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Original Research

Short-term Deaths After Percutaneous Coronary Intervention Discharge: Prevalence, Risk Factors, and Hospital Risk-Adjusted Mortality

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ABSTRACT

Background: Little is known about patients who die shortly after discharge following any procedures, including percutaneous coronary intervention (PCI). Our aim was to explore the implications of using 30-day deaths after discharge as part of a quality measure for PCI.

Methods: New York State's PCI registry was used to find PCI deaths that occurred after discharge within 30 days of the procedure from January 1, 2015, to November 30, 2017. Patient risk factors and hospital risk-adjusted 30-day mortality before and after discharge were also investigated.

Results: A total of 2121 (1.55%) patients who underwent PCI died within 30 days of the index procedure, and 730 (34.4%) deaths occurred after discharge, with 30% of deaths after discharge (10% of all deaths) occurring during readmission. Among nonemergency patients, 56% of 30-day deaths occurred after discharge. No risk-adjusted 30-day in-hospital and after-discharge hospital mortality outliers were in common. Only 4 of 10 low outliers and 6 of 10 high outliers for 30-day in-hospital mortality and 30-day total (in-hospital plus after-discharge) mortality were in common.

Conclusions: A large percentage of early deaths after PCI occur after discharge, particularly among lower-risk patients. Future efforts should be focused on monitoring these patients. Hospital risk-adjusted mortality assessments are impacted substantially by inclusion of after-discharge deaths, and decisions about their inclusion will affect quality assessment and public reporting initiatives. The pros and cons of including them should be examined carefully.

Introduction

As an alternative to coronary artery bypass graft (CABG) surgery for patients with severe coronary artery disease requiring revascularization, percutaneous coronary interventions (PCIs) have proven to be very safe and associated with low short-term mortality and complications. Nevertheless, in-hospital mortality is between 1% and 2%[1,2] for all patients who undergo PCI and is roughly 3% for patients who have experienced an acute myocardial infarction (AMI) within 24 hours of admission.[2]

Although most early deaths after PCI occur in the hospital in the same admission as the PCI, there is another group of patients who are discharged alive but die within a short period of time (30 days is usually the period that is reported) after the index procedure. This group has been demonstrated to comprise 30% to 40% of all short-term deaths for a variety of cardiac procedures, including CABG surgery, transcatheter aortic valve replacement, and PCI.[3–5] Consequently, it is important to understand which patients are at the highest risk of death after discharge and to take action to reduce the number of these deaths. In addition, although short-term mortality is only one of many components of institutional quality of care for patients who undergo PCI, it is an important one and should be defined in a manner that best measures what optimal care should be.

The purposes of this study were to examine the relative frequency of short-term PCI deaths occurring after discharge, the patient-level factors associated with them, and the impact those deaths have on assessments of hospital quality and public reporting of short-term deaths.

Methods

Databases

The primary data source was New York State's Percutaneous Coronary Interventions Reporting System, a mandatory PCI registry in New

Abbreviations: AMI, acute myocardial infarction; CABG, coronary artery bypass graft; MI, myocardial infarction; PCI, percutaneous coronary intervention.

Keywords: 30-day mortality; mortality after discharge; percutaneous coronary intervention.

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York that has been used since 1992 to report hospital and cardiologist-level outcomes to hospitals and the public.[2] The registry contains detailed information about each patient undergoing PCI in the state, including demographics; preprocedural risk factors; periprocedural complications; types of devices used; extent of disease and lesions treated; dates of admission, discharge, and procedure; discharge disposition and destination; and hospital and operator identifiers. These data are matched to New York State's administrative data system (Statewide Planning and Research Cooperative System) for purposes of auditing completeness and the accuracy of in-hospital mortality reporting and for obtaining detailed health insurance and patient residence information. The Percutaneous Coronary Interventions Reporting System data was also matched to New York's Vital Statistics data file and the National Death Index to obtain deaths occurring after discharge within 30 days of the index procedure for New York State patients and out-of-state patients, respectively.

Patients, hospitals, and outcomes

A total of 148,601 patients underwent PCI as inpatients and outpatients in nonfederal New York hospitals between January 1, 2015, and November 30, 2017. Patients were excluded from the study if they were not US residents (n = 346), underwent a second PCI within 30 days of the index procedure (n = 40), or could not be matched to the Statewide Planning and Research Cooperative System (n = 11,051). The remaining 137,164 patients were subjects of the study.

A total of 66 hospitals in New York State in which PCI was performed each year of the study period were included in the study. The main outcome studied was mortality after discharge but within 30 days of the index procedure. In some analyses, this outcome was contrasted with in-hospital mortality within 30 days of the index procedure and with mortality within 30 days of the procedure regardless of discharge status.

Statistical analysis

Patients who underwent PCI who died within 30 days of the index procedure were classified on the basis of whether they died in the index admission or after discharge from the hospital. Patients discharged to hospice who die within 30 days are regarded as inpatient deaths by the registry. Patients were subdivided on the basis of patient risk, with emergency and nonemergency patients subdivided into multiple categories on the basis of short-term risk of mortality. For all patients who died within 30 days of PCI, mortality rates were compared by in-hospital vs after-discharge mortality using χ^2 tests (.05 significance level). This was done separately for emergency and nonemergency patients.

Among patients discharged alive, those who died within 30 days after the index procedure were compared with survivors using χ^2 tests (.05 significance level) and standardized differences (10% significance level) with regard to numerous patient characteristics, postprocedural length of stay, in-hospital complications, and discharge destination. Patient characteristics included demographics, payer, severity of coronary artery disease, ventricular function, vessels diseased, and comorbidities.

Stepwise logistic regression models for 3 30-day mortality measures (in-hospital, after-discharge, and total 30-day mortality) were developed to identify which variables described above were significantly independently associated with each outcome. Probabilities of mortality for each patient were obtained from each model and were summed for each hospital to obtain the predicted number of deaths for the hospital. The ratio of observed to predicted deaths was obtained for each hospital and then multiplied by the statewide mortality for the measure of interest to obtain a risk-adjusted mortality rate for that hospital for the measure. Confidence intervals were obtained for each risk-adjusted rate to identify hospitals with significantly higher or lower mortality than the statewide rate (high outliers and low outliers).[2]

Hospital outlier status was compared for each of the 3 measures, and hospital-level risk-adjusted mortality correlations were obtained for pairs of the 3 measures. Although they were used in analyses identifying the factors significantly associated with 30-day after-discharge mortality, length of stay, in-hospital complications, and discharge status were not included as candidates in these models because they were created to estimate hospital performance after controlling for patient risk, and those variables are potentially related to performance.

Results

A total of 2121 (1.55%) of 137,164 patients who underwent PCI in the study died within 30 days of the index procedure. Of those deaths, 730 (34.4% of all deaths) occurred after discharge (see Table 1). As indicated in Table 1, a higher percentage of all PCI deaths among low-risk patients tended to occur after discharge; however, the overall mortality rate for deaths after discharge was lower than that among high-risk patients. For example, although elective patients had the lowest mortality after discharge within 30 days of the index procedure (0.21%), 65 (56%) of 116 30-day deaths occurred after discharge. On the other hand, patients with shock and anoxic brain injury who underwent PCI experienced the highest (5.11%) short-term mortality after discharge; however, only 60 (11%) of 570 30-day deaths occurred after discharge.

Of the 730 deaths that occurred after discharge from the index admission, 219 (30%) occurred during readmission to a hospital. A total of 25,622 (18.7%) patients were classified as emergency patients (shock at the time of the procedure, anoxic brain injury, or AMI within 24 hours before the procedure). Of the 1248 emergency patients who died, 253 (20.3%) died after discharge. In a subset of emergency patients with AMI, 185 (29.2%) of 634 deaths occurred after discharge. Of 111,542 nonemergency patients, 477 (54.6%) of 873 deaths occurred after discharge (see Table 1). For the 730 patients who underwent PCI who died after discharge, 182 (24.9%) died within 1 week and 392 (53.7%) died within 2 weeks (data not shown in Table 1).

Table 2 presents 30-day mortality rates for patients discharged alive by discharge destination. As indicated, the overall 30-day mortality rate for patients discharged alive was 0.5%. Most (96.5%) discharges were to patients' homes, and this group of patients had the lowest (0.4%) 30-day mortality rate. Patients discharged/transferred to another acute care facility (0.7% of all live discharges) had the highest 30-day mortality rate (12.6%), followed by 1.5% of live discharges who were discharged to a nursing home, with a 3.2% mortality rate.

Among emergency patients discharged alive, the 30-day mortality rate was 1.0%. Discharges to acute care facilities and nursing homes were more common for emergency patients (2.3% and 2.4% of all emergency patient discharges, respectively) than for nonemergency patients, and those patients had the highest 30-day mortality rates (17.1% and 3.9%, respectively). For nonemergency patients, a higher percentage of live discharges were to patients' homes (97.3% vs 92.9% for emergency patients). Discharges to acute care facilities and nursing homes were less frequent (0.4% and 1.3%, respectively) for nonemergency patients than for emergency patients, and although 30-day mortality rates for those destinations (6.6% and 2.9%, respectively) were still higher than those for other discharge destinations, they were lower than their counterparts for emergency patients.

Table 3 compares frequencies of numerous patient characteristics for discharged patients who underwent PCI who did and did not die within 30 days after the index procedure. Risk factors that were significantly associated ($P < .05$; standardized difference, >10) with higher 30-day mortality after discharge were age of >75 years, female sex, Medicare and "other" insurance, body mass index of <25, left ventricular ejection fraction of <40%, ST-elevation myocardial infarction

Table 1. Short-term deaths during or after percutaneous coronary intervention by discharge status and type of admission: New York State, December 1, 2014, to November 30, 2017.

	In-hospital death within 30 d of the procedure n (%)	Death after discharge within 30 d of the procedure n (%)	Death within 30 d of the procedure n (%)
All patients (N = 137,164)	1391 (1.01)	730 (0.53)	2121 (1.55)[a]
Emergency patients (N = 25,622)	995 (3.88)	253 (0.99)	1248 (4.87)
Emergency patient subgroups			
Refractory shock and anoxic injury (N = 1175)	510 (43.40)	60 (5.11)	570 (48.51)
Nonrefractory shock (N = 597)	119 (19.93)	22 (3.69)	141 (23.62)
AMI without shock/anoxic injury (N = 23,850)	449 (1.85)	185 (0.76)	634 (2.61)
STEMI (N = 16,309)	302 (1.85)	134 (0.82)	436 (2.67)
NSTEMI (N = 7541)	64 (0.85)	37 (0.49)	101 (1.34)
Nonemergency patients (N = 111,542)	396 (0.36)	477 (0.43)	873 (0.78)
MI 1-7 d (N = 21,848)	188 (0.86)	221 (1.01)	409 (1.87)
UA without MI within 7 d (N = 58,381)	157 (0.27)	191 (0.33)	348 (0.60)
Elective (N = 31,313)	51 (0.16)	65 (0.21)	116 (0.37)

[a] There is a significant difference between time of death and where the death occurs (in hospital or after discharge).
AMI, acute myocardial infarction; MI, myocardial infarction; NSTEMI, non–ST-elevation myocardial infarction; STEMI, ST-elevation myocardial infarction; UA, unstable angina.

(MI) within 1 day, MI onset 1 to 7 days earlier, previous CABG surgery, anoxic injury, shock, left main disease, number of vessels diseased, in-hospital complications, longer length of stay, discharges to destinations other than home, and numerous comorbidities. Previous PCIs were associated with lower 30-day mortality after discharge.

Significant independent risk factors for 30-day mortality after discharge are presented in the logistic regression model results in Table 4. Many of the risk factors have been identified in earlier studies and reports on in-hospital mortality and in-hospital/30-day mortality for PCI (age, body mass index, ST-elevation MI, shock, 3-vessel disease, and comorbidities).[1,2] Other variables that were significantly associated with mortality after discharge were discharge destination and rural residence. Length of stay and in-hospital complications were not independently associated with 30-day mortality after discharge.

Supplemental Table S1 presents hospital risk-adjusted mortality outlier status based on logistic regression models for 3 separate 30-day mortality outcomes: in-hospital, after-discharge, and total 30-day mortality. As is demonstrated in Supplemental Table S1, there is considerable commonality among the models with regard to significant covariates. Death after discharge was not related to in-hospital mortality ($R^2 = -0.08$, $P = .54$) (see Table 5 and Central Illustration) (Central Illustration excludes 4 hospitals with 3-year volume of <100). Risk-adjusted postdischarge mortality was significantly lower than the statewide mortality for 3 hospitals and significantly higher for 5 hospitals. For in-hospital mortality, there were 7 low and 8 high outliers. None of the high or low outliers were in common for postdischarge and in-hospital mortality.

The correlation between risk-adjusted 30-day in-hospital mortality and risk-adjusted 30-day mortality before or after discharge was relatively low ($R^2 = 0.70$) given that the deaths in the former measure comprised two-thirds of the deaths in the latter measure. Of 10 unique hospitals identified by either model as a low outlier, only 4 were in common, and of 10 hospitals identified by either model as a high outlier, only 6 were in common (see Table 5).

Table 2. Discharge destination and mortality rate 30 days after index percutaneous coronary intervention: New York State, December 1, 2014, to November 30, 2017.

	Number of patients		Death after discharge within 30 d of the procedure	
	n	%	n	%
All patients discharged alive	135,677	–	730	0.5
Home	130,917	96.5	506	0.4
Acute care facility	1000	0.7	126	12.6
Nursing home	2031	1.5	64	3.2
Inpatient physical medicine and rehabilitation	1064	0.8	30	2.8
Others	665	0.5	4	0.6
Emergency patients discharged alive	24,569	–	253	1.0
Home	22,817	92.9	121	0.5
Acute care facility	574	2.3	98	17.1
Nursing home	590	2.4	23	3.9
Inpatient physical medicine and rehabilitation	341	1.4	9	2.6
Others	247	1.0	2	0.8
Nonemergency patients discharged alive	111,108	–	477	0.4
Home	108,100	97.3	385	0.4
Acute care facility	426	0.4	28	6.6
Nursing home	1441	1.3	41	2.9
Inpatient physical medicine and rehabilitation	723	0.7	21	2.8
Others	418	0.4	2	0.5

Discussion

Our study found that a total of 1.55% of patients who underwent PCI discharged in New York State died within 30 days of the index procedure, and 34% of those deaths occurred after discharge. Although the lowest-risk elective patients who underwent PCI experienced the lowest rate of 30-day deaths after discharge (0.21%), those deaths comprised 56% of all 30-day deaths among elective patients. A much smaller percentage (11%) of all 30-day deaths occurred after discharge among patients at highest risk of refractory shock and anoxic brain injury; however, because of that group's much higher risk, a total of 5.11% of those patients experienced 30-day deaths after discharge. Thus, 30-day deaths after discharge are important for low-risk patients because they comprise a high percentage of their 30-day deaths, and they are important for high-risk patients because they have a fairly high absolute mortality. It is also notable that among all patients who underwent PCI, 30% of the deaths after discharge occurred during readmission to a hospital.

With respect to risk factors associated with short-term mortality after discharge, 2 variables not typically found in earlier models of PCI short-term mortality are discharges/transfers to other than home (to an acute care facility, nursing home, or other destination) and rural residence. It is not surprising that discharges to places like another acute care facility or a nursing home are associated with higher mortality given that the need for more intensive care signals that a patient is in danger of complications or death. Nevertheless, it is valuable to confirm that these patients need to be carefully monitored at least for the short term after discharge. Rural residence is probably a marker for difficulty in obtaining medical care after discharge, and this is also an important finding.

Table 3. Patient characteristics for discharged patients undergoing PCI by death status 30 days after the procedure: New York State, December 1, 2014 to November 30, 2017.

	Patients discharged alive					
	Died within 30 d of the procedure (N = 730)		Alive 30 d after the procedure (N = 134,947)		Standardized difference (%)	*P* value[a]
	Number Died	%	Number Lived	%		
Total	730	0.53	134,947	99.47		
Age (y)						
<55	75	10.27	23,868	17.69	21.49	<.0001
55-64	154	21.10	38,891	28.82	17.91	<.0001
65-74	184	25.21	40,051	29.68	10.03	<.0001
75-84	214	29.32	25,104	18.60	25.29	<.0001
≥85	103	14.11	7033	5.21	30.45	<.0001
Female	258	35.34	39,583	29.33	12.87	.0004
Residence place						
Rural	69	9.45	9475	7.02	8.85	.01
Urban	611	83.70	117,626	87.16	9.83	.01
Missing	50	6.85	7846	5.81	4.25	.01
Payer						
Medicare only	134	18.36	19,083	14.14	11.44	<.0001
Medicare with other insurance	401	54.93	54,399	40.31	29.58	<.0001
Medicaid only	26	3.56	7181	5.32	8.55	<.0001
Private pay only	61	8.36	25,170	18.65	30.47	<.0001
Others	108	14.79	29,114	21.57	17.64	<.0001
Body mass index (kg/m^2)						
<18.5	25	3.42	1155	0.86	17.81	<.0001
18.5-24.9	241	33.01	27,767	20.58	28.35	<.0001
25.0-30.0	222	30.41	50,822	37.66	15.34	<.0001
20.1-34.9	152	20.82	33,709	24.98	9.90	<.0001
35.0-40.0	52	7.12	13,772	10.21	10.97	<.0001
>40.0	38	5.21	7722	5.72	2.27	<.0001
Ejection fraction (%)						
<20	54	7.40	1179	0.87	33.19	<.0001
20-29	104	14.25	5391	3.99	36.17	<.0001
30-39	146	20.00	10,698	7.93	35.35	<.0001
40-49	135	18.49	20,265	15.02	9.31	<.0001
≥50	291	39.86	97,414	72.19	68.85	<.0001
Previous MI						
No MI or MI for >20 d	225	30.82	87,360	64.74	72.16	<.0001
MI with ST elevation						
MI <6 h	137	18.77	13,281	9.84	25.69	<.0001
MI 6-11 h	32	4.38	2142	1.59	16.48	<.0001
MI 12-23 h	20	2.74	1121	0.83	14.45	<.0001
MI without ST elevation						
MI <6 h	9	1.23	1074	0.80%	4.36	<.0001
MI 6-11 h	10	1.37	2021	1.50%	1.07	<.0001
MI 12-23 h	23	3.15	4444	3.29	0.81	<.0001
MI 1-14 d	268	36.71	23,065	17.09	45.35	<.0001
MI 15-20 d	6	0.82	439	0.33	6.58	<.0001
Previous PCIs	269	36.85	59,210	43.88	14.36	.0001
Previous CABG surgery	144	19.73	20,494	15.19	11.98	.0007
Carotid/cerebrovascular disease						
None	607	83.15	121,474	90.02	20.24	<.0001
Cerebrovascular disease, TIA only	18	2.47	2842	2.11	2.41	<.0001
Cerebrovascular disease, not TIA only	105	14.38	10,631	7.88	20.79	<.0001
Peripheral vascular disease	120	16.44	12,253	9.08	22.18	<.0001
Anoxic injury	9	8.33	99	91.67	14.34	<.0001
Shock						
None	652	89.32	134,939	98.90	44.08	<.0001
Refractory shock	56	7.67	846	0.62	37.85	<.0001
Nonrefractory shock	22	3.01	649	0.48	20.91	<.0001
Congestive heart failure						
None	454	62.19	117,922	87.38	60.59	<.0001
At current admission	221	30.27	10,362	7.68	60.15	<.0001
Before current admission	55	7.53	6663	4.94	10.75	<.0001
Malignant ventricular arrhythmia	26	3.56	995	0.74	19.56	<.0001
Chronic lung disease						
None	629	86.16	126,491	93.73	25.36	<.0001
Mild	59	8.08	6370	4.72	13.76	<.0001
Moderate	21	2.88	1592	1.18	12.05	<.0001
Severe	21	2.88	494	0.37	19.97	<.0001
Diabetes with insulin therapy	174	23.84	20,762	15.39	21.40	<.0001
Stent thrombosis	8	1010	965	0.72	4.02	.22
Emergency PCI due to Dx cath. complication	0	0.00	33	0.02	2.21	.67
Organ transplant	6	0.82	853	0.63	2.23	.52
Contraindication to antiplatelet therapy	1	0.14	229	0.17	0.84	.83

(*continued on next page*)

Table 3. (*continued*)

	Patients discharged alive					
	Died within 30 d of the procedure (N = 730)		Alive 30 d after the procedure (N = 134,947)		Standardized difference (%)	*P* value[a]
	Number Died	%	Number Lived	%		
Renal failure						
Creatinine <1.5 mg/dL, no dialysis	538	73.70	121,712	90.19	43.88	<.0001
Creatinine 1.6-2.5 mg/dL, no dialysis	98	13.42	8048	5.96	25.41	<.0001
Creatinine >2.5 mg/dL, no dialysis	22	3.01	1292	0.96	14.77	<.0001
Dialysis	72	9.86	3895	2.89	28.84	<.0001
Left main disease	69	9.45	5815	4.31	20.41	<.0001
Number of vessels diseased						
Fewer than 2 vessels diseased	313	42.88	74,226	55.00	24.43	<.0001
2 vessels diseased	243	33.29	42,937	31.82	3.14	<.0001
3 vessels diseased	174	23.84	17,784	13.18	27.69	<.0001
Length of stay after the procedure (d)						
0-1	304	41.64	92,016	68.19	55.33	<.0001
2	108	14.79	18,368	13.61	3.39	<.0001
3	73	10.00	9547	7.07	10.48	<.0001
4	54	7.40	4660	3.45	17.47	<.0001
>4	191	26.16	10,356	7.67	50.86	<.0001
Number of in-hospital complications						
None	701	96.03	133,357	98.82%	17.70	<.0001
1	25	3.42	1325	0.98	16.69	<.0001
2 or more	4	0.55	265	0.20	5.77	<.0001
Discharge destination						
Home	506	69.32	130,411	96.64	77.99	<.0001
Acute care facility	126	17.26	874	0.65	60.77	<.0001
Nursing home	64	8.77	1967	1.46	33.63	<.0001
Inpatient physical medicine and rehabilitation	30	4.11	1034	0.77	21.79	<.0001
Others	4	0.55	661	0.49	0.81	<.0001

[a] Denotes, for each variable, significant difference in categories within the variable for deaths within 30 days of the procedure.
CABG, coronary artery bypass graft; cath, catheterization; Dx, diagnosis; MI, myocardial infarction; PCI, percutaneous coronary intervention; TIA, transient ischemic attack.

Very few earlier studies have investigated risk factors for short-term mortality after discharge for patients with cardiac conditions. Anwaruddin et al[3] found that 29% of patients who underwent transfemoral transaortic valve replacement in the Transcatheter Valve Therapy Registry who died within 30 days after the procedure experienced out-of-hospital deaths. Most out-of-hospital deaths were among patients with cardiovascular and pulmonary etiologies. In addition to age and sex, numerous comorbidities were associated with 30-day out-of-hospital death. Longer lengths of stay and in-hospital complications were also linked to higher mortality rates.[3]

In the only other study that compared short-term PCI deaths before and after discharge that we are aware of, Hannan et al[4] examined out-of-hospital deaths among patients who underwent PCI in New York

Table 4. Risk factors significantly associated with 30-day mortality after hospital discharge for patients undergoing percutaneous coronary intervention: New York State, December 1, 2014, to November 30, 2017.

Risk factor	Percentage (%)	Regression coefficient	OR (95% CI)	*P* value[a]
Age ≥75 y	23.92	0.4961	1.64 (1.38-1.96)	<.0001
Medicare insurance	54.55	0.3153	1.37 (1.13-1.66)	.001
Rural residence	7.03	0.3284	1.39 (1.08-1.79)	.01
Body mass index ≥25 kg/m^2	78.49	−0.4673	0.63 (0.54-0.73)	<.0001
Ejection fraction ≥50%	72.01	−0.7247	0.48 (0.41-0.57)	<.0001
ST-elevation MI within 24 hours	12.33	0.5956	1.81 (1.49-2.21)	<.0001
Peripheral vascular disease	9.12	0.2297	1.26 (1.02-1.55)	.03
Anoxic injury	0.08	0.8751	2.40 (1.13-5.08)	.02
Shock				
None	99.24	–	Reference	–
Refractory shock	0.40	1.4850	4.42 (3.17-6.15)	<.0001
Nonrefractory shock	0.36	0.8384	2.31 (1.45-3.70)	.0005
Congestive heart failure, current	7.80	0.6398	1.90 (1.58-2.28)	<.0001
Chronic lung disease				
None	93.69	–	Reference	–
Mild	4.74	0.3070	1.36 (1.03-1.79)	.03
Moderate	1.19	0.5044	1.66 (1.06-2.60)	.03
Severe	0.38	1.5288	4.61 (2.88-7.38)	<.0001
Diabetes with insulin therapy	15.43	0.3373	1.40 (1.16-1.69)	.0004
Creatinine ≥2.5 mg/dL or renal dialysis	3.89	0.6811	1.98 (1.56-2.51)	<.0001
3-vessel disease	13.24	0.2816	1.33 (1.11-1.59)	.002
Discharges to other than home	3.61	1.5757	4.83 (4.02-5.81)	<.0001

MI, myocardial infarction; OR, odds ratio.
[a] *P* value denotes significance of association between variable and 30-day mortality after discharge.

Table 5. Hospital risk-adjusted mortality according to time period and discharge status: New York State, December 1, 2014, to November 30, 2017.

Outlier status	Statistical model for death after discharge within 30 d of procedure	Statistical model for in-hospital death within 30 d of procedure	Statistical model for death within 30 d of procedure regardless of discharge status
Low outlier (significantly lower than expected mortality)	3	7	7
			4 outliers in both models
	No outliers in both models		
High outlier (significantly higher than expected mortality)	5	8	8
			6 outliers in both models
	No outliers in both models		

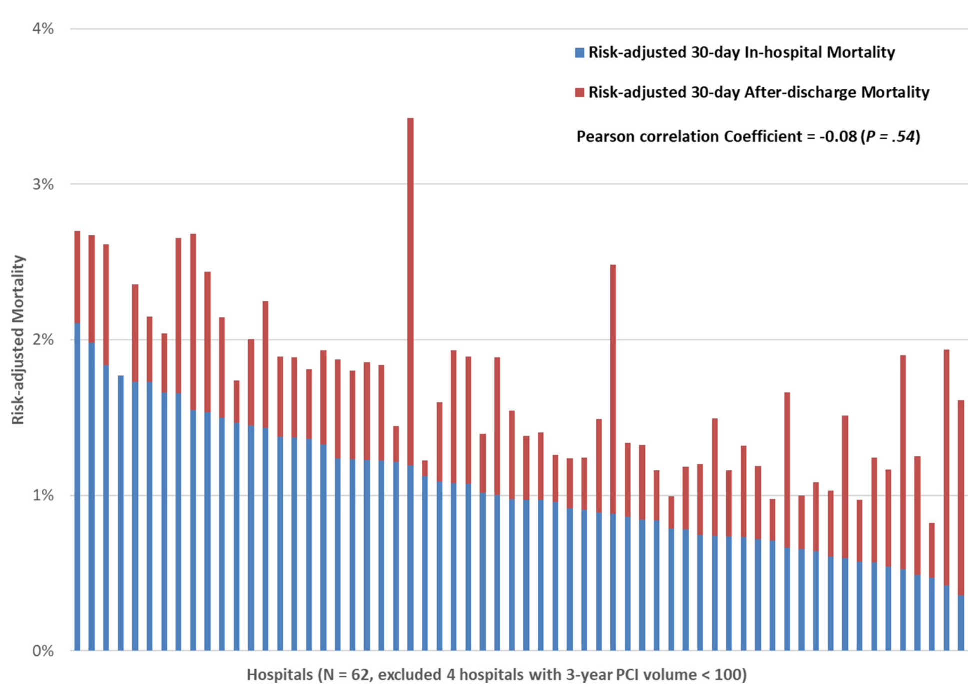
Pearson correlation between 30-day death after discharge and 30-day in-hospital death = −0.08 (P = .54). Pearson correlation between 30-day in-hospital death and 30-day in-hospital/after-discharge death = 0.70 (P < .0001).

in 2007. The findings were that 41% of all in-hospital and 30-day postdischarge deaths occurred after discharge. In addition, in comparison to in-hospital deaths, patients who died after discharge were younger, had better ventricular function, were less likely to have experienced recent MIs, and were less likely to have had in-hospital complications.[4]

Our study builds on the earlier New York study in a few ways in addition to using data that were published >10 years after the earlier study. First, after separating deaths after discharge into several risk levels, we found that the percentage of 30-day deaths that occurs after discharge rises with decreasing patient risk, with a maximum of 56% for elective patients. We also found that although the percentage is much lower for higher-risk patients, the absolute 30-day mortality after discharge can be quite high (<5% for patients with refractory shock or anoxic brain injury). Although most of the factors associated with death after discharge are similar to the ones that are associated with in-hospital deaths (and therefore do not shed much light on which patients to prioritize for monitoring), our findings emphasize that there is a need to carefully monitor discharged patients in general. Furthermore, we also found that 2 variables not contained in in-hospital mortality models (rural residence and discharge destination) are independently associated with 30-day deaths after discharge.

Most importantly, our study examined the correspondence between hospitals' risk-adjusted 30-day mortality for in-hospital deaths and deaths occurring after discharge, and the impact of adding 30-day deaths after discharge to in-hospital deaths on assessments of hospital performance. This was done because although short-term mortality is only one of several measures that have been used and proposed for assessing quality of care for patients who undergo PCI,[6] it is certainly an important one and the one that has been most frequently used.

We found that although there was not a statistically significant negative correlation between hospitals' risk-adjusted 30-day mortality before discharge and after discharge, there were no outliers in common, suggesting a poor correspondence between the 2 measures. More importantly, we compared the 2 most commonly used measures for assessing hospital quality, 30-day in-hospital mortality and 30-day total mortality, to determine whether hospital risk-adjusted mortality assessments are affected by including deaths that occur after discharge. The finding was that there is a relatively weak correlation between the 2 measures given that one is part of the other one (1391 of the 2021 total 30-day deaths are in-hospital deaths) and that the hospital outliers for the measures were not well aligned (only 4 of the 10 low outliers identified by either method were in common, and only 6 of the 10 high outliers identified by either method were in common).



Central Illustration.
Hospital risk-adjusted in-hospital and after-discharge mortality within 30 days of index percutaneous coronary intervention (PCI). Mortality was risk-adjusted using demographics, ventricular function, extent of cardiovascular disease, and comorbidities.

Thus, the choice of whether to include deaths after discharge has a very large effect on assessments of hospital quality in public reporting initiatives and on initiatives to confidentially inform hospitals of their risk-adjusted mortality rates for purposes of quality assurance and quality improvement. Consequently, the pros and cons should be carefully considered, and different professional and governmental organizations may arrive at different conclusions. The determination of whether to include deaths after discharge for quality assurance/quality improvement purposes in a particular database should include considerations regarding the ability to obtain deaths after discharge, the cause of death, the degree to which hospitals should be responsible for following up with patients after discharge, differences among hospitals in discharge patterns, how often complications of the procedure or complications related to suboptimal hospital management of comorbidities occur after discharge, and a host of other factors. These considerations are all important for a procedure like PCI, for which elective patients are frequently discharged within 24 hours of undergoing the procedure.[7] It should be noted that most databases that report short-term mortality for cardiac procedures use a mortality measure that includes deaths after discharge within 30 days of the procedure.[2,8–11] An exception is the National Cardiovascular Data Registry, which uses risk-adjusted in-hospital mortality for PCI benchmarking and quality improvement efforts.[1]

Limitations

A limitation of the study is that it does not compare cause of death between in-hospital deaths and deaths after discharge. Cause of death is not included in the study because we do not trust the accuracy of the results, particularly for deaths after discharge, where cardiac causes are likely attributed to deaths without an obvious cause. Nevertheless, it is undoubtedly true that a lower percentage of deaths that occurred after discharge were related to cardiac causes than deaths that occurred before discharge. This may be an important consideration when determining whether to include deaths after discharge in hospital quality assessments. Another limitation is that these results are specific to New York State, and they may not be representative of other states or regions.

Conclusions

A large percentage of 30-day deaths after PCI occur after discharge, particularly among nonemergency patients. The implications of these findings are extremely relevant as we continue to sharpen our focus on health equity and social determinants of health, and future efforts should be focused on monitoring discharged patients more intensively. Hospital risk-adjusted mortality assessments that are used for quality assurance/quality improvement initiatives and public reporting are impacted considerably by the inclusion of deaths that occur after discharge, and the pros and cons of including them should be examined carefully for PCI and other procedures.

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Declaration of competing interest

Alice K. Jacobs is a site principal investigator for Abbott Vascular. Edward L. Hannan, Ye Zhong, Jacqueline Tamis-Holland, Frederick S.K. Ling, Peter B. Berger, Ferdinand J. Venditti, and Spencer B. King and author Kimberly Cozzens reported no financial interests.

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Ethics statement and patient consent

Institutional review board approval and patient consent was not required because this was a retrospective study with encrypted identifiers.

Supplementary material

To access the supplementary material accompanying this article, visit the online version of the *Journal of the Society for Cardiovascular Angiography & Interventions* at 10.1016/j.jscai.2022.100559.

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