ORIGINAL RESEARCH

Association Between Subsequent Hospitalizations and Recurrent Acute Myocardial Infarction Within 1 Year After Acute Myocardial Infarction

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BACKGROUND: Patients who survive acute myocardial infarction (AMI) are at high risk for recurrence. We determined whether rehospitalizations after AMI further increased risk of recurrent AMI.

METHODS AND RESULTS: The study included Medicare fee-for-service patients aged ≥65 years discharged alive after AMI from acute-care hospitals in fiscal years 2009–2014. The outcome was recurrent AMI within 1 year of the index AMI. The Clinical Classifications Software (CCS) was used to classify rehospitalizations into disease categories. A Cox regression model was fit accounting for CCS-specific hospitalizations as time-varying variables and patient characteristics at discharge for the index AMI, adjusting for the competing risk of death. The rate of 1-year recurrent AMI was 5.3% (95% CI, 5.27%–5.41%), and median (interquartile range) time from discharge to recurrent AMI was 115 (34–230) days. Eleven disease categories (diabetes mellitus, anemia, hypertension, coronary atherosclerosis, chest pain, heart failure, pneumonia, chronic obstructive pulmonary disease, gastrointestinal hemorrhage, renal failure, complication of implant or graft) were associated with increased risk of recurrent AMI. Septicemia was associated with lower recurrence risk. Hazard ratios ranged from 1.6 (95% CI, 1.55–1.70, heart failure) to 1.1 (95% CI, 1.04–1.25, pneumonia) to 0.6 (95% CI, 0.58–0.71, septicemia).

CONCLUSIONS: Patient risk of recurrent AMI changed based on the occurrence of hospitalizations after the index AMI. Improving post–acute care to prevent unplanned rehospitalizations, especially rehospitalizations for chronic diseases, and extending the focus of outcomes measures to condition-specific rehospitalizations within 30 days and beyond is important for the secondary prevention of AMI.

Key Words: cardiovascular prevention ■ myocardial infarction ■ rehospitalization
Accordingly, we used national Medicare inpatient claims data to assess the association between subsequent hospitalizations and recurrent AMI within 1 year after an initial AMI and identify clinically important hospitalizations that increased the risk of recurrence. This study, which was based on 100% national data and detailed follow-up information about patients with AMI, is ideally positioned to generate information to update risk stratification for recurrent AMI in the year after hospital discharge.

**METHODS**

Restricted by our Data Use Agreement with the Centers for Medicare & Medicaid Services (CMS), the Medicare data used for this study cannot be made publicly available to other researchers for purposes of reproducing the results or replicating the procedure. However, Medicare data are available from the Centers for Medicare & Medicaid Services upon request (https://www.cms.gov/Research-Statistics-Data-and-Systems/Files-for-Order/Data-Disclosures-Data-Agreements/DUA__Forms.html).

**Study Sample**

We used the Centers for Medicare & Medicaid Services Medicare denominator files to identify all beneficiaries aged 65 years or older enrolled in the fee-for-service program for at least 12 months in fiscal years (FY) 2009–2014 (October 1, 2008 to September 31, 2014), a period in which all diagnosis codes were classified according to the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). We linked these enrollment data to Medicare fee-for-service inpatient claims to identify beneficiaries who were discharged alive after hospitalization for AMI at an acute-care hospital in the United States. This was designated the index AMI hospitalization. If a patient had >1 AMI hospitalization during the study period, we selected the first AMI during the study period as the index AMI. Data from FY 2008 were used to identify patients who were rehospitalized with AMI in FY 2009; FY 2015 data were used to ensure 1 year of follow-up for patients hospitalized with AMI during FY 2014.

AMI was defined as an ICD-9-CM principal discharge diagnosis code of 410.xx. We excluded patients with ICD-9-CM codes 410.x2 because the codes represent subsequent episodes of care related to the index AMI. We also excluded patients who had a length of stay ≤1 day (because these patients were unlikely to have had an AMI), had conflicting dates of death and hospitalization, or were subsequently transferred to another acute-care hospital for continuing care after the initial AMI.

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**Nonstandard Abbreviations and Acronyms**

| Abbreviation | Description |
|--------------|-------------|
| AMI          | acute myocardial infarction |
| CABG         | coronary artery bypass grafting |
| CAD          | coronary artery disease |
| CATH         | cardiac catheterization |
| CCS          | Clinical Classifications Software |
| COPD         | chronic obstructive pulmonary disease |
| DM           | diabetes mellitus |
| FY           | fiscal years |
| HR           | hazard ratio |
| HTN          | hypertension |
| ICD-9-CM     | International Classification of Diseases, Ninth Revision, Clinical Modification |
| IQR          | interquartile range |
| PCI          | percutaneous coronary intervention |
| UTI          | urinary tract infection |

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risk markers for adverse outcomes is limited, and many of the available data focus on mortality. There is scant information on the association between subsequent hospitalizations and recurrent AMI. A comprehensive, contemporary, national evaluation of such rehospitalizations could provide important information for the prevention of recurrent AMI, particularly among Medicare beneficiaries who are a high-risk population for AMI.
Patient baseline characteristics included age (continuous), sex, race (white, black, other), and clinical comorbidities identified using the method employed by the Centers for Medicare & Medicaid Services to profile hospital 30-day mortality measures for AMI. We determined comorbidities from secondary diagnosis codes for the index AMI hospitalization as well as the principal and secondary diagnosis codes from all hospitalizations during the 12 months before the index AMI. Because the maximum number of diagnosis codes in Medicare data increased from 10 to 25 in 2011, we restricted the 2011–2015 data to the first 10 diagnosis codes to calculate comorbidities.

Outcome
The primary outcome was recurrent AMI within 1 year of discharge for the initial AMI. For patients with >1 recurrent AMI, the first recurrence was selected. Deaths during the 1-year follow-up period without a recurrent AMI hospitalization were treated as competing risks in the analysis. Secondary outcomes included 30-day all-cause mortality, 30-day all-cause readmission, and 1-year all-cause mortality using the index AMI discharge as the time zero. Mean length of stay and mean Medicare payment for the index AMI hospitalization were also assessed.

Subsequent Hospitalizations
We identified all subsequent hospitalizations within 1 year after discharge for the initial AMI. For patients with a recurrent AMI, subsequent hospitalizations were restricted to the period prior to the recurrent AMI. Because of the large volume of individual ICD-9-CM codes, we used the Clinical Classifications Software (CCS), a diagnosis and procedure categorization algorithm developed by the Agency for Healthcare Research and Quality, to characterize the subsequent hospitalizations. Using the CCS single-level diagnosis-specific algorithm, we collapsed >14,000 individual ICD-9-CM principal discharge diagnosis codes into 285 clinically homogeneous, meaningful, and mutually exclusive disease categories (Table S1). If a patient had >1 hospitalization for the same disease category, the first one was selected. We excluded CCS hospitalizations that occurred at a frequency <1% to avoid counting hospitalizations for less frequent diseases in the Medicare population.

Statistical Analysis
We divided patients into 2 samples, 2009–2011 and 2012–2014. We used the first sample to conduct the main analysis and the second to confirm the findings. We compared baseline characteristics between patients who had a recurrent AMI and those who did not have a recurrent AMI using the chi-squared test for categorical variables and the t test for continuous variables. Using the 2009–2011 sample, for each patient, we estimated the baseline risk at the time of discharge of having a recurrent AMI within 1 year after discharge by fitting a Cox proportional hazards model with Markov Chain Monte Carlo simulations that modeled time to first recurrent AMI as a function of a patient’s baseline characteristics described above. The model also included in-hospital treatments (percutaneous coronary intervention, coronary artery bypass grafting, and cardiac catheterization), length of stay, and discharge to home (yes/no) because these variables may be associated with the outcome. We retained a variable in the model if the posterior probability of its nonzero coefficient was >0.95. We used the regression coefficients estimated from this model to calculate a baseline risk score for recurrent AMI for each patient. We standardized the score through the Z score method and stratified patients into 1 of 3 risk groups based on the risk score distribution: low (<10th percentile), average (10th–90th percentile), and high (>90th percentile). The baseline risk group represented a patient’s risk of recurrent AMI at discharge. We used variables selected using the 2009–2011 data to calculate the score for patients in the 2012–2014 data as well.

We fit a single-variable Cox regression model to describe the observed relationship between 1-year recurrent AMI and a CCS-specific condition-related subsequent hospitalization, without accounting for patient baseline risk of recurrence. The time a hospitalization occurred was used as a time-varying variable in the analysis. We repeated this analysis for each of the potential subsequent hospitalizations. To further assess the association between rehospitalizations and 1-year recurrent AMI, we fit the Cox regression model with Markov Chain Monte Carlo simulations that modeled recurrent AMI as a function of all potential subsequent hospitalizations (event, yes/no, and time) as time-varying variables, adjusted for the patient baseline risk score for recurrent AMI. We retained a rehospitalization in the model if the posterior probability of its nonzero coefficient was >0.95. To further assess the change in risk of recurrent AMI between patients with and without at least 1 subsequent rehospitalization, we fit the Cox model with a binary time-varying indicator (1=had ≤1 subsequent CCS-specific condition-related rehospitalizations; 0=no rehospitalization), stratified by baseline risk group and further by age group. If a patient had >1 CCS-specific condition-related rehospitalization, the time that the first event occurred was used for the model.

Analyses were conducted using SAS version 9.4, 64-bit Windows (SAS Institute Inc., Cary, NC). As
### Table 1. Patient Baseline Characteristics by Study Sample

| Demographics, n (%) | Fiscal Year 2009–2011 | Fiscal Year 2012–2014 |
|---------------------|------------------------|-----------------------|
| Age, mean (SD)      | 78.3 (8.6)             | 78.2 (8.5)            |
| Female              | 218,034 (48.7)         | 207,463 (48.7)        |
| White               | 391,029 (87.3)         | 373,133 (87.5)        |
| Black               | 35,049 (7.8)           | 32,874 (7.7)          |
| Other               | 21,612 (4.8)           | 20,419 (4.8)          |

| Prior cardiovascular events, n (%) | Fiscal Year 2009–2011 | Fiscal Year 2012–2014 |
|-----------------------------------|------------------------|-----------------------|
| Heart failure                     | 57,891 (12.9)          | 53,063 (12.4)         |
| AMI                               | 18,926 (4.2)           | 16,607 (3.9)          |
| Unstable angina                   | 11,499 (2.6)           | 10,219 (2.4)          |
| Chronic atherosclerosis           | 326,924 (73.0)         | 310,783 (72.9)        |
| Cardiopulmonary respiratory failure or shock | 20,232 (4.5) | 18,717 (4.4) |
| Anterior MI (ICD-9 410.00–410.19) | 40,964 (9.2)           | 39,685 (9.3)          |
| Inferior/lateral/posterior MI (ICD-9 410.20–410.69) | 60,444 (13.5) | 58,558 (13.7) |

| Comorbidities, n (%) | Fiscal Year 2009–2011 | Fiscal Year 2012–2014 |
|---------------------|------------------------|-----------------------|
| Hypertension        | 299,244 (66.8)         | 284,380 (66.7)        |
| Stroke              | 17,964 (1.8)           | 16,798 (1.8)          |
| Renal failure       | 52,288 (11.7)          | 47,971 (11.2)         |
| COPD                | 88,711 (19.8)          | 83,582 (19.6)         |
| Pneumonia           | 64,817 (14.5)          | 61,108 (14.3)         |
| Protein-calorie malnutrition | 21,010 (4.7) | 20,090 (4.7) |
| Dementia            | 48,997 (10.9)          | 46,521 (10.9)         |
| Functional disability | 10,927 (2.4)          | 10,162 (2.4)          |
| Peripheral vascular disease | 27,609 (6.2) | 25,358 (5.9) |
| Metastatic cancer   | 29,141 (6.5)           | 27,664 (6.5)          |
| Major trauma in past year | 26,039 (5.8) | 24,762 (5.8) |
| Major psychiatric disorder | 9,417 (2.1) | 8,867 (2.1) |
| Chronic liver disease | 3,009 (0.7)           | 2,835 (0.7)           |
| Depression          | 25,098 (5.6)           | 23,821 (5.6)          |
| Diabetes mellitus   | 139,047 (31.1)         | 130,064 (30.5)        |
| Parkinson or Huntington disease | 6,186 (1.4) | 5,845 (1.4) |
| Anemia              | 11,079 (2.4)           | 10,498 (2.4)          |
| Asthma              | 10,699 (2.4)           | 10,178 (2.4)          |

| In-hospital procedures, n (%) | Fiscal Year 2009–2011 | Fiscal Year 2012–2014 |
|-----------------------------|------------------------|-----------------------|
| Percutaneous coronary intervention | 181,125 (40.5) | 174,586 (40.9) |
| Coronary artery bypass grafting | 41,365 (9.2) | 40,676 (9.5) |
| Cardiac catheterization     | 260,515 (58.2)         | 250,689 (58.6)        |

| Discharge disposition, n (%) | Fiscal Year 2009–2011 | Fiscal Year 2012–2014 |
|-----------------------------|------------------------|-----------------------|
| Home                        | 253,528 (56.6)         | 241,745 (56.7)        |
| Home with care              | 69,802 (15.6)          | 65,712 (15.4)         |
| Skilled nursing facility or intermediate care facility | 84,997 (19.0) | 80,767 (18.9) |

(Continued)
of 2019, the data were 5 years old. Analyses were repeated using the 2012–2014 data. Deaths before recurrent AMI were addressed using the Fine and Gray20 method for competing risks. The Lee, Wei, and Amato method 21 of robust sandwich variance matrix estimation was used to adjust for within-hospital clustering of patients. All statistical testing was 2-sided, and \( P < 0.05 \) was considered statistically significant. The study followed the guidelines for cohort studies described in the Strengthening the Reporting of Observational Studies in Epidemiology Statement: Guidelines for Reporting Observational Studies. 22 The Yale University Institutional Review Board reviewed the study protocol and granted a waiver of informed consent for the use of the deidentified database.

### RESULTS

#### Study Sample and Patient Baseline Characteristics

The study included 884,931 (447,690 in 2009–2011 and 437,241 in 2012–2014) unique patients who were discharged alive after AMI, were not transferred to another acute-care hospital, and were hospitalized for >1 day during their index admission. Overall, patients had a mean age of 78.0 (SD, 8.6) years, and 47.7% were female. The most common comorbidities were chronic atherosclerosis (73.3%), hypertension (67.9%), diabetes mellitus (32.1%), and anemia (25.2%). During the index AMI hospitalization, 42.2% of patients had a percutaneous coronary intervention, 9.1% underwent coronary artery bypass grafting, and 58.2% had cardiac catheterization. The median length of stay was 4 (interquartile range [IQR], 2–7) days, and 57.5% of patients were discharged to home. Patient characteristics were no different between the 2009–2011 and 2012–2014 samples (Table 1).

| Outcome | Fiscal Year 2009–2011 | Fiscal Year 2012–2014 |
|---------|-----------------------|-----------------------|
|         | Without Recurrent AMI | Without Recurrent AMI |
|         | (n=426,426)           | (n=419,120)           |
|         | With Recurrent AMI    | With Recurrent AMI    |
|         | (n=21,264)            | (n=18,121)            |
|         | Aggregated            | Aggregated            |
|         | (n=447,690)           | (n=437,241)           |
| **Outcome** | **Fiscal Year 2009–2011** | **Fiscal Year 2012–2014** |
| **Length of stay, mean (SD) days** | 6 (5.4) | 6 (5.5) | 5 (4.6) | 5 (5.1) | 5 (5.1) | 5 (4.2) |
| **Medicare payment, median (IQR), $1000** | 10.8 (8.3–16.1) | 10.8 (8.4–16.2) | 10.3 (7.1–14.2) | 11.1 (8.5–16.7) | 11.1 (8.5–16.8) | 10.4 (7.1–14.8) |
| **30-day mortality after discharge, n (%)** | 23,061 (5.2) | 22,487 (5.3) | 574 (2.7) | 21,743 (5.0) | 21,240 (5.1) | 503 (2.8) |
| **1-year mortality after discharge, n (%)** | 86,692 (19.4) | 81,729 (19.2) | 4963 (23.3) | 76,542 (17.5) | 72,639 (17.3) | 3903 (21.5) |
| **30-day all-cause readmission after discharge, n (%)** | 85,234 (19.0) | 76,967 (18.1) | 8270 (38.9) | 72,910 (16.7) | 65,913 (15.7) | 6997 (38.6) |

AMI indicates acute myocardial infarction; COPD, chronic obstructive pulmonary disease; ICD-9, International Classification of Diseases, Ninth Revision; IQR, interquartile range; and MI, myocardial infarction.

### Outcome

For the 2009–2011 and 2012–2014 samples, the rates of 1-year recurrent AMI were 5.3% (95% CI, 5.27–5.41) and 4.6% (95% CI, 4.54–4.67), respectively (\( P < 0.001 \)). Among these patients who had a recurrent AMI, the median (IQR) days from discharge to a recurrent AMI was 115 (34–230) for the 2009–2011 sample and 106 (31–217) for the 2012–2014 sample. In the 2009–2011 and 2012–2014 samples, respectively, the median (IQR) survived days among patients who died within 1 year without a recurrent AMI were 56 (20–128) and 53 (19–121), and the median (IQR) survived days among patients who died with a recurrent AMI were 105 (49–188) and 97 (48–179).

All-cause mortality rates after the index AMI and before a recurrent AMI were 17.5% (95% CI, 17.4–17.6) and 15.7% (95% CI, 15.6–15.8) for the 2009–2011 and 2012–2014 samples, respectively. Compared with patients without a recurrent AMI, patients with a recurrent AMI had a higher 30-day postdischarge all-cause mortality rate (5.3% versus 2.7%; \( P < 0.001 \)), higher 30-day all-cause readmission rate (38.9% versus 18.1%; \( P < 0.001 \)), higher 1-year all-cause mortality rate (23.3% versus 19.2%; \( P < 0.001 \)), lower median Medicare payment ($10,300 versus $10,500), and shorter mean (SD) length of stay (5 [4.6] days versus 6 [5.5] days). These observed outcomes were similar in the 2009–2011 and 2012–2014 samples (Table 1).

### Association Between Patient Baseline Characteristics and Recurrent AMI

In the 2009–2011 sample, the 5 baseline characteristics most strongly associated with 1-year
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recurrent AMI were AMI before the index admission (hazard ratio [HR], 1.8 [95% CI, 1.76–1.93]), unstable angina (HR, 1.5 [95% CI, 1.41–1.59]), diabetes mellitus (HR, 1.4 [95% CI, 1.39–1.47]), chronic atherosclerosis (HR, 1.3 [95% CI, 1.26–1.35]), and renal failure (HR, 1.2 [95% CI, 1.14–1.23]; Figure 1). Patients with a standardized risk <-1.2 times the SD, between −1.2 and 1.2, and >1.2 were stratified into low-, average-, and high-risk groups, respectively (Figure 2). The mean (SD) estimated rates of 1-year recurrent AMI were 1.7% (0.47) for the low-risk group, 5.1% (2.03) for average risk, and 14.3% (5.31) for high risk. Within a risk group, the rate of recurrence increased with patient age (Figure 3, top panel). Results were similar for the 2012–2014 sample (Figure 3, bottom panel).

Figure 1. Patient baseline characteristics associated with recurrent AMI within 1 year after the initial AMI.
AMI indicates acute myocardial infarction; CABG, coronary artery bypass grafting; CATH, cardiac catheterization; COPD, chronic obstructive pulmonary disease; and PCI, percutaneous coronary intervention.

Subsequent Hospitalizations

Among 285 CCS-specific conditions, 19 occurred in at least 1% of patients and were included in the model for the 2009–2011 sample (Table 2). The median (IQR) tetrachoric correlations among parts of these conditions were low (0.11 [95% CI, 0.08–0.16] in 2009–2011 and 0.12 [95% CI, 0.09–0.18] in 2012–2014). The highest correlation occurred between chronic obstructive pulmonary disease and bronchiectasis (CCS-127) and respiratory failure/insufficiency/arrest (CCS-131), which was 0.40 in 2009–2011 and 0.41 in 2012–2014. Among 447 690 patients in the 2009–2011 sample, 36.0% (n=161 327) had at least 1 rehospitalization for 1 of these 19 CCS-specific conditions before a recurrent AMI within 1 year. The 5 most common rehospitalization events were congestive heart failure (CCS-108,
9.8%), coronary atherosclerosis and other heart disease (CCS-101, 6.6%), septicemia (CCS-2, 4.0%), cardiac dysrhythmias (CCS-106, 3.7%), and pneumonia (CCS-122, 3.4%). The 5 events that occurred soonest after discharge were complications of surgical procedures or medical care (CCS-238; median, 53 [IQR, 12–165] days), coronary atherosclerosis and other heart disease (CCS-101; median, 54 [IQR, 19–154]...
days), congestive heart failure (CCS-108; median, 62 [IQR, 18–161] days), respiratory failure/insufficiency/arrest (CCS-131; median, 88 [IQR, 28–198] days), and cardiac dysrhythmias (CCS-106; median, 90 [IQR, 25–204] days; Figure 4, top panel). The findings were similar for the 2012–2014 sample (Figure 4, bottom panel). In-hospital mortality for these CCS-specific hospitalizations ranged from 0.3% (nonspecific chest pain, CCS-102) to 21.9% (septicemia, CCS-2).

### Association Between Subsequent Hospitalizations and Recurrent AMI

Most of the 19 subsequent hospitalizations were associated with an increased recurrent AMI risk in the descriptive analysis without accounting for patient baseline risk of recurrent AMI (Table 3). The Cox model based on the 2009–2011 data identified 12 CCS-specific subsequent hospitalizations significantly associated to recurrent AMI risk (Figure 5). These hospitalizations were septicemia (CCS-2), diabetes mellitus with complications (CCS-50), deficiency and other anemia (CCS-59), hypertension with complications and secondary hypertension (CCS-99), coronary atherosclerosis and other heart disease (CCS-101), nonspecific chest pain (CCS-102), congestive heart failure (CCS-108), pneumonia (CCS-122), chronic obstructive pulmonary disease and bronchiectasis (CCS-127), gastrointestinal hemorrhage (CCS-153), acute and unspecified renal failure (CCS-157), and complication of device (implant or graft; CCS-237). All these rehospitalizations except septicemia (CCS-2) were associated with increased risk of recurrent AMI; septicemia (CCS-2) was associated with a lower risk of recurrent AMI (Figure 5). The HRs ranged from 1.6 (95% CI, 1.55–1.70, heart failure [CCS-108]) to 1.1 (95% CI, 1.04–1.25, pneumonia [CCS-122]); the HR for septicemia (CCS-2) was 0.6 (95% CI, 0.58–0.71; Figure 5).

Overall, 26.9% of patients in 2009–2011 and 22.5% of patients in 2012–2014 had at least 1 of the identified subsequent CCS-specific hospitalizations significantly associated with increased risk of recurrent AMI. For the low-, average-, and high-risk groups in the 2009–2011 sample, having at least 1 CCS-specific hospitalization was associated with an increase in the risk of recurrent AMI by 210% (95% CI, 77%–149%), 73% (95% CI 66%–79%), and 43% (95% CI 34%–52%), respectively. The younger age group (65–74 years) in the average-risk strata was most likely to have a recurrence with at least 1 CCS-specific hospitalization (Figure 6, left panel). The findings were similar for the 2012–2014 cohort (Figure 6, right panel).

### DISCUSSION

In this study, we demonstrated that hospitalizations after AMI were associated with the risk of a subsequent AMI. Although patient baseline characteristics...
were also associated with the risk of a recurrent AMI, we showed that patient risk of recurrence was influenced by hospitalizations that occurred after discharge. Among the 12 rehospitalization categories identified in this study, 11 were associated with increased risk of recurrent AMI, with the increase in risk ranging from 14% (pneumonia) to 62% (heart failure). We found that patients who survived a hospitalization for septicemia had a lower risk of a recurrent AMI.

There are several potential explanations for the associations between subsequent hospitalizations and increased patient risk of recurrent AMI. It is possible that the hospitalization is a marker for the presence and severity of comorbidities. Sick patients tend to have more comorbidities\textsuperscript{23} and are more likely to be rehospitalized after AMI.\textsuperscript{24} We adjusted for baseline comorbidities, but information about the severity does not reside within the administrative codes in our Medicare database. Additionally, the hospitalizations may be a marker for postdischarge quality of care. Postdischarge care factors, such as continuity of care, type of care, and care providers, could impact AMI patient outcomes.\textsuperscript{25–27} Studies have identified associations between poor postdischarge care and subsequent hospitalizations,\textsuperscript{28–30} including recurrent AMI. Many subsequent hospitalizations identified by our study, including those for diabetes mellitus, anemia, hypertension, coronary atherosclerosis, chest pain, heart failure, pneumonia, chronic obstructive pulmonary disease and bronchiectasis, respiratory failure, gastrointestinal hemorrhage, renal failure, and complications of an implant or graft, have been individually identified as potential risk markers for recurrent AMI or major cardiovascular events in previous studies.\textsuperscript{6,8,31} Another possible explanation for our findings is that the hospitalization itself increased the risk. The reason for the hospitalization may have been associated with inflammation, a known contributor to AMI risk, or to other factors associated with AMI, such as stress or depression. It is also possible that the hospitalization

Figure 4. Median (interquartile range [IQR]) days to subsequent rehospitalizations within 1 year after discharge for index AMI.

The median (IQR) days to recurrent AMI were 115 (34–230) in the 2009–2011 sample and 106 (31–217) in the 2012 to 2014 sample. AMI indicates acute myocardial infarction; CAD, coronary artery disease; CCS_101, Coronary atherosclerosis and other heart disease; CCS_102, Nonspecific chest pain; CCS_106, Cardiac dysrhythmias; CCS_108, Congestive heart failure; CCS_109, Acute cerebrovascular disease; CCS_122, Pneumonia; CCS_131, Respiratory failure; insufficiency; arrest; CCS_153, Gastrointestinal hemorrhage; CCS_157, Acute and unspecified renal failure; CCS_159, Urinary tract infections; CCS_2, Septicemia; CCS_226, Fracture of neck of femur; CCS_237, Complication of device; implant or graft; CCS_238, Complications of surgical procedures or medical care; CCS_50, Diabetes mellitus with complications; CCS_55, Fluid and electrolyte disorders; CCS_59, Deficiency and other anemia; CCS_99, Hypertension with complications and secondary hypertension; CCS, Clinical Classifications Software; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; HTN, hypertension; and UTI, urinary tract infection.
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led to the discontinuation of secondary preventive medications or the addition of medications to a patient’s regimen, which may have resulted in nonadherence to the regimen.

The negative association of septicemia with recurrent AMI may represent a survivorship bias because patients who survived sepsis may have been healthier than those who died with sepsis and were therefore

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Table 3. Observed Association Between a Targeted CCS-Specific Condition-Related Subsequent Hospitalization and 1-Year Recurrent AMI Based on a Single-Variable Cox Regression Model

| Rehospitalization                                      | FY 2009–2011 | FY 2012–2014 |
|--------------------------------------------------------|--------------|--------------|
|                                                        | HR (95% CI)  | HR (95% CI)  |
| Septicemia (CCS-2; except in labor)                    | 0.80 (0.72–0.89) | 0.87 (0.78–0.97) |
| Diabetes mellitus with complications (CCS-50)          | 2.10 (1.85–2.37) | 2.50 (2.18–2.86) |
| Fluid and electrolyte disorders (CCS-55)               | 1.49 (1.31–1.68) | 1.74 (1.51–2.01) |
| Deficiency and other anemia (CCS-59)                   | 1.87 (1.64–2.14) | 1.97 (1.68–2.31) |
| Hypertension with complications and secondary hypertension (CCS-99) | 2.35 (2.11–2.62) | 2.39 (2.13–2.69) |
| Coronary atherosclerosis and other heart disease (CCS-101) | 1.70 (1.61–1.80) | 1.94 (1.82–2.08) |
| Nonspecific chest pain (CCS-102)                      | 1.79 (1.63–1.97) | 1.89 (1.68–2.13) |
| Cardiac dysrhythmias (CCS-106)                        | 1.26 (1.16–1.37) | 1.25 (1.13–1.38) |
| Congestive heart failure (CCS-108; non-hypertensive)   | 2.12 (2.03–2.21) | 2.00 (1.90–2.11) |
| Acute cerebrovascular disease (CCS-109)                | 1.03 (0.90–1.18) | 1.00 (0.88–1.17) |
| Pneumonia (CCS-122; except that caused by tuberculosis or sexually transmitted disease) | 1.46 (1.33–1.59) | 1.57 (1.42–1.73) |
| Chronic obstructive pulmonary disease and bronchiectasis (CCS-127) | 1.93 (1.75–2.13) | 1.75 (1.55–1.97) |
| Respiratory failure; insufficiency; arrest (CCS-131; adult) | 1.54 (1.38–1.73) | 1.28 (1.11–1.47) |
| Gastrointestinal hemorrhage (CCS-153)                  | 1.42 (1.28–1.58) | 1.48 (1.32–1.67) |
| Acute and unspecified renal failure (CCS-157)          | 1.60 (1.45–1.76) | 1.47 (1.31–1.63) |
| Urinary tract infections (CCS-159)                     | 1.37 (1.22–1.54) | 1.35 (1.17–1.56) |
| Fracture of neck of femur (CCS-226; hip)              | 1.40 (1.18–1.66) | 1.26 (1.02–1.56) |
| Complication of device; implant or graft (CCS-237)     | 1.98 (1.80–2.17) | 2.13 (1.91–2.37) |
| Complications of surgical procedures or medical care (CCS-238) | 0.90 (0.79–1.04) | 1.03 (0.88–1.20) |

AMI indicates acute myocardial infarction; CCS, Clinical Classifications Software; FY, fiscal years; and HR, hazard ratio.

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Figure 5. Association between subsequent rehospitalizations and recurrent AMI after discharge for index AMI, accounting for baseline risk of recurrence.

AMI indicates acute myocardial infarction; CAD, coronary artery disease; CCS, Clinical Classifications Software; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; and HTN, hypertension.
less likely to have a recurrent AMI. Our data showed that approximately 22% of AMI survivors rehospitalized for sepsis died during the sepsis hospitalization.

Our study, based on real-world data, has several important characteristics. We focused on the first year after an initial AMI, a period that has the highest risk of recurrent AMI. Our findings provide real-world empirical evidence of the importance of accounting for postdischarge rehospitalizations to help ensure better long-term outcomes. We showed that patient risk stratification for recurrent AMI was a dynamic measure that could change immediately after discharge. The CCS categories allowed the grouping of similar medical conditions to provide hospitals and physicians a parsimonious, clinically meaningful, and practically useful composite measure of rehospitalizations. Such a composite measure could be used more easily than a traditional approach based on individual ICD diagnosis codes. The 12 subsequent hospitalizations identified in the study were based on the CCS categories, which represent all principal diagnosis codes for rehospitalizations. These CCS categories are easy to collect and readily available at the time of discharge for the rehospitalization.

A model that combines rehospitalizations with patient baseline characteristics would allow hospitals and physicians to reevaluate patient risk for recurrent AMI throughout the first year and may help patients understand that their risk of recurrence depends not only on their baseline characteristics but also the sequence of rehospitalizations that occur after their initial AMI. The ability to identify individuals with the highest risk of recurrent AMI after a rehospitalization may aid in the provision of targeted, intensive, and higher-quality longitudinal care after discharge. Additionally, insight regarding the long-term risk of subsequent hospitalizations associated with recurrent AMI is important from a patient perspective as educating patients regarding their long-term risk might provide an even stronger incentive to follow-up and adhere to medications. Our study also provides evidence that hospitals and primary care physicians caring for patients with a history of AMI should be aware that subsequent hospitalizations can change patient risk of recurrent AMI.

Our study has several limitations. We considered only the first recurrent AMI and acknowledge that patients may experience multiple recurrent events, in which a recurrent event model can be fit. The subsequent hospitalizations identified in our study were based on the CCS categories, which represent multiple principal discharge diagnosis codes, while an individual rehospitalization only represents a single principal diagnosis code that could be more clinically important. We accounted for only inpatient rehospitalizations and did not consider outpatient care, observation stays, or emergency department visits. We treated subsequent rehospitalizations independently and acknowledge that some hospitalizations may have been related. Nevertheless, we found that the median tetrachoric correlation among these rehospitalizations was not high, indicating these rehospitalizations were not strongly related to each other. We
did not address whether the association between a subsequent hospitalization and a recurrent AMI depended on the hospitalization-free duration from an index AMI discharge to a rehospitalization, which could be clinically important. We restricted the 2011–2015 data to the first 10 diagnosis codes to align with the 2009–2010 data, which only contained 10 diagnosis codes. Accordingly, we may have missed some comorbidity information carried by the additional codes. Our study was limited by the availability of data resources, and therefore it did not incorporate information on medication adherence, nursing home stays, and home health services, which were associated with rehospitalizations and recurrent AMI in prior work.\textsuperscript{32–34} Moreover, we used comorbidity information from administrative data. These data lack detailed clinical information on patient functional status, left ventricular function, non–ST-segment–elevation myocardial infarction, and ST-segment elevation myocardial infarction, which could be important for assessing risk of recurrence and reducing measurement error.

In conclusion, patient risk of recurrent AMI changed on the basis of the occurrence of subsequent hospitalizations. Improving post–acute care to prevent unplanned rehospitalizations, especially those for chronic diseases, and extending the current focus on all-cause 30-day rehospitalizations to condition-specific rehospitalizations beyond the 30-day period are important for the secondary prevention of AMI. Moreover, there should be strong efforts to ensure that patients who experience these events have optimal secondary prevention strategies.

ARTICLE INFORMATION
Received October 8, 2019; accepted January 31, 2020.

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Disclosures
Dr Krumholz was a recipient of a research grant, through Yale, from Medtronic and the US Food and Drug Administration to develop methods for postmarket surveillance of medical devices; is a recipient of research agreements with Medtronic and Johnson & Johnson (Janssen), through Yale, to develop methods of clinical trial data sharing; was a recipient of a research agreement, through Yale, from the Shenzhen Center for Health Information for work to advance intelligent disease prevention and health promotion; collaborates with the National Center for Cardiovascular Diseases in Beijing; chairs a Cardiac Scientific Advisory Board for UnitedHealth; is a participant/representativeative of the IBM Watson Development Board; is a member of the Advisory Board for Element Science and the Physician Advisory Board for Aetna; received payment from the Arnold & Porter Law Firm for work related to the Sanofi clopidogrel litigation and from the Ben C. Martin Law Firm for work related to the Cook inferior vena cava filter litigation; and is the founder of Hugo, a personal health information platform. Drs Krumholz and Normand work under contract to the Centers for Medicare & Medicaid Services to develop and maintain performance measures that are publicly reported. The remaining authors have no disclosures to report.

Supplementary Material
Table S1

REFERENCES
1. Brown TM, Deng L, Becker DJ, Bittner V, Levitan EB, Rosenson RS, Safford MM, Mintzer P. Trends in mortality and recurrent coronary heart disease events after an acute myocardial infarction among Medicare beneficiaries, 2001–2009. Am Heart J. 2015;170:249–255.
2. Buch P, Rasmussen S, Gislason GH, Rasmussen JN, Kober L, Gadsbøll N, Stender S, Madsen M, Torp-Pedersen C, Abildstrom SZ. Temporal decline in the prognostic impact of a recurrent acute myocardial infarction 1985 to 2002. Heart. 2007;93:210–215.
3. Chaudhry SI, Khan RF, Chen J, Dharmarajan K, Dodson JA, Masoudi FA, Wang Y, Krumholz HM. National trends in recurrent hospitalizations 1 year after acute myocardial infarction in Medicare beneficiarics: 1999–2010. J Am Heart Assoc. 2014;3:e001197. DOI: 10.1161/JAHA.114.001197.
4. Smolina K, Wright FL, Rayner M, Goldacre MJ. Long-term survival and recurrence after acute myocardial infarction in England, 2004 to 2010. Circ Cardiovasc Qual Outcomes. 2012;5:532–540.
5. Krumholz HM, Normand S-LT, Wang Y. Twenty-year trends in outcomes for older adults with acute myocardial infarction in the United States. JAMA Intern Med. 2019;2:e191938.
6. Gilpin E, Ricou F, Dittrich H, Nicod P, Henning H, Ross J. Factors associated with recurrent myocardial infarction within one year after acute myocardial infarction. Am Heart J. 1991;122:457–465.
7. McCormick D, Gurrwitz JH, Lessard D, Yarzebski J, Gore JM, Goldberg RJ. Use of aspirin, β-blockers, and lipid-lowering medications before recurrent acute myocardial infarction. Arch Intern Med. 1999;561.
8. Wang Y, Li J, Zheng X, Jiang Z, Hu S, Wadhera RK, Bai X, Lu J, Wang Q, Li Y, et al. Risk factors associated with major cardiovascular events 1 year after acute myocardial infarction. JAMA Netw Open. 2018;1:e181079.
9. Shang P, Liu GG, Zheng X, Ho PM, Hu S, Li J, Jiang Z, Li X, Bai X, Gao Y, et al. Association between medication adherence and 1-year major cardiovascular adverse events after acute myocardial infarction in China. J Am Heart Assoc. 2019;8:011793. DOI: 10.1161/JAHA.118.011793.
10. Shore S, Jones PG, Maddox TM, Bradley SM, Stolker JM, Arnold SV, Parashar S, Peterson P, Bhatt DL, Sperutz J, et al. Longitudinal persistence with secondary prevention therapies relative to patient risk after myocardial infarction. Heart. 2015;101:800–807.
11. Arnold SV, Smolderen KG, Buchanan DM, Li Y, Sperutz JA. Perceived stress in myocardial infarction: long-term mortality and health status outcomes. J Am Coll Cardiol. 2012;60:1756–1763.
12. Roe MT, Chen AY, Thomas L, Wang TY, Alexander KP, Hammill BG, Gliber WB, Ohman EM, Peterson ED. Predicting long-term mortality in older patients after non-ST-segment elevation myocardial infarction: the CRUSADE long-term mortality model and risk score. Am Heart J. 2011;162:875–883.e1.
13. Ketchum ES, Dickstein K, Kjekshus J, Pitt B, Wong MF, Linker DT, Levy WC. The Seattle Post Myocardial Infarction Model (SPMI): prediction of mortality after acute myocardial infarction with left ventricular dysfunction. Eur Heart J Acute Cardiovasc Care. 2014;3:46–55.
14. Plakhv Y, Shiyovich A, Gluzt H. Predictors of long-term (10-year) mortality postmyocardial infarction: age-related differences. Soroka Acute Myocardial Infarction (SAM1) Project. J Cardiol. 2015;65:216–223.
15. Smolderen KG, Buchanan DM, Gosch K, Whooley M, Chan PS, Vaccarino V, Parashar S, Shah AJ, Ho PM, Sperutz JA. Depression treatment and 1-year mortality after acute myocardial infarction: insights from the TRUMPH Registry (Translational Research Investigating Underlying Disparities in Acute Myocardial Infarction Patients’ Health Status). Circulation. 2017;135:1681–1689.
16. Tu JV, Austin PC, Walld R, Roos L, Agran J, McDonald KM. Development and validation of the Ontario acute myocardial infarction mortality prediction rules. J Am Coll Cardiol. 2001;37:992–997.
17. Krumholz HM, Wang Y, Mattera JA, Wang Y, Han LF, Ingber MJ, Roman S, Normand S-LT. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with an acute myocardial infarction. *Circulation*. 2006;113:1683–1692.

18. Centers for Medicare & Medicaid Services. 5010 implementation—Processing additional International Classification of Diseases, 9th Revision—Clinical Modification (ICD-9-CM) diagnosis and procedure codes in Pricer, Grouper, and the Medicare Code Editor (MCE), Pub 100-04. 2010. Available at: https://www.cms.gov/Regulations-and-Guidance/Transmittals/2010-Transmittals-Items/CMS1237956.html. Accessed January 16, 2020.

19. Elixhauser A, Steiner C, Palmer L. Clinical Classifications Software (CCS), 2015. U.S. Agency for Healthcare Research and Quality. Available at: https://www.hcup-us.ahrq.gov/toolssoftware/ccs/CCSUsersGuide.pdf. Accessed January 16, 2020.

20. Fine JP, Gray RJ. A proportional hazards model for the subdistribution of a competing risk. *J Am Stat Assoc*. 1999;94:496–509.

21. Lee EW, Wei LJ, Amato DA, Leurgans S. Cox-type regression analysis for large numbers of small groups of correlated failure time observations. In: Klein JP, Goel PK, eds. Survival Analysis: State of the Art. Dordrecht: Kluwer Academic; 1992:237–247.

22. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *PLoS Med*. 2007;4:e296.

23. Di Bartolomeo S, Marino M, Guastaroba P, Valenf, De Palma R. Self-controlled case-series study to verify the effect of adherence to beta-blockers in secondary prevention of myocardial infarction. *J Am Heart Assoc*. 2015;4:e001575. DOI: 10.1161/JAHA.114.001575.

24. Wang Y, Pandolfi MM, Fine J, Metesersky ML, Wang C, Ho S-Y, Galusha D, Nuti SV, Murugiah K, Spenard A, et al. Community-level association between home health and nursing home performance on quality and hospital 30-day readmissions for Medicare patients. *Home Health Care Manag Pract*. 2016;28:201–205.
SUPPLEMENTAL MATERIAL
### Table S1. Clinical Classifications Software categories.

| CCS ID | Disease category |
|--------|------------------|
| 1      | Tuberculosis     |
| 2      | Septicemia (except in labor) |
| 3      | Bacterial infection; unspecified site |
| 4      | Mycoses          |
| 5      | HIV infection    |
| 6      | Hepatitis        |
| 7      | Viral infection  |
| 8      | Other infections; including parasitic |
| 9      | Sexually transmitted infections (not HIV or hepatitis) |
| 10     | Immunizations and screening for infectious disease |
| 11     | Cancer of head and neck |
| 12     | Cancer of esophagus |
| 13     | Cancer of stomach |
| 14     | Cancer of colon |
| 15     | Cancer of rectum and anus |
| 16     | Cancer of liver and intrahepatic bile duct |
| 17     | Cancer of pancreas |
| 18     | Cancer of other GI organs; peritoneum |
| 19     | Cancer of bronchus; lung |
| 20     | Cancer; other respiratory and intrathoracic |
| 21     | Cancer of bone and connective tissue |
| 22     | Melanomas of skin |
| 23     | Other non-epithelial cancer of skin |
| 24     | Cancer of breast |
| 25     | Cancer of uterus |
| 26     | Cancer of cervix |
| 27     | Cancer of ovary |
| 28     | Cancer of other female genital organs |
| 29     | Cancer of prostate |
| 30     | Cancer of testis |
| 31     | Cancer of other male genital organs |
| 32     | Cancer of bladder |
| 33     | Cancer of kidney and renal pelvis |
| 34     | Cancer of other urinary organs |
| 35     | Cancer of brain and nervous system |
| 36     | Cancer of thyroid |
| 37     | Hodgkin’s disease |
| 38     | Non-Hodgkin’s lymphoma |
| 39     | Leukemias |
| 40     | Multiple myeloma |
| 41     | Cancer; other and unspecified primary |
| 42     | Secondary malignancies |
| 43     | Malignant neoplasm without specification of site |
|   | Description                                                                 |
|---|------------------------------------------------------------------------------|
| 44| Neoplasms of unspecified nature or uncertain behavior                         |
| 45| Maintenance chemotherapy; radiotherapy                                        |
| 46| Benign neoplasm of uterus                                                    |
| 47| Other and unspecified benign neoplasm                                         |
| 48| Thyroid disorders                                                            |
| 49| Diabetes mellitus without complication                                        |
| 50| Diabetes mellitus with complications                                          |
| 51| Other endocrine disorders                                                    |
| 52| Nutritional deficiencies                                                     |
| 53| Disorders of lipid metabolism                                                 |
| 54| Gout and other crystal arthropathies                                          |
| 55| Fluid and electrolyte disorders                                               |
| 56| Cystic fibrosis                                                              |
| 57| Immunity disorders                                                           |
| 58| Other nutritional; endocrine; and metabolic disorders                        |
| 59| Deficiency and other anemia                                                   |
| 60| Acute posthemorrhagic anemia                                                  |
| 61| Sickle cell anemia                                                           |
| 62| Coagulation and hemorrhagic disorders                                         |
| 63| Diseases of white blood cells                                                 |
| 64| Other hematologic conditions                                                  |
| 650| Adjustment disorders                                                         |
| 651| Anxiety disorders                                                            |
| 652| Attention-deficit, conduct, and disruptive behavior disorders                 |
| 653| Delirium, dementia, and amnestic and other cognitive disorders               |
| 654| Developmental disorders                                                      |
| 655| Disorders usually diagnosed in infancy, childhood, or adolescence             |
| 656| Impulse control disorders, NEC                                                |
| 657| Mood disorders                                                               |
| 658| Personality disorders                                                        |
| 659| Schizophrenia and other psychotic disorders                                  |
| 660| Alcohol-related disorders                                                    |
| 661| Substance-related disorders                                                  |
| 662| Suicide and intentional self-inflicted injury                                 |
| 663| Screening and history of mental health and substance abuse codes             |
| 670| Miscellaneous disorders                                                      |
| 76| Meningitis (except that caused by tuberculosis or sexually transmitted disease) |
| 77| Encephalitis (except that caused by tuberculosis or sexually transmitted disease) |
| 78| Other CNS infection and poliomyelitis                                        |
| 79| Parkinson’s disease                                                          |
| 80| Multiple sclerosis                                                           |
| 81| Other hereditary and degenerative nervous system conditions                  |
| 82| Paralysis                                                                    |
| 83| Epilepsy; convulsions                                                        |
| 84| Headache; including migraine                                                 |
| 85| Coma; stupor; and brain damage                                               |
| Page | Description |
|------|-------------|
| 86   | Cataract    |
| 87   | Retinal detachments; defects; vascular occlusion; and retinopathy |
| 88   | Glaucoma    |
| 89   | Blindness and vision defects  
  Inflammation; infection of eye (except that caused by tuberculosis or sexually transmitted disease) |
| 90   | Other eye disorders |
| 91   | Otitis media and related conditions |
| 92   | Conditions associated with dizziness or vertigo |
| 93   | Other ear and sense organ disorders |
| 94   | Other nervous system disorders |
| 95   | Heart valve disorders  
  Peri-; endo-; and myocarditis; cardiomyopathy (except that caused by tuberculosis or sexually transmitted disease) |
| 96   | Essential hypertension |
| 97   | Hypertension with complications and secondary hypertension |
| 98   | Acute myocardial infarction |
| 99   | Coronary atherosclerosis and other heart disease |
| 100  | Nonspecific chest pain |
| 101  | Pulmonary heart disease |
| 102  | Other and ill-defined heart disease |
| 103  | Conduction disorders |
| 104  | Cardiac dysrhythmias |
| 105  | Cardiac arrest and ventricular fibrillation |
| 106  | Congestive heart failure; nonhypertensive |
| 107  | Acute cerebrovascular disease |
| 108  | Occlusion or stenosis of precerebral arteries |
| 109  | Other and ill-defined cerebrovascular disease |
| 110  | Transient cerebral ischemia |
| 111  | Late effects of cerebrovascular disease |
| 112  | Peripheral and visceral atherosclerosis |
| 113  | Aortic; peripheral; and visceral artery aneurysms |
| 114  | Aortic and peripheral arterial embolism or thrombosis |
| 115  | Other circulatory disease |
| 116  | Phlebitis; thrombophlebitis and thromboembolism |
| 117  | Varicose veins of lower extremity |
| 118  | Hemorrhoids |
| 119  | Other diseases of veins and lymphatics |
| 120  | Pneumonia (except that caused by tuberculosis or sexually transmitted disease) |
| 121  | Influenza |
| 122  | Acute and chronic tonsillitis |
| 123  | Asthma |
| 124  | Acute bronchitis |
| 125  | Other upper respiratory infections |
| 126  | Chronic obstructive pulmonary disease and bronchiectasis |
| 127  | Aspiration pneumonitis; food/vomitus |
| Code | Diagnosis                                                                 |
|------|--------------------------------------------------------------------------|
| 130  | Pleurisy; pneumothorax; pulmonary collapse                               |
| 131  | Respiratory failure; insufficiency; arrest (adult)                       |
| 132  | Lung disease due to external agents                                      |
| 133  | Other lower respiratory disease                                          |
| 134  | Other upper respiratory disease                                          |
| 135  | Intestinal infection                                                     |
| 136  | Disorders of teeth and jaw                                               |
| 137  | Diseases of mouth; excluding dental                                      |
| 138  | Esophageal disorders                                                     |
| 139  | Gastroduodenal ulcer (except hemorrhage)                                |
| 140  | Gastritis and duodenitis                                                 |
| 141  | Other disorders of stomach and duodenum                                  |
| 142  | Appendicitis and other appendiceal conditions                           |
| 143  | Abdominal hernia                                                         |
| 144  | Regional enteritis and ulcerative colitis                               |
| 145  | Intestinal obstruction without hernia                                    |
| 146  | Diverticulosis and diverticulitis                                        |
| 147  | Anal and rectal conditions                                               |
| 148  | Peritonitis and intestinal abscess                                       |
| 149  | Biliary tract disease                                                    |
| 150  | Liver disease; alcohol-related                                           |
| 151  | Other liver diseases                                                     |
| 152  | Pancreatic disorders (not diabetes)                                      |
| 153  | Gastrointestinal hemorrhage                                              |
| 154  | Noninfectious gastroenteritis                                            |
| 155  | Other gastrointestinal disorders                                         |
| 156  | Nephritis; nephrosis; renal sclerosis                                    |
| 157  | Acute and unspecified renal failure                                      |
| 158  | Chronic kidney disease                                                  |
| 159  | Urinary tract infections                                                 |
| 160  | Calculus of urinary tract                                               |
| 161  | Other diseases of kidney and ureters                                     |
| 162  | Other diseases of bladder and urethra                                    |
| 163  | Genitourinary symptoms and ill-defined conditions                        |
| 164  | Hyperplasia of prostate                                                  |
| 165  | Inflammatory conditions of male genital organs                           |
| 166  | Other male genital disorders                                             |
| 167  | Nonmalignant breast conditions                                           |
| 168  | Inflammatory diseases of female pelvic organs                           |
| 169  | Endometriosis                                                            |
| 170  | Prolapse of female genital organs                                        |
| 171  | Menstrual disorders                                                      |
| 172  | Ovarian cyst                                                             |
| 173  | Menopausal disorders                                                     |
| 174  | Female infertility                                                       |
| 175  | Other female genital disorders                                           |
Contraceptive and procreative management

Spontaneous abortion

Induced abortion

Postabortion complications

Ectopic pregnancy

Other complications of pregnancy

Hemorrhage during pregnancy; abruptio placenta; placenta previa

Hypertension complicating pregnancy; childbirth and the puerperium

Early or threatened labor

Prolonged pregnancy
  Diabetes or abnormal glucose tolerance complicating pregnancy; childbirth; or the
  puerperium

Malposition; malpresentation

Fetopelvic disproportion; obstruction

Previous C-section

Fetal distress and abnormal forces of labor

Polyhydramnios and other problems of amniotic cavity

Umbilical cord complication

OB-related trauma to perineum and vulva

Forceps delivery

Other complications of birth; puerperium affecting management of mother

Normal pregnancy and/or delivery

Skin and subcutaneous tissue infections

Other inflammatory condition of skin

Chronic ulcer of skin

Other skin disorders
  Infective arthritis and osteomyelitis (except that caused by tuberculosis or sexually
  transmitted disease)

Rheumatoid arthritis and related disease

Osteoarthritis

Other non-traumatic joint disorders

Spondylosis; intervertebral disc disorders; other back problems

Osteoporosis

Pathological fracture

Acquired foot deformities

Other acquired deformities

Systemic lupus erythematosus and connective tissue disorders

Other connective tissue disease

Other bone disease and musculoskeletal deformities

Cardiac and circulatory congenital anomalies

Digestive congenital anomalies

Genitourinary congenital anomalies

Nervous system congenital anomalies

Other congenital anomalies

Liveborn

Short gestation; low birth weight; and fetal growth retardation
Intrauterine hypoxia and birth asphyxia
Respiratory distress syndrome
Hemolytic jaundice and perinatal jaundice
Birth trauma
Other perinatal conditions
Joint disorders and dislocations; trauma-related
Fracture of neck of femur (hip)
Spinal cord injury
Skull and face fractures
Fracture of upper limb
Fracture of lower limb
Other fractures
Sprains and strains
Intracranial injury
Crushing injury or internal injury
Open wounds of head; neck; and trunk
Open wounds of extremities
Complication of device; implant or graft
Complications of surgical procedures or medical care
Superficial injury; contusion
Burns
Poisoning by psychotropic agents
Poisoning by other medications and drugs
Poisoning by nonmedicinal substances
Other injuries and conditions due to external causes
Syncope
Fever of unknown origin
Lymphadenitis
Gangrene
Shock
Nausea and vomiting
Abdominal pain
Malaise and fatigue
Allergic reactions
Rehabilitation care; fitting of prostheses; and adjustment of devices
Administrative/social admission
Medical examination/evaluation
Other aftercare
Other screening for suspected conditions (not mental disorders or infectious disease)
Residual codes; unclassified
E Codes: All (external causes of injury and poisoning)
E Codes: Cut/pierceb
E Codes: Drowning/submersion
E Codes: Fall
E Codes: Fire/burn
E Codes: Firearm
| Code | Category                          |
|------|----------------------------------|
| 2606 | E Codes: Machinery               |
| 2607 | E Codes: Motor vehicle traffic (MVT) |
| 2608 | E Codes: Pedal cyclist; not MVT  |
| 2609 | E Codes: Pedestrian; not MVT     |
| 2610 | E Codes: Transport; not MVT      |
| 2611 | E Codes: Natural/environment     |
| 2612 | E Codes: Overexertion            |
| 2613 | E Codes: Poisoning               |
| 2614 | E Codes: Struck by; against      |
| 2615 | E Codes: Suffocation             |
| 2616 | E Codes: Adverse effects of medical care |
| 2617 | E Codes: Adverse effects of medical drugs |
| 2618 | E Codes: Other specified and classifiable |
| 2619 | E Codes: Other specified; NEC    |
| 2620 | E Codes: Unspecified             |
| 2621 | E Codes: Place of occurrence     |