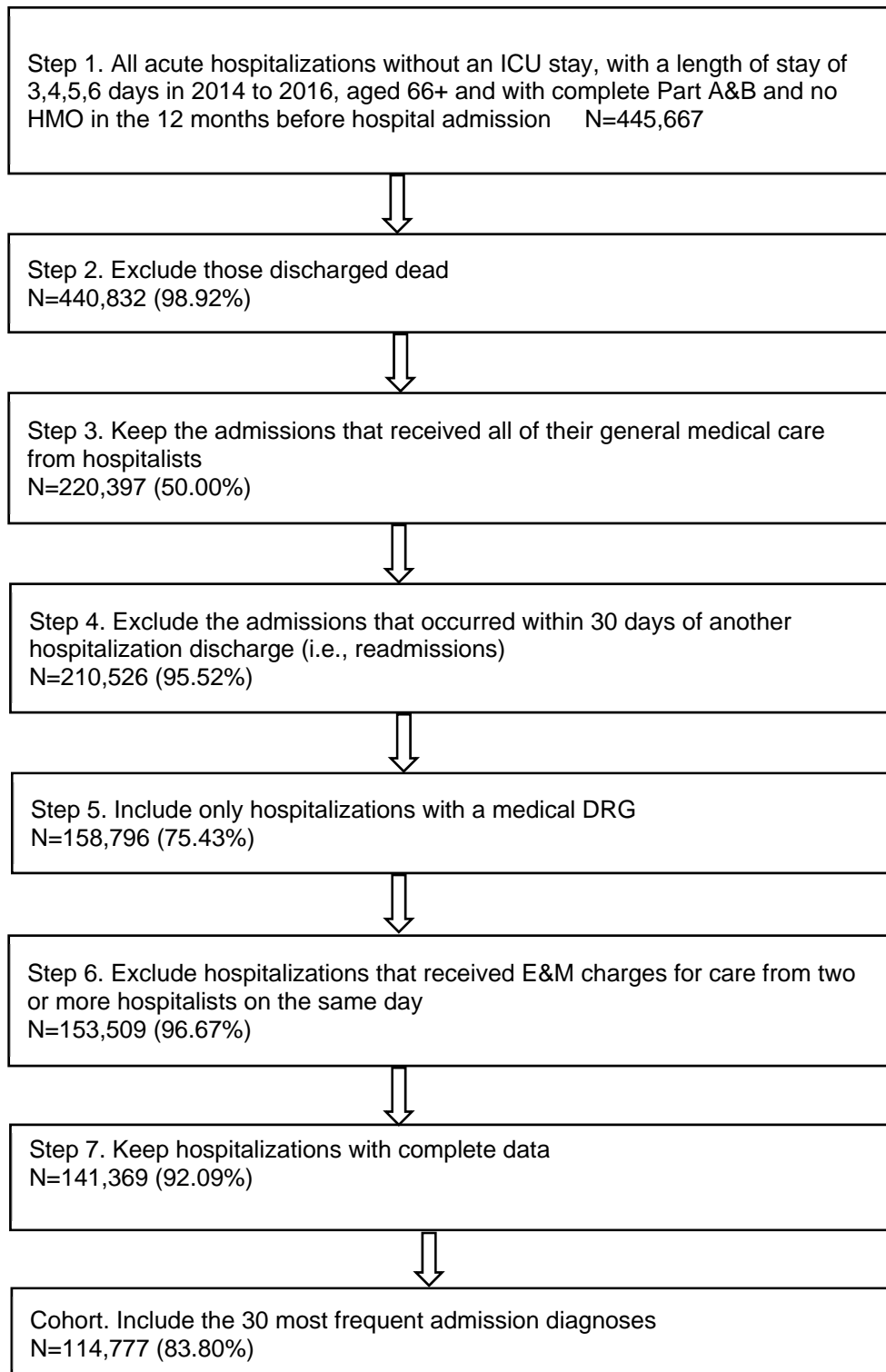
eAppendix. Expressing schedule continuity by the median number of consecutive days worked in a year.

In exploratory analyses, we found that the distribution of the number of consecutive days worked in a year for each hospitalist was highly skewed (Appendix e-Figures 3-5). We took two approaches to deal with this. The first is the approach described in the main analyses, which was to count all the working days in a year for each hospitalist and calculate the percent of those working days that were part of a 7-day or longer block of consecutive working days. The second method was to calculate the median number of days that were part of blocks of consecutive days during the year, for each hospitalist. For each hospitalist, we grouped each block of consecutive days worked. Appendix e-Figure 3 shows an example for 10 randomly selected hospitalists. We then calculated for each hospitalist the median number of consecutive days worked in that year. For each admission, we calculated the mean of the median of consecutive days for all the treating hospitalists, weighted by the number of days they provided care for that admission (assessed by E&M charge). We then ranked all admissions by the weighted mean of the median days consecutively worked by the treating hospitalists, and expressed that as quartile of hospitalist continuity, similar to the main analyses. The outcomes of these analyses are shown in Appendix e-Table 6 and e-Figure 7.

eFigure 1. Cohort selection for identifying hospitalists (steps 1-4) and hospitalist schedules (steps 4-7). Abbreviations: E&M, evaluation and management; ICU: intensive care unit.

Step 1. Choose all outpatient and inpatient E&M claims between 01/01 and 12/31 in each year.
2016: N=26,561,616   2015: N=26,258,354   2014: N=26,234,587

Step 2. Select the E&M Claims from generalists (general practice, family practice, internal medicine and geriatric medicine) and expand the E&M claims to the number of E&M daily charges if the claims include multiple days.
2016: N=9,780,025   2015: N=9,965,831   2014: N=10,178,736

Step 3. Identify all generalist physicians with E&M claims.
2016: N=53,858   2015: N=53,791   2014: N=52,869

Step 4. Select the hospitalists: generalist physicians who have at least 100 E&M charges and the percentage of their inpatient E&M charges is >=90%
2016: N=2,662   2015: N=2,519   2014: N=2,294

Step 5. Select all inpatient E&M claims for all the hospitalists, and expand to E&M daily charges.
2016: N=2,790,765   2015: N=2,735,284   2014: N=2,625,677

Step 6. Select the non-ICU E&M charges
2016: N=1,126,763   2015: N=1,023,512   2014: N=1,002,018

Step 7. Define a working day for each hospitalist as a day with at least two E&M charges. Then calculate the working schedule as the percentage of total working days in that year that were part of a block of 7 or more continuous days (in sensitivity analyses we used 3-6 day blocks of continuous days).

eFigure 2. Cohort selection for identifying outcomes of hospitalist care. Abbreviations: ICU: intensive care unit; HMO, health maintenance organization; DRG, diagnosis-related group E&M, evaluation and management.

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┌─────────────────────────────────────────────────────────────────┐
│ Step 1. All acute hospitalizations without an ICU stay, with a    │
│ length of stay of 3,4,5,6 days in 2014 to 2016, aged 66+ and with │
│ complete Part A&B and no HMO in the 12 months before hospital     │
│ admission      N=445,667                                          │
└─────────────────────────────────────────────────────────────────┘
                              ↓
┌─────────────────────────────────────────────────────────────────┐
│ Step 2. Exclude those discharged dead                             │
│ N=440,832 (98.92%)                                                │
└─────────────────────────────────────────────────────────────────┘
                              ↓
┌─────────────────────────────────────────────────────────────────┐
│ Step 3. Keep the admissions that received all of their general    │
│ medical care from hospitalists                                    │
│ N=220,397 (50.00%)                                                │
└─────────────────────────────────────────────────────────────────┘
                              ↓
┌─────────────────────────────────────────────────────────────────┐
│ Step 4. Exclude the admissions that occurred within 30 days of    │
│ another hospitalization discharge (i.e., readmissions)            │
│ N=210,526 (95.52%)                                                │
└─────────────────────────────────────────────────────────────────┘
                              ↓
┌─────────────────────────────────────────────────────────────────┐
│ Step 5. Include only hospitalizations with a medical DRG          │
│ N=158,796 (75.43%)                                                │
└─────────────────────────────────────────────────────────────────┘
                              ↓
┌─────────────────────────────────────────────────────────────────┐
│ Step 6. Exclude hospitalizations that received E&M charges for    │
│ care from two or more hospitalists on the same day                │
│ N=153,509 (96.67%)                                                │
└─────────────────────────────────────────────────────────────────┘
                              ↓
┌─────────────────────────────────────────────────────────────────┐
│ Step 7. Keep hospitalizations with complete data                  │
│ N=141,369 (92.09%)                                                │
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                              ↓
┌─────────────────────────────────────────────────────────────────┐
│ Cohort. Include the 30 most frequent admission diagnoses          │
│ N=114,777 (83.80%)                                                │
└─────────────────────────────────────────────────────────────────┘
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eFigure 3. This figure presents an analysis of 10 randomly selected hospitalists in 2016, examining the distribution of their blocks of working days. For example, with hospitalist #5, most of the blocks were of 1, 2, or 3 consecutive working days, but approximately 12% were 5 day blocks and 5% were blocks of 10 or more consecutive days. All 10 hospitalists had some blocks of just one consecutive working day although, for most of the hospitalists, that represented a low percent of their total working days, as shown in Appendix e-Figure 4.

Percentage of total blocks
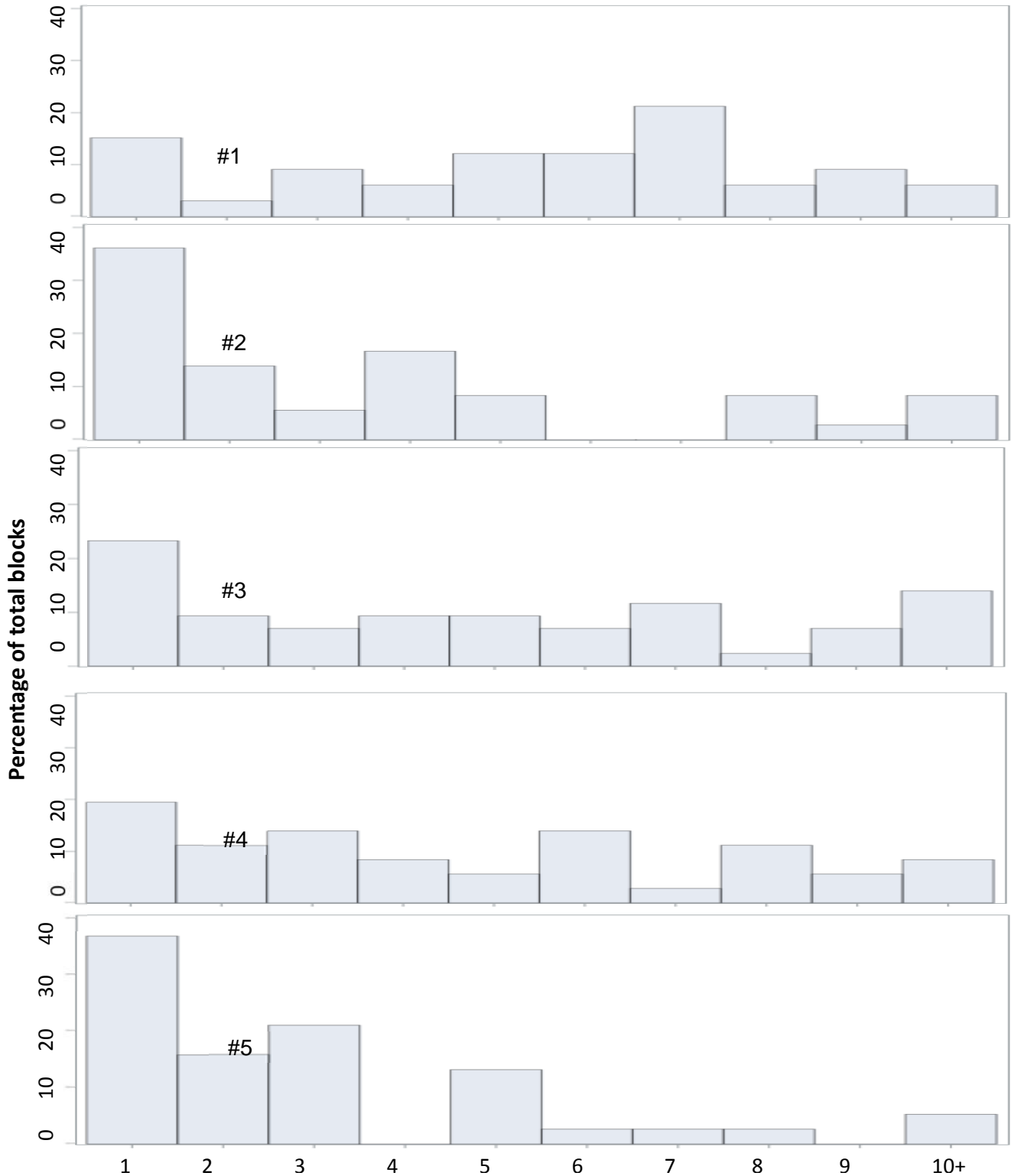
Consecutive days worked
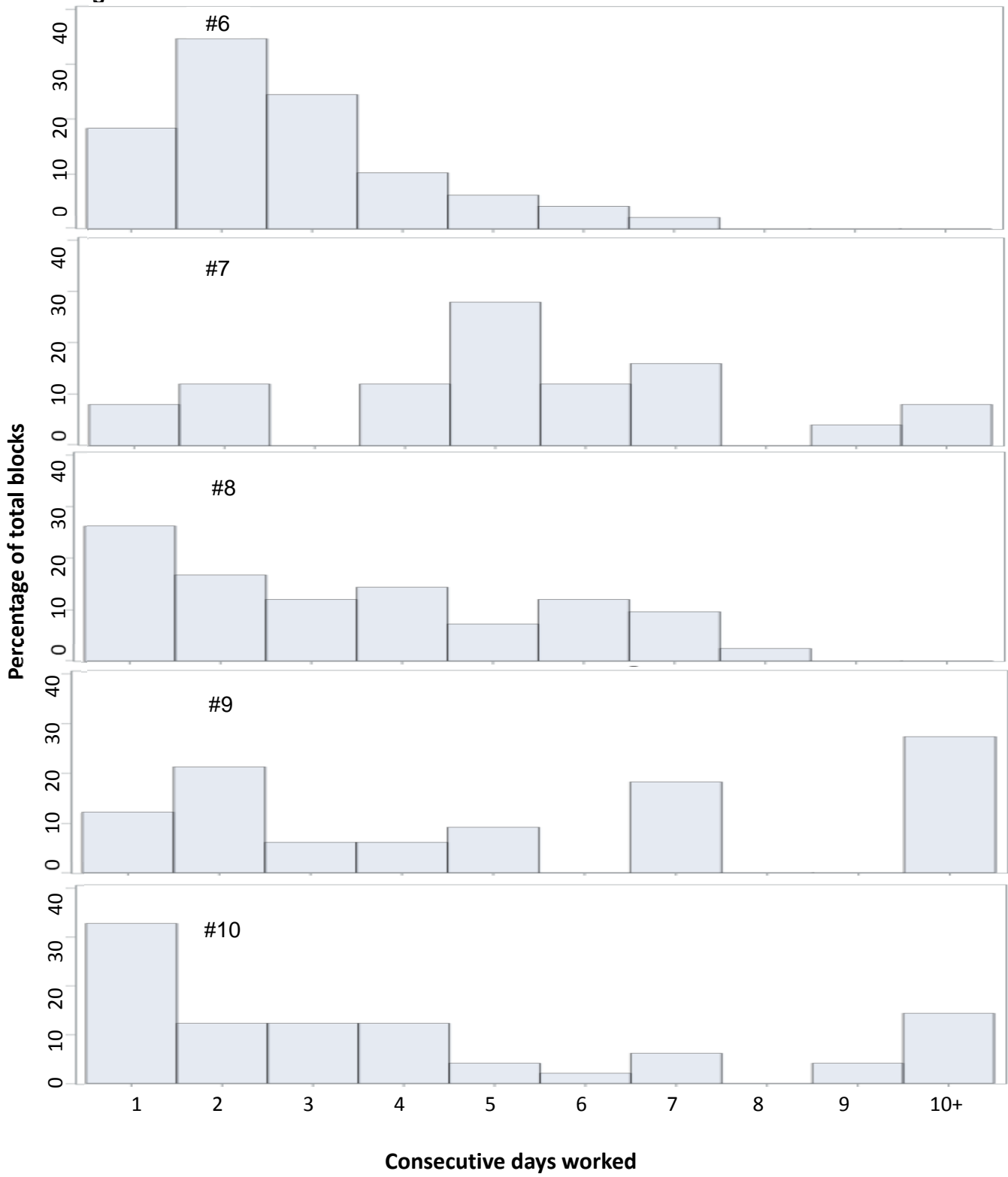
eFigure 4. Distribution of consecutive days worked for all hospitalists in 2016. All the working days for all hospitalists were grouped by whether they were part of a single working day or a block of 2, 3, 4, 5, 6, 7, 8, 9 or 10 or more consecutive working days. Shown in the figure is the percentage distribution of the blocks, and also the percentage distribution of total working days in those blocks.
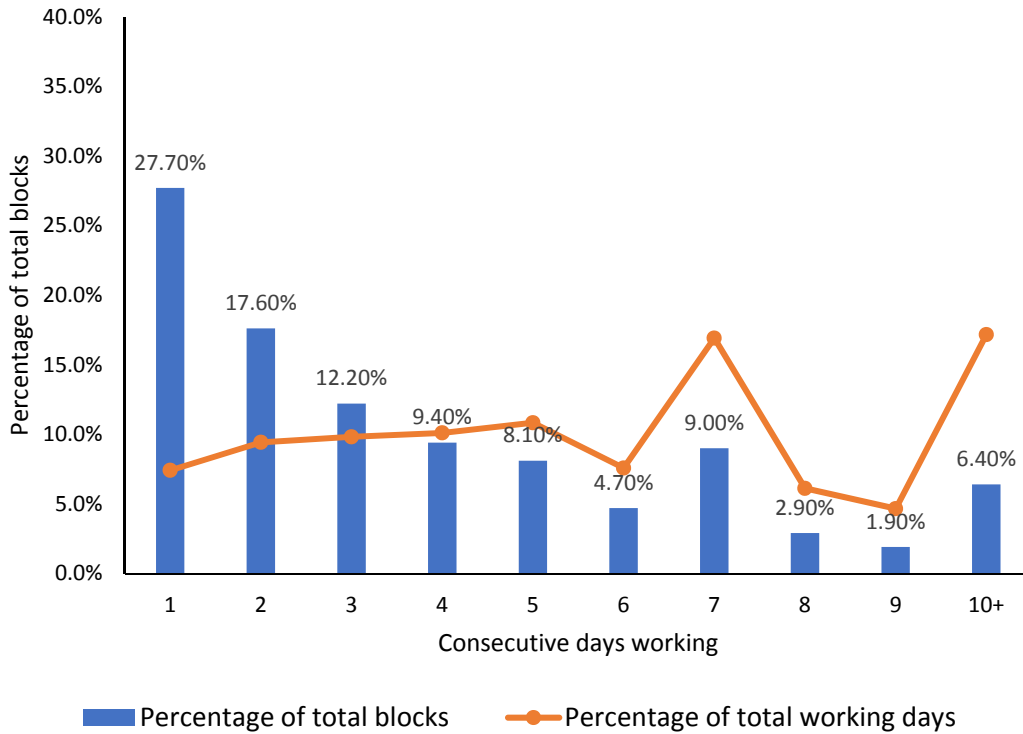
eFigure 5. Distribution of skewness in hospitalist schedules.[1] Skewness is a statistical measure to define the extent to which a distribution differs from a normal distribution. A zero value means a symmetric distribution, a negative value indicates that the tail is on the left side of the distribution, and a positive value indicates that the tail is on the right side of the distribution. We checked the distribution of working days in a row for each hospitalist. We found that only 19.9% of hospitalist schedules were normally distributed (-0.5<=skewness<=0.5), 26.6% were moderately skewed (0.5<skewness<=1 or -1<=skewness<-0.5), and 53.5% of hospitalist schedules were highly skewed (skewness<-1 or skewness>1).[1]
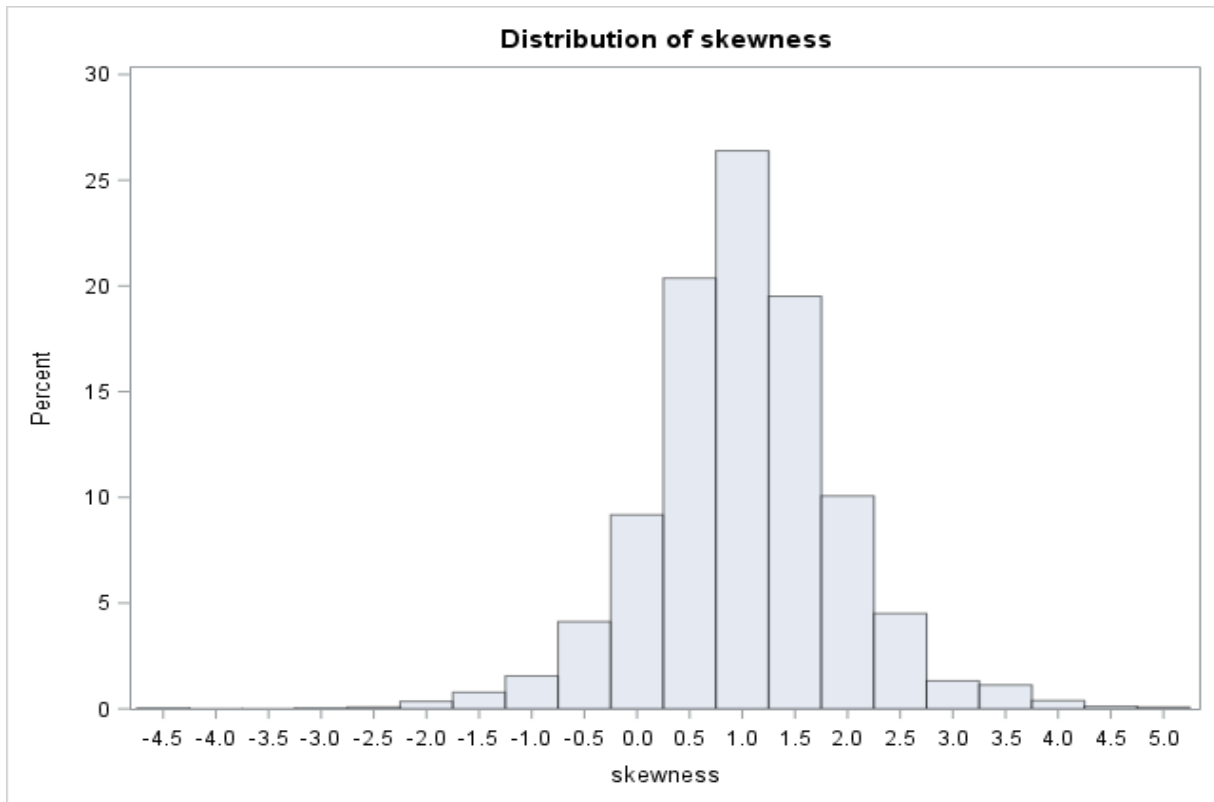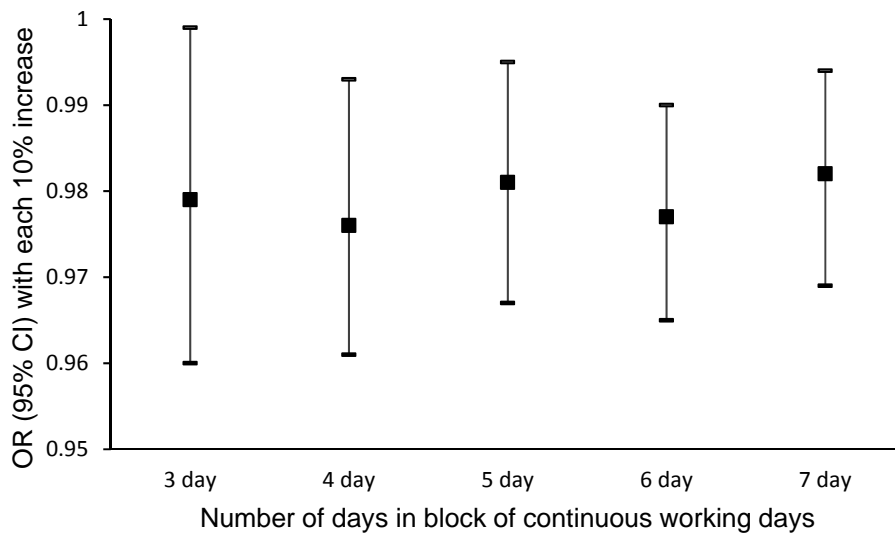
eFigure 6. The effect of varying the method of estimating continuity of hospitalist schedule on the association between hospitalist schedule and 30-day mortality. In the main analyses continuity of hospitalist schedule was estimated as the percent of all working days in a year of a given hospitalist that were part of a block of 7 or more consecutive working days, as described in Appendix Figure 2.

As shown in Appendix Figure 3, using a block of 3, 4, 5, or 6 continuous working days produces similar results. The odds (+/- 95% CIs) of 30-day mortality are expressed as a continuous function, each 10% increase in the ranking of weighted mean hospitalist schedule for an admission.

Abbreviations: OR, odds ratio; CI, confidence interval.

eFigure 7. Penalized B-splines smoothing curve and 95% confidence band for weighted average of median working days and 30 day mortality.[2,3] We measured the knots from 10 to 2000, and degree of freedom is stable to 1. The measure suggests a linear pattern in the dependence of 30 day mortality on the weighted average of median working days between 1 and 14 working days.
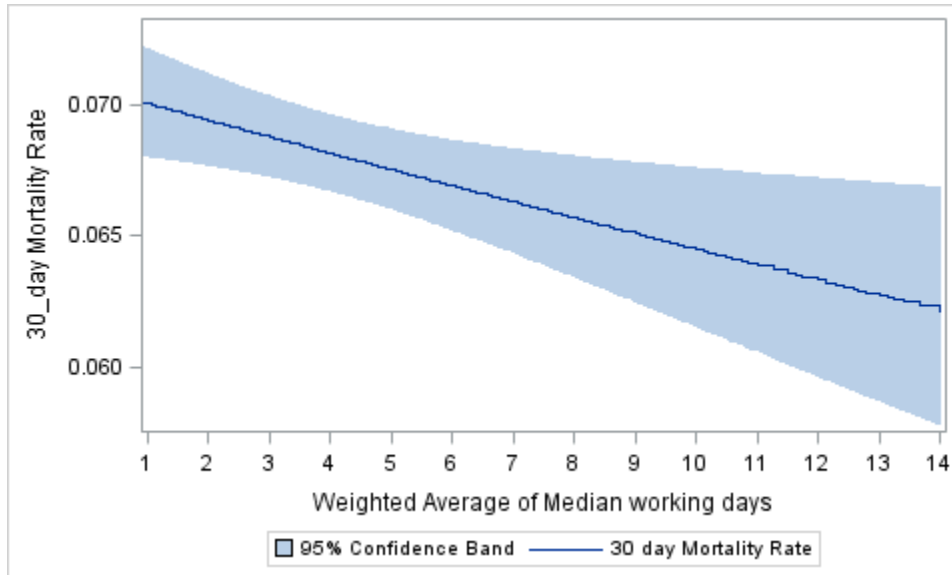
eTable 1. Odds of 30-day mortality for medical admissions aged 66+ and without an Intensive Care Unit (ICU) stay during hospitalization, by patient characteristics, from a conditional logistic model for 01/01/2014 - 11/30/2016, 100% TX Medicare data. [a]

Characteristic	N (%)	Observed rate	Odds Ratio[*] (95% Confidence Interval)
All	114,777	6.8%	
	Mean ± STD, Median (Q1-Q3)		
Age (Per year)	79.9 ± 8.3 80.0 (73.0-86.0)		1.06 (1.06-1.07)
Education (Percent of persons age 25+ in ZIP code with high school education) (Per percent)	82.6 ± 11.5 84.8 (76.7-91.7)		1.00 (0.99-1.01)
Weighted average of hospitalist schedules (7 day block)			
Q1	29,068 (25.3%)	7.2%	Reference
Q2	28,697 (25.0%)	6.9%	0.92 (0.85-0.98)
Q3	28,721 (25.0%)	6.6%	0.90 (0.83-0.98)
Q4	28,291 (24.7%)	6.5%	0.88 (0.81-0.95)
Year			
2014	39,137 (34.1%)	6.9%	Reference
2015	39,412 (34.3%)	6.8%	0.98 (0.93-1.04)
2016	36,228 (31.6%)	6.7%	0.99 (0.93-1.05)
Gender			
Male	44,730 (39.0%)	7.7%	Reference
Female	70,047 (61.0%)	6.2%	0.75 (0.71-0.79)
Medicaid			
No	90,447 (78.8%)	6.8%	Reference
Yes	24,330 (21.1%)	6.6%	1.03 (0.96-1.10)
Race			
White	85,497 (74.5%)	7.1%	Reference
Black	10,236 (8.9%)	5.9%	0.86 (0.78-0.95)
Hispanic	16,757 (14.6%)	6.2%	0.96 (0.88-1.05)
Other	2,287 (2.0%)	5.5%	0.86 (0.71-1.03)
Residence prior to hospitalization			
Community	108,511 (94.5%)	6.7%	Reference
Nursing facility or other institutions	6,266 (5.5%)	9.0%	1.48 (1.33-1.64)
Length of stay			
3 days	48,555 (42.3%)	5.4%	Reference
4 days	32,176 (28.0%)	6.8%	1.21 (1.14-1.29)
5 days	20,578 (17.9%)	8.2%	1.44 (1.35-1.54)
6 days	13,468 (11.7%)	9.7%	1.81 (1.68-1.94)
Number of hospitalizations in 12 months before admission (Per hospitalization)			
0	57,100 (49.8%)	5.5%	Reference
1	29,000 (25.3%)	7.4%	1.17 (1.10-1.26)
2	21,198 (18.5%)	8.4%	1.22 (1.12-1.33)
3 and above	7,479 (6.5%)	9.4%	1.42 (1.26-1.60)
Emergency hospitalization			
No	21,326 (18.6%)	6.6%	Reference

Yes	93,451 (81.4%)	6.9%	1.19 (1.10-1.29)
Weekend hospitalization			
No	79,503 (69.3%)	6.8%	Reference
Yes	35,274 (30.7%)	6.9%	0.99 (0.94-1.04)
Admission diagnosis [b]			
102 Nonspecific Chest Pain	3,709 (3.2%)	3.9%	Reference
106 Cardiac dysrhythmias	2,294 (2.0%)	5.5%	1.34 (1.04-1.72)
108 Congestive heart failure; nonhypertensive	4,134 (3.6%)	8.0%	1.58 (1.28-1.96)
109 Acute cerebrovascular disease	2,296 (2.0%)	9.8%	1.86 (1.47-2.35)
122 Pneumonia (except that caused by tuberculosis or sexually transmitted disease)	6,760 (5.9%)	7.3%	1.39 (1.14-1.70)
127 Chronic obstructive pulmonary disease and bronchiectasis	2,971 (2.6%)	4.0%	1.23 (0.96-1.58)
131 Respiratory failure	1,028 (0.9%)	12.1%	1.71 (1.27-2.28)
133 Other lower respiratory disease	17,057 (14.9%)	7.2%	1.68 (1.40-2.02)
145 Intestinal obstruction without hernia	1,535 (1.3%)	5.2%	1.32 (1.01-1.75)
153 Gastrointestinal hemorrhage	3,967 (3.5%)	5.1%	1.21 (0.97-1.51)
155 Other gastrointestinal disorders	2,433 (2.1%)	6.9%	1.42 (1.12-1.80)
157 Acute and unspecified renal failure	2,991 (2.6%)	9.2%	1.69 (1.36-2.11)
159 Urinary tract infections	5,432 (4.7%)	5.4%	1.13 (0.92-1.40)
163 Genitourinary symptoms	1,223 (1.1%)	5.5%	1.33 (0.99-1.78)
197 Skin and subcutaneous tissue infections	3,539 (3.1%)	2.4%	1.00 (0.78-1.27)
2 Septicemia	3,891 (3.4%)	9.2%	1.70 (1.38-2.10)
204 Arthropathy following intestinal bypass, unspecified site	1,831 (1.6%)	4.4%	1.28 (0.98-1.68)
205 Spondylosis; intervertebral disc disorders; other back problems	1,785 (1.6%)	5.8%	1.41 (1.08-1.84)
211 Sleep related leg cramps	3,482 (3.0%)	4.5%	1.22 (0.97-1.55)
231 Fatigue fracture of vertebra, site unsp, init for fx	1,542 (1.3%)	5.2%	1.34 (1.01-1.77)
245 Syncope and collapse	2,927 (2.6%)	4.0%	1.15 (0.90-1.46)
246 Fever presenting with conditions classified elsewhere	3,613 (3.2%)	4.4%	1.12 (0.89-1.40)

250 Nausea and vomiting	2,940 (2.6%)	6.4%	1.42 (1.13-1.79)
251 Abdominal pain	6,875 (6.0%)	5.0%	1.27 (1.03-1.56)
252 Malaise and fatigue	7,175 (6.3%)	8.2%	1.77 (1.46-2.15)
259 Insomnia, unspecified	9,666 (8.4%)	11.4%	2.78 (2.31-3.34)
55 Fluid and electrolyte disorders	3,041 (2.7%)	9.1%	1.70 (1.37-2.12)
59 Deficiency and other anemia	1,310 (1.1%)	7.7%	1.49 (1.13-1.98)
93 Meniere's disease	1,276 (1.1%)	2.7%	1.28 (0.93-1.76)
95 Other nervous system disorder	2,054 (1.8%)	7.1%	1.50 (1.17-1.93)
Comorbidity			
Alcohol abuse			
No	113,901 (99.2%)	6.8%	Reference
Yes	876 (0.8%)	8.9%	1.22 (0.94-1.58)
Cardiac Arrhythmia			
No	69,506 (60.6%)	6.2%	Reference
Yes	45,271 (39.4%)	7.7%	0.95 (0.90-1.01)
Blood Loss Anemia			
No	111,276 (97.0%)	6.8%	Reference
Yes	3,501 (3.0%)	7.7%	0.85 (0.74-0.97)
Congestive Heart Failure			
No	75,074 (65.4%)	6.2%	Reference
Yes	39,703 (34.6%)	8.0%	1.09 (1.03-1.16)
Chronic Pulmonary Disease			
No	74,660 (65.1%)	6.7%	Reference
Yes	40,117 (34.9%)	7.0%	0.97 (0.91-1.02)
Coagulopathy			
No	106,303 (92.6%)	6.6%	Reference
Yes	8,474 (7.4%)	9.8%	1.14 (1.05-1.24)
Deficiency Anemia			
No	96,408 (84.0%)	6.6%	Reference
Yes	18,369 (16.0%)	7.8%	1.09 (1.02-1.17)
Depression			
No	87,360 (76.1%)	6.6%	Reference
Yes	27,417 (23.9%)	7.4%	1.03 (0.97-1.09)
Diabetes Complicated			
No	89,722 (78.2%)	7.0%	Reference
Yes	25,055 (21.8%)	6.0%	0.94 (0.87-1.01)
Diabetes Uncomplicated			
No	70,839 (61.7%)	7.1%	Reference
Yes	43,938 (38.3%)	6.3%	0.99 (0.93-1.05)
Drug Abuse			
No	114,323 (99.6%)	6.8%	Reference
Yes	454 (0.4%)	6.8%	1.09 (0.73-1.62)
Fluid and Electrolyte Disorders			
No	74,548 (65.0%)	5.8%	Reference
Yes	40,229 (35.0%)	8.7%	1.19 (1.12-1.27)
AIDS/HIV			
No	114,675 (99.9%)	6.8%	Reference
Yes	102 (0.1%)	2.9%	0.97 (0.37-2.55)
Hypertension complicated			
No	82,270 (71.7%)	6.6%	Reference

Yes	32,507 (28.3%)	7.2%	0.81 (0.75-0.87)
Hypertension Uncomplicated			
No	21,406 (18.7%)	6.9%	Reference
Yes	93,371 (81.4%)	6.8%	0.81 (0.76-0.87)
Hypothyroidism			
No	81,744 (71.2%)	6.8%	Reference
Yes	33,033 (28.8%)	6.9%	0.92 (0.88-0.98)
Liver Disease			
No	109,258 (95.2%)	6.7%	Reference
Yes	5,519 (4.8%)	8.2%	1.21 (1.08-1.34)
Lymphoma			
No	112,584 (98.1%)	6.7%	Reference
Yes	2,193 (1.9%)	10.5%	1.44 (1.24-1.66)
Metastatic Cancer			
No	110,707 (96.4%)	6.3%	Reference
Yes	4,070 (3.6%)	20.6%	4.22 (3.81-4.68)
Obesity			
No	100,619 (87.7%)	7.1%	Reference
Yes	14,158 (12.3%)	4.7%	0.79 (0.73-0.87)
Other Neurological Disorders			
No	96,120 (83.8%)	6.4%	Reference
Yes	18,657 (16.2%)	8.9%	1.12 (1.05-1.20)
Pulmonary Circulation Disorders			
No	106,444 (92.7%)	6.7%	Reference
Yes	8,333 (7.3%)	8.4%	1.13 (1.03-1.24)
Peptic Ulcer Disease excluding bleeding			
No	112,773 (98.2%)	6.8%	Reference
Yes	2,004 (1.8%)	7.1%	0.89 (0.74-1.06)
Peripheral Vascular Disorders			
No	85,514 (74.5%)	6.3%	Reference
Yes	29,263 (25.5%)	8.2%	1.14 (1.08-1.21)
Paralysis			
No	111,517 (97.2%)	6.8%	Reference
Yes	3,260 (2.8%)	8.5%	1.17 (1.03-1.34)
Psychoses			
No	109,698 (95.6%)	6.7%	Reference
Yes	5,079 (4.4%)	8.9%	1.11 (1.01-1.24)
Renal Failure			
No	80,916 (70.5%)	6.4%	Reference
Yes	33,861 (29.5%)	7.7%	1.14 (1.06-1.23)
Weight Loss			
No	101,128 (88.1%)	6.1%	Reference
Yes	13,649 (11.9%)	11.7%	1.49 (1.40-1.59)
Valvular Disease			
No	98,143 (85.5%)	6.7%	Reference
Yes	16,634 (14.5%)	7.4%	0.91 (0.85-0.98)
Solid Tumor without Metastasis			
No	100,299 (87.4%)	6.1%	Reference
Yes	14,478 (12.6%)	11.4%	1.24 (1.15-1.34)
Rheumatoid Arthritis/collagen			
No	106,161 (92.5%)	6.9%	Reference
Yes	8,616 (7.5%)	5.2%	0.81 (0.73-0.90)

a. Admissions were limited to those with a medical diagnosis-related group diagnosis who received all their generalist care (evaluation and management [E&M] charges from general internal medicine, family medicine or geriatric physicians) from hospitalists (defined as generalist physicians with >80% of E&M charges generated on care of hospitalized patients). Admissions with <3 or >6-day length of stay were excluded, as were admissions with >1 E&M charge from a hospitalist in a day.
b. Admission diagnoses were categorized by the Clinical Classification Software (CCS) [22, 23]

eTable 2. Intraclass correlation coefficients (ICCs) from multilevel model predicting whether an admission received care from hospitalists who were in the highest quartile in mean weighted schedule continuity. All the admission characteristics included in Appendix Table 1, with the exception of quartile of hospitalist schedule, were included in the model that included admission characteristics.

	ICC for an admission being in highest quartile of hospitalist continuity[a]
Null Model	0.4191
Model plus admission characteristics	0.4189

a. The ICCs are presented to four decimal places to illustrate the negligible impact of admission characteristics on the variation in mean weighted schedule continuity among admissions.

eTable 3. Association of each 10% increase in weighted mean hospital schedule continuity with 30-day mortality, readmission, and rate of discharge home.

Outcome		OR or HR (and 95% CI) with each 10% increase in schedule continuity
30-day mortality		0.981 (0.968, 0.994)
30-day readmission		0.990 (0.983, 0.998)
Discharge home		1.002 (1.001, 1.003)

Abbreviations: OR, odds ratio; HR, hazard ratio; CI, confidence interval.

eTable 4. Association of continuity of hospitalist schedule, by quartile, with unadjusted and adjusted 30-day mortality, readmission and rate of discharge home. The first E&M charge from each admission was excluded in the determination of which hospitalists provided care during the admission. This was done because the first E&M charge might be from an on-call hospitalist or nocturnist if the patient were admitted in off-hours.

	Q1 27,806	Q2 28,064	Q3 27,820	Q4 27,470
30-day Mortality				
Unadjusted Rate	7.20%	6.89%	6.67%	6.41%
OR (95% CI)	Reference	0.92 (0.85-0.99)	0.92 (0.85-0.99)	0.87 (0.80-0.95)
30-day Readmission				
Unadjusted Rate	16.61%	16.51%	16.93%	16.45%
HR (95% CI)	Reference	0.97 (0.93-1.01)	0.99 (0.94-1.04)	0.95 (0.90-1.01)
Discharge Home				
Unadjusted Rate	44.32%	43.16%	44.07%	46.87%
OR (95% CI)	Reference	1.01 (0.97-1.06)	1.02 (0.97-1.06)	1.08 (1.03-1.14)

eTable 5. Correlation among 3098 hospitalists in their ranking of continuity of their schedules, with continuity of their schedules calculated as the percent of working days that were part of a 3, 4, 5, 6 or 7 day block of continuous working days. The ranking is expressed as quartiles (Table 5A) or as 1 through 3098 (Table 5B).

A. Ranking continuity of hospitalist schedule by quartile.

	3 days	4 days	5 days	6 days	7 days
3 days	1	0.94	0.89	0.85	0.83
4 days		1	0.95	0.90	0.89
5 days			1	0.94	0.92
6 days				1	0.97
7 days					1

B. Ranking continuity of hospitalist schedules by 1 through 3098.

	3 days	4 days	5 days	6 days	7 days
3 days	1	0.91	0.82	0.74	0.69
4 days		1	0.93	0.85	0.80
5 days			1	0.92	0.88
6 days				1	0.95
7 days					1

eTable 6. Association of continuity of the schedules of the treating hospitalists, by quartile, with unadjusted and adjusted 30-day mortality, 30-day readmission and rate of discharge home. The schedule continuity for each hospitalist was measured as the median number of consecutive days worked in a year. For each admission, the mean of the median days for each of the treating hospitalists was calculated, weighted by the number of E&M charges by each hospitalist submitted for the admission. The results are similar to those obtained when we assessed continuity of hospitalist schedules as the percent of total working days that were part of a 7-day or longer block of consecutive working days (Table 2). OR, odds ratio; CI, confidence interval; HR, hazards ratio.

	Q1 n=29,088 (25.34%)	Q2 n=29,365 (25.58%)	Q3 n=30,978 (26.99%)	Q4 n=25,346 (22.08%)
30-day Mortality				
Unadjusted Rate	7.13%	6.92%	6.62%	6.49%
OR (95% CI)	Reference	0.96 (0.89-1.03)	0.92 (0.85-0.99)	0.88 (0.81-0.96)
30-day Readmission				
Unadjusted Rate	16.87%	16.41%	16.60%	16.39%
HR (95% CI)	Reference	0.96 (0.92-1.01)	0.95 (0.91-0.99)	0.93 (0.89-0.98)
Discharge Home				
Unadjusted Rate	44.58%	43.80%	44.49%	45.61%
OR (95% CI)	Reference	1.07 (1.03-1.11)	1.05 (1.01-1.10)	1.06 (1.01-1.11)

eReferences

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