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Which Patients Require More Care after Hospital Discharge? An Analysis of Post-Acute Care Use among Elderly Patients Undergoing Elective Surgery

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BACKGROUND: The use of post-acute care is common among the elderly and accounts for $62 billion in annual Medicare expenditures. However, little is known about post-acute care use after surgery.

STUDY DESIGN: Data were merged between the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) and Medicare claims for 2005 to 2008. Post-acute care use, including skilled nursing facilities (SNF), inpatient rehabilitation facilities (IRF), and home health care (HHC) were analyzed for 3 operations: colectomy, pancreatectomy, and open abdominal aortic aneurysm repair. Controlling for both preoperative risk factors and the occurrence of postoperative complications, we used multinomial logistic regression to estimate the odds of use for each type of post-acute care after elective surgery compared with home discharge.

RESULTS: Post-acute care was used frequently for patients undergoing colectomy (40.0%; total n = 10,932), pancreatectomy (46.0%; total n = 2,144), and open abdominal aortic aneurysm (AAA) repair (44.9%; total n = 1,736). Home health was the most frequently reported post-acute care service for each operation (range 23.2% to 31.5%) followed by SNF (range 12.0% to 15.0%), and then by IRF (range 2.5% to 5.4%). The majority of patients with at least 1 inpatient complication were discharged to post-acute care (range 58.6% for open AAA repair to 64.4% for colectomy). In multivariable analysis, specific preoperative risk factors, including advanced age, poor functional status, and inpatient complications were significantly associated with increased risk-adjusted odds of discharge to post-acute care for each operation studied.

CONCLUSIONS: Among elderly patients, post-acute care use is frequent after surgery and is significantly associated with several preoperative risk factors and postoperative inpatient complications. Further work is needed to ensure that post-acute care services are used appropriately and cost-effectively. (J Am Coll Surg 2015;220:1113−1121. © 2015 by the American College of Surgeons)

Post-acute care services represent a range of health care services that aim to optimize patients' recovery after a hospital stay. Over the past 2 decades, while hospital length of stay has decreased, there has been a corresponding and substantial increase in the use of post-acute care (PAC), including skilled nursing facilities (SNF), inpatient rehabilitation facilities (IRF), and home health care (HHC).[1-3] Nearly half of hospitalized Medicare patients use PAC after discharge, accounting for more than $62 billion in 2012 expenditures.[4,5] As a result, the Centers for Medicare and Medicaid Services (CMS) is developing payment policies aimed at reducing costs and ensuring appropriate use of PAC.

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Abbreviations and Acronyms

AAA = abdominal aortic aneurysm
DVT = deep vein thrombosis
HHC = home health care
IRF = inpatient rehabilitation facility
PAC = post-acute care
SNF = skilled nursing facility
SSI = surgical site infection

Each form of PAC offers a unique set of services with varying levels of clinician availability and oversight. The IRFs deliver intensive physical and occupational therapy for at least 3 hours a day,[6] while SNFs offer less strenuous rehabilitation programs, but provide at least 8 hours of daily nursing care and have a nurse or physician available 24 hours a day.[7] Home health care provides in-home nursing care for patients under physician supervision.[8] Aside from these loosely defined criteria, no guidelines exist to help providers determine which patients would benefit most from each form of PAC.[4]

Little is known regarding current use of PAC services for surgical patients. The objective of this study was therefore to describe PAC use patterns using a dataset that links data from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) with Medicare data. We aimed to identify clinical factors associated with PAC use, including preoperative risk factors and postoperative complications. Our intent was to provide guidance for the eventual development of best practices and payment policies regarding use of PAC services for surgical patients.

METHODS

Data sources and study sample

For this study, we used a merged dataset: Medicare inpatient claims data linked to the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) for years 2005 to 2008. The details of this dataset, the linkage procedure, and the linkage validation have been described elsewhere.[9] In brief, patient records from the 100% Medicare provider analysis and review file (MedPAR) were linked to ACS-NSQIP records using indirect identifiers and a deterministic linkage algorithm. The ACS-NSQIP is an institution-based, multispecialty, clinical registry for patients undergoing surgery. Data collected include preoperative risk factors, type of operation performed, and details on more than a dozen postoperative complications, including mortality.

Using CPT codes (Appendix 1, online only), we identified patients undergoing colectomy, pancreatectomy, and open abdominal aortic aneurysm (AAA) repair. These procedures are frequently performed, represent a range of surgical specialties, and fit our a priori assumption of high PAC needs based on high complication rates. Patients who were admitted from a chronic care facility (transitional care unit, sub-acute hospital, skilled nursing home, or unskilled facility) before the operation were excluded because it was not possible to distinguish new use of PAC from a return to their facility of origin. Because we were interested in identifying risk factors for PAC use after elective surgery, we excluded patients who were American Society of Anesthesiologists (ASA) class 5, those who underwent emergent surgery, or those who were entirely functionally dependent (n = 2,714 for colectomy, n = 49 for pancreatectomy, n = 479 for open AAA repair). We also excluded patients with missing data for discharge destination (n = 479 for colectomy, n = 53 for pancreatectomy, n = 84 for open AAA repair).

Outcomes

Our primary outcome of interest was the postoperative discharge destination. This was identified from a hospital-reported variable in Medicare inpatient claims. Line item billing data were available from SNFs and IRFs; however, these data capture only PAC use for which Medicare was the primary payer for these services. Discharge destination was coded as a categorical variable: SNF, IRF, HHC, and discharge to home, the last of which was used as the reference category. To control for the effects of patient death before discharge and to further stabilize our standard errors, inpatient death was included in the categorical outcomes variable. However, because this outcome is not central to our investigation, the results for the mortality category are not presented in detail here.

Covariates

We conceptualized the use of PAC as determined by 2 patient level metrics—health status at the time of the operation and health status at the time of discharge, the latter accounting for deterioration in health during the postoperative hospital stay. Preoperative condition was characterized by the following variables, all obtained from ACS-NSQIP: age, sex, admission source (home, acute care facility, other), American Society of Anesthesiologists class, functional status (independent, partially dependent, fully dependent), number of comorbidities (0, 1, 2, $\geq$3), wound class (clean/clean-contaminated, contaminated, dirty), emergency case, and the indication for operation. In order to characterize changes in health during the hospitalization, we included the occurrence of inpatient complications as recorded by ACS-NSQIP: surgical site infection (superficial, deep/organ-space), wound dehiscence, pneumonia,

Table 1. Patient Characteristics and Postoperative Complications Occurring Before Discharge for Patients Undergoing Colectomy, Pancreatectomy and Open Abdominal Aortic Aneurysm Repair

Patient characteristics	Colectomy (n = 10,932)	Pancreatectomy (n = 2,144)	Abdominal aortic aneurysm, open, (n = 1,736)
Discharge destination, %			
Home	57.8	51.0	49.8
Skilled nursing facility	14.3	12.0	15.0
Inpatient rehabilitation	2.5	2.5	5.4
Home health care	23.2	31.5	24.5
Age, y, mean	76.1	74.0	74.8
Age category, %			
65−74 y	44.6	55.9	50.4
75−84 y	41.7	39.8	44.0
>84 y	13.8	4.3	5.7
Sex, %			
Female	56.1	51.4	28.3
Male	43.9	48.7	71.7
ASA category, %			
I and II	37.0	24.6	5.2
III	56.7	70.4	70.2
IV	6.3	4.9	24.6
Functional status, %			
Independent	92.6	96.7	96.3
Partially dependent	7.4	3.3	3.7
Number of comorbidities, %			
0	19.0	20.1	9.0
1	39.7	38.0	46.6
2	25.6	28.1	27.5
≥3	15.7	13.8	16.9
Wound class, %			
I and II	86.6	90.8	97.9
III	8.9	6.4	1.4
IV	4.5	2.8	0.6
Postoperative complications occurring before discharge, %			
Death	2.0	2.9	5.2
Superficial surgical site infection	3.9	6.5	1.9
Deep/organ space surgical site infection	2.2	7.1	1.9
Dehiscence	0.9	1.7	1.7
Pneumonia	3.1	4.5	17.6
Pulmonary embolism	0.7	0.8	1.2
Respiratory failure	3.9	5.7	28.1
Deep vein thrombosis	1.1	1.3	3.2
Renal failure	1.1	1.0	11.7
Urinary tract infection	3.0	5.0	5.9
Cardiac complication	1.0	1.6	7.4
Sepsis/septic shock	5.3	11.9	19.5
Any complication	15.4	25.7	23.4
Length of stay, d, median (IQR)	7 (5,10)	9 (7,14)	7 (6,10)

Data for discharge destination obtained from Medicare inpatient claims; all other data obtained from ACS NSQIP (2005 to 2008).
ASA, American Society of Anesthesiologists; IQR, interquartile range.

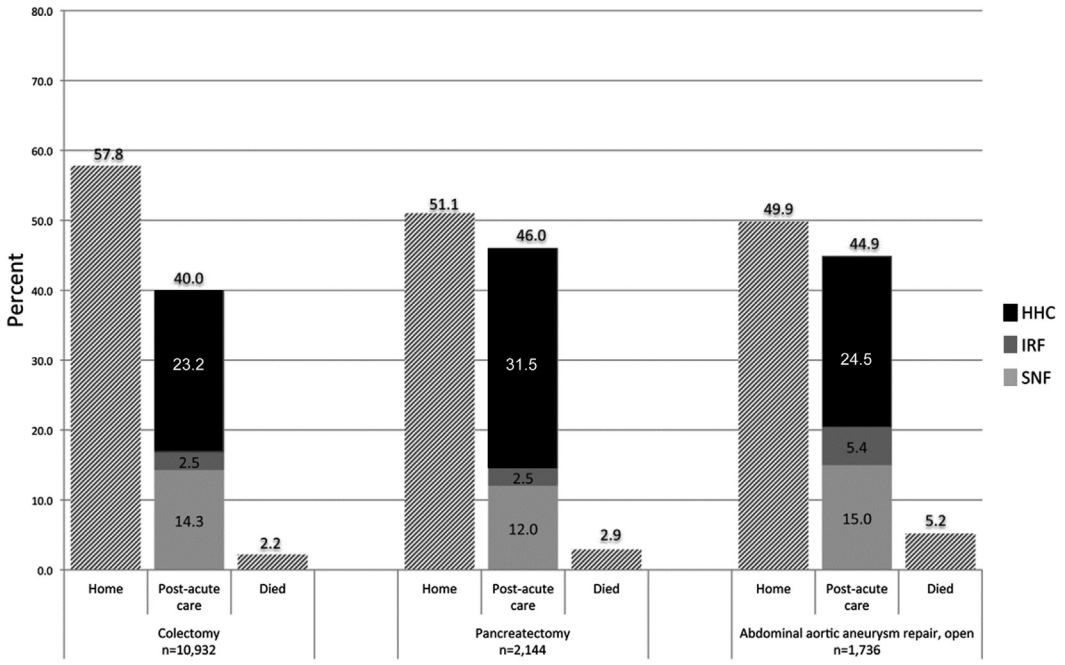

Figure 1. Discharge destination for patients undergoing colectomy, pancreatectomy, and open abdominal aortic aneurysm repair. Black bar, home health care; medium gray bar, inpatient rehabilitation facility; light gray bar, skilled nursing facility; striped bar, discharged to home or died before discharge. HHC, home health care; IRF, inpatient rehabilitation facility; PAC, post-acute care; SNF, skilled nursing facility. Died, died before discharge.

pulmonary embolism, respiratory failure (unplanned reintubation or failure to wean from ventilator for >48 hours), deep vein thrombosis (DVT), renal failure, urinary tract infection, cardiac complication (myocardial infarction or cardiac arrest), and sepsis. We did not report on the occurrence of reoperation because we were unable to determine whether the reoperation occurred during the index hospital stay. To explain the difference in complication rates between the studied operations, we also calculated length of stay data, which we report as the number of days from operation until discharge.

Statistical analysis

We calculated descriptive statistics (mean, median, or proportions) for all relevant patient characteristics for each type of operation. For each operation, we then compared the number of patients who were discharged to each possible discharge destination (outcomes variable) based on the occurrence of each type of postoperative complication. To determine the risk-adjusted estimates of the association of each of these complications with our outcome of interest, we built a multivariate multinomial logistic regression model for each operation type, using Huber-White (robust) standard errors to account for clustering by hospital. This multinomial model was used to estimate risk-adjusted odds ratios comparing each outcome category to the reference category of discharge to home. We adjusted for all preoperative risk factors and the indication for operation (consistent with those used by ACS-NSQIP), as well as the occurrence of each type of postoperative complication. For ease of exposition and consistent with our primary objectives, we report only on the effects of each type of postoperative complication, but include the results for all additional variables in Appendices 2 and 3 (online only).

Data preparation and analysis were performed using SAS (version 9.3, SAS Institute Inc) and Stata (version 13.1, StataCorp LP). The study was approved by the RAND Health institutional review board.

RESULTS

There were 10,932 patients who underwent colectomy, 2,144 who underwent pancreatectomy, and 1,736 who underwent open AAA repair in our sample (Table 1). The average patient age ranged from 74 years for pancreatectomy patients to 76.1 years for colectomy patients. For all operations, patients were most frequently American Society of Anesthesiologists category III, functionally independent, and with an average number of complications between 1.4 for pancreatectomy and 1.7 for both colectomy and open AAA repair. The most common complication was sepsis after colectomy (5.3%) and

Table 2. Discharge Disposition for Patients With and Without a Complication Occurring Before Hospital Discharge

Complication	Colectomy, (n = 10,932) n						Pancreatectomy, (n = 2,144) n						Abdominal aortic aneurysm, open, (n = 1,736) n					
		Discharge disposition, %						Discharge disposition, %						Discharge disposition, %				
	Total	Home	SNF	IRF	HHC	Died	Total	Home	SNF	IRF	HHC	Died	Total	Home	SNF	IRF	HHC	Died
Any complication	1,684	22.6	25.9	5.8	32.7	13.0	551	27.0	20.2	5.4	37.0	10.3	406	20.2	27.6	11.6	19.5	21.2
No complication	9,248	64.2	12.1	1.9	21.5	0.3	1,593	59.3	9.2	1.5	29.6	0.4	1,330	58.9	11.2	3.5	26.1	0.4
Superficial SSI	426	20.4	21.8	4.2	50.0	3.5	140	21.4	15.7	5.7	55.7	1.4	14	21.4	21.4	0.0	50.0	7.1
Deep/organ space SSI	238	10.9	27.7	8.0	40.8	12.6	152	25.7	24.3	6.6	36.2	7.2	14	28.6	28.6	7.1	7.1	28.6
Dehiscence	93	11.8	26.9	9.7	36.6	15.1	36	16.7	27.8	13.9	33.3	8.3	13	15.4	46.2	23.1	7.7	7.7
Pneumonia	343	19.5	28.6	9.9	22.5	19.5	96	19.8	19.8	9.4	21.9	29.2	133	15.8	35.3	11.3	17.3	20.3
Pulmonary embolism	71	19.7	31.0	8.5	32.4	8.5	18	22.2	16.7	5.6	38.9	16.7	9	22.2	22.2	0.0	44.4	11.1
Respiratory failure	429	10.5	27.5	9.1	18.2	34.7	123	10.6	27.6	8.1	14.6	39.0	213	13.6	29.1	14.1	13.6	29.6
Deep vein thrombosis	123	13.8	38.2	11.4	22.8	13.8	28	10.7	32.1	14.3	35.7	7.1	24	4.2	29.2	25.0	33.3	8.3
Renal failure	121	16.5	19.0	5.0	18.2	41.3	22	13.6	0.0	4.6	18.2	63.6	89	12.4	23.6	10.1	11.2	42.7
Urinary tract infection	329	29.2	31.0	4.0	30.7	5.2	107	31.8	18.7	4.7	42.1	2.8	45	17.8	31.1	26.7	17.8	6.7
Cardiac complication	106	13.2	13.2	2.8	7.6	63.2	34	8.8	5.9	0.0	14.7	70.6	56	8.9	10.7	5.4	7.1	67.9
Sepsis/septic shock	577	15.9	26.5	8.0	25.7	23.9	254	22.1	20.1	5.1	36.6	16.1	148	12.2	23.7	12.2	16.2	35.8

HHC, home health care; IRF, inpatient rehabilitation facility; SNF, skilled nursing facility; SSI, surgical site infection.

pancreatectomy (11.9%), and respiratory failure after open AAA repair (28.1%). The overall incidence of at least 1 inpatient postoperative complication was highest for pancreatectomy (25.7%) and lowest for colectomy (15.4%); 25.7% of pancreatectomy patients had at least 1 complication. The in-hospital mortality rates for colectomy, pancreatectomy, and open AAA repair were 2.0%, 2.9%, and 5.2%, respectively. Malignancy was the primary indication for surgery in both colectomy (56.1%) and pancreatectomy (68.1%; Appendix 1, online only). The median lengths of stay after surgery were 7, 9, and 7 days for colectomy, pancreatectomy, and open AAA repair, respectively.

Overall PAC use was common for patients undergoing these operations (colectomy 40.0%, pancreatectomy 46.0%, AAA repair 44.9%). The distribution of discharge destinations for each operation is displayed in Figure 1. Home health was the most commonly used PAC for each operation (colectomy, 23.2%; n = 2,536, pancreatectomy, 31.5%; n = 675, AAA repair, 24.5%; n = 425) followed by SNF (colectomy, 14.3%; n = 1,563, pancreatectomy, 12.0%; n = 257, AAA repair, 15.0%; n = 260). Fewer than 6% of patients were discharged to an IRF after these operations (colectomy, 2.5%; n = 273, pancreatectomy, 2.5%; n = 54, AAA repair, 5.6%; n = 94).

The majority of patients with at least 1 complication were discharged to PAC (colectomy, 64.4%; pancreatectomy, 62.6%; AAA repair, 58.6%). In contrast, the majority of patients without a complication were discharged home (Table 2). With few exceptions, each type of inpatient complication was associated with high use of PAC. Most notably, discharge to PAC occurred in more than 75% of patients with the following complications: colectomy patients with superficial or deep/organ space SSI; pancreatectomy patients with superficial SSI, dehiscence, or DVT; and open AAA repair patients with dehiscence, DVT, or urinary tract infection.

Analysis of discharge destination revealed that both colectomy and pancreatectomy patients who experienced inpatient complications were most frequently discharged to HHC; those undergoing open AAA repair who experienced inpatient complications were most frequently discharged to SNF. Patients with superficial SSI were most frequently discharged with HHC (colectomy, 50.0%; pancreatectomy, 55.7%; open AAA repair 50.0%).

For IRF, use varied by complication for each procedure type. For patients undergoing colectomy, IRF was most frequently used for patients with pneumonia or DVT; for patients undergoing pancreatectomy, IRF was most frequently used for patients with wound dehiscence or DVT; and for patients undergoing open AAA repair,

Table 3. Complications Occurring Before Discharge as Predictors of Post-Acute Care Use

	Colectomy, OR (95% CI)			Pancreatectomy, OR (95% CI)			Abdominal aortic aneurysm, open, OR (95% CI)		
Inpatient complications	**SNF**	**IRF**	**HHC**	**SNF**	**IRF**	**HHC**	**SNF**	**IRF**	**HHC**
Superficial surgical site infection	4.32 (3.05, 6.12)	3.82 (2.16, 6.75)	6.20 (4.71, 8.16)	2.48 (1.41, 4.36)	3.98 (1.99, 7.97)	3.67 (2.22, 6.05)	3.03 (0.59, 15.48)	—	1.72 (0.15, 20.32)
Deep/organ space surgical site infection	6.87 (4.02, 11.74)	7.39 (3.69, 14.82)	7.03 (4.36, 11.33)	2.29 (1.12, 4.65)	2.35 (0.88, 6.24)	1.45 (0.75, 2.80)	0.85 (0.08, 9.44)	0.42 (0.01, 22.2)	1.60 (0.11, 24.16)
Dehiscence	4.00 (1.76, 9.09)	5.49 (2.01, 14.94)	3.61 (1.70, 7.65)	2.86 (1.09, 7.50)	7.45 (2.45, 22.64)	1.90 (0.72, 5.00)	8.70 (1.73, 43.85)	—	0.68 (0.05, 8.67)
Pneumonia	1.94 (1.30, 2.89)	2.83 (1.65, 4.85)	1.54 (1.06, 2.25)	1.19 (0.50, 2.82)	2.66 (0.91, 7.76)	1.09 (0.51, 2.31)	3.63 (2.09, 6.31)	1.99 (0.95, 4.16)	1.33 (0.43, 4.17)
Pulmonary embolism	4.09 (1.90, 8.83)	5.00 (1.74, 14.36)	2.68 (1.31, 5.49)	1.27 (0.31, 5.26)	1.14 (0.15, 8.86)	2.68 (0.91, 7.92)	3.10 (0.58, 16.63)	—	1.19 (0.07, 20.80)
Respiratory failure	3.92 (2.58, 5.95)	5.61 (3.26, 9.63)	2.20 (1.45, 3.32)	5.50 (2.60, 11.66)	4.11 (1.11, 15.26)	1.13 (0.45, 2.83)	5.32 (2.58, 10.99)	7.03 (3.27, 15.15)	14.28 (5.89, 34.61)
Deep vein thrombosis	4.99 (2.54, 9.82)	7.19 (3.13, 16.51)	2.42 (1.24, 4.70)	9.94 (1.86, 53.07)	—	4.62 (1.27, 16.80)	—	—	3.33 (0.21, 53.45)
Renal failure	2.29 (1.11, 4.72)	2.33 (0.84, 6.49)	1.59 (0.81, 3.12)	—	3.41 (0.3, 38.78)	1.20 (0.18, 7.85)	4.24 (1.63, 11.05)	4.28 (1.32, 13.93)	21.98 (7.24, 66.68)
Urinary tract infection	1.76 (1.23, 2.52)	0.90 (0.46, 1.74)	1.41 (1.02, 1.96)	1.4 (0.68, 2.89)	1.68 (0.47, 6.01)	1.61 (1.10, 2.37)	4.14 (1.51, 11.35)	11.60 (4.19, 32.1)	1.76 (0.53, 5.80)
Cardiac complication	2.11 (0.88, 5.07)	1.88 (0.48, 7.33)	0.84 (0.33, 2.16)	1.33 (0.22, 8.09)	—	2.95 (0.81, 10.75)	2.20 (0.68, 7.12)	4.31 (1.10, 16.90)	—
Sepsis/septic shock	2.01 (1.43, 2.83)	2.94 (1.81, 4.77)	1.48 (1.08, 2.04)	2.22 (1.26, 3.91)	2.14 (1.06, 4.35)	2.00 (1.25, 3.22)	1.72 (0.66, 4.44)	2.45 (0.98, 6.12)	16.49 (5.85, 46.5)

Model adjusts for patient preoperative risk factors, indication for operation, and the occurrence of complication before hospital discharge. Odds ratios compare each discharge destination with the reference category of discharge to home. Odds ratios are considered statistically significant if the 95% CI does not include the value 1.
HHC, home health care; IRF, inpatient rehabilitation facility; OR, odds ratio; SNF, skilled nursing facility.

IRF was most frequently used for patients with DVT or urinary tract infection.

In multivariable analysis controlling for preoperative risk factors, the occurrence of almost all inpatient complications was associated with a significant increase in the risk-adjusted odds of discharge to PAC vs discharge to home (Table 3). This was particularly true for colectomy patients, for whom the odds of discharge to PAC were significantly elevated for all types of PAC. For these patients, superficial SSI and deep/organ space SSI were associated with the largest increases in odds of discharge to each type of PAC. For pancreatectomy patients, risk-adjusted odds of discharge to PAC were greatest for patients with respiratory failure and wound dehiscence. For open AAA repair patients, renal failure and sepsis or septic shock were associated with the highest risk-adjusted odds of discharge to each type of PAC. Increasing age, admission from another acute care facility, partially or fully dependent functional status, and increasing number of comorbidities were all associated with an increased risk-adjusted odds of discharge to PAC for each type of operation (Appendix 3, online only).

DISCUSSION

The use of post-acute care services is a costly and resource intensive component of our health care system. Using a unique merged dataset, we found that about 45% of elderly patients undergoing colectomy, pancreatectomy, and open AAA repair are discharged to PAC. Post-acute care use after these operations is significantly associated with several preoperative risk factors as well as the occurrence of inpatient complications.

Previous studies have similarly described the relationship between use of PAC and certain preoperative risk factors and postoperative complications.[10-12] For example, Legner and colleagues[10] noted that, in the state of Washington, surgical patients suffering complications during the index hospitalization had 2.4 times higher odds of discharge to post-acute institutional care. These studies, however, did not describe differences in use of different PAC services, nor did they report the use of PAC associated with specific operations or complications.

One study in Canada analyzed the use of HHC in elderly patients undergoing colon cancer resection and found that almost 80% of patients were discharged home and almost half the patients received HHC.[13] In our study, colectomy patients were discharged home or with HHC 83.6% of the time. The total rate of HHC use in our colectomy cohort was 23.1%, less than half the rate used in Canada. This variation between countries suggests that use of PAC may also depend on nonclinical factors such as national health policy including payment policy, the availability of post-acute care resources, health beliefs, and social support systems.

In our study, the rate of discharge to IRF ranged from 1.5% to 3.4% in our cohort, far lower than the 16% observed in a study on patients undergoing joint replacement.[14] This finding indicates that patients in our study have very different post-discharge needs compared with those undergoing orthopaedic surgery. After large abdominal operations, patients are likely to require advanced wound care, nursing supervision, and pharmacotherapy, including intravenous antibiotics. Regaining independence by means of intensive physical therapy is not nearly as common for these patients.

Post-acute care services aim to facilitate and accelerate a patient's recovery after hospitalization. However, hospital readmissions after discharge to PAC are common, particularly for debilitated patients.[15] While hospital readmissions continue to be scrutinized as a marker of hospital quality, efforts will be needed not only to improve care transitions from hospital to home but also from hospital to PAC. Yet, in our current system of care, such attempts to coordinate care between these 2 settings are rare.[3] Particularly in a climate in which many providers feel pressure to reduce hospital length of stay, and in light of the fact that close to half of the patients in our study used PAC after surgery, improving the transition between inpatient and post-acute services clearly warrants further attention from clinicians and policy makers alike.

Under the Affordable Care Act (ACA), Medicare is experimenting with a series of demonstration projects that incentivize a more efficient mix of acute and PAC services.[1,16] One example is a bundled payment system, under which hospitals and PAC providers are paid for a fixed "bundle" of services, including post-hospital care. As with previous changes in Medicare payment policies,[1,7,17] these reforms will likely result in a reorganization of care delivery and alterations in the types of care provided.[18,19] One concern is that payment reform will result in greater use of the lowest costs and least intensive PAC, potentially resulting in misuse of services.[3] To prevent such unintended consequences, further research is needed to ensure that each PAC service is reserved for patients who will benefit most from the specific type of care offered. In our study, between 25% and 33% of patients undergoing colectomy or pancreatectomy, who suffered from a deep/organ space SSI, were discharged to either an SNF or with HHC. However, whether this practice pattern reflects the optimal care for these patients remains unknown. A better understanding of the relative costs and benefits of each PAC service for individual patients would facilitate better health care resource management, and

possibly promote discharge planning early in a patient's hospital course.[20]

Our study has a number of limitations. First, the use of PAC after hospitalization is influenced by several factors not available in our data. These include the regional availability of PAC, local practice norms, patients' financial means, social support, and hospital volume.[21] Furthermore, discharge destination is often driven by financial rather than clinical factors,[1,22] so patient finances may also play a part in determining which type of PAC is used. For example, because patients require the supplemental Medicare Part D for coverage of outpatient medications, some patients without this package may prefer to be discharged to an SNF, for which all expenses, including those for pharmaceuticals, are covered by Part A. Our data include only Medicare patients, who tend to be older and sicker than the general population, and we are therefore unable to account for disparities related to insurance status.[23] Second, the discharge destination variable we used was self-reported by the discharging hospital and may not perfectly describe patients' actual disposition. Third, some of our analyses relied on relatively small sample sizes for certain complications, resulting in unstable estimates. However, this was rare and our models still performed well enough to detect significant differences at each level of the model. Finally, we were unable to directly measure patients' discharge needs, which may be the most powerful predictor of PAC services. However, by taking into account the occurrence of postoperative complications before discharge, we attempted to more closely approximate patient need at the time of discharge.

CONCLUSIONS

In conclusion, we found that use of PAC after surgery is very common, occurring in about 45% of Medicare patients undergoing colectomy, pancreatectomy, and open AAA repair. For these operations, use of PAC appears to be significantly associated with several preoperative risk factors as well as the type of procedure performed and the occurrence of postoperative complications before hospital discharge. Home health care is the most commonly used PAC modality, followed by skilled nursing facilities. These findings can be used to inform preoperative counseling and to guide early discharge planning. However, future research should attempt to define the appropriate use of each available PAC service in different patient populations.

Author Contributions

Study conception and design: Sacks, Lawson, Dawes, Gibbons, Ko
Acquisition of data: Lawson, Zingmond, Ko
Analysis and interpretation of data: Sacks, Lawson, Dawes, Gibbons, Zingmond, Ko
Drafting of manuscript: Sacks, Lawson, Dawes
Critical revision: Sacks, Lawson, Dawes, Gibbons, Zingmond, Ko

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Appendix 1. Current Procedural Terminology Codes Used to Identify Patient Cohort

Colectomy

44140, 44141, 44143, 44144, 44145, 44146, 44147, 44150, 44151, 44160, 44204, 44205, 44206, 44207, 44208, 44210

Pancreatectomy

48105, 48120, 48140, 48145, 48146, 48148, 48150, 48152, 48153, 48154, 48155

Open abdominal aortic aneurysm repair

34830, 34831, 34832, 35081, 35082, 35091, 35092, 35102, 35103

Appendix 2. Indications for Operation as Predictors of Discharge to Post-Acute Care

Indication for operation	Overall, n (%)	SNF, OR (95% CI)	IRF, OR (95% CI)	HHC, OR (95% CI)
Colectomy, n	10,932			
Benign neoplasm	1,743 (15.9)	1 (Ref)	1 (Ref)	1 (Ref)
Diverticulitis	1,502 (13.7)	1.43 (1.05, 1.93)	1.02 (0.59, 1.77)	1.3 (1.05, 1.61)
Fistula	237 (2.2)	2.38 (1.48, 3.85)	0.74 (0.27, 2.09)	1.93 (1.33, 2.81)
Hemorrhage	40 (0.4)	1.51 (0.55, 4.18)	0.49 (0.06, 4.19)	0.98 (0.4, 2.39)
Infectious colitis	75 (0.6)	1.73 (0.77, 3.85)	0.62 (0.13, 3.03)	1.67 (0.87, 3.24)
Malignancy	6,130 (56.1)	1.78 (1.42, 2.23)	1.03 (0.68, 1.55)	1.49 (1.27, 1.74)
Crohn disease/UC	155 (1.4)	2.59 (1.4, 4.78)	0.98 (0.31, 3.15)	1.93 (1.24, 3)
Obstruction/perforation	451 (4.1)	2.73 (1.89, 3.93)	1.52 (0.81, 2.84)	1.74 (1.29, 2.35)
Other	518 (4.7)	2.04 (1.42, 2.92)	0.72 (0.34, 1.51)	1.56 (1.19, 2.05)
Vascular insufficiency	86 (0.8)	2.49 (1.24, 5.01)	2.17 (0.79, 5.96)	1.35 (0.71, 2.58)
Laparoscopy	3,910 (35.8)	0.50	0.27	0.56
Pancreatectomy, n	2,144			
Benign	447 (20.9)	1 (Ref)	1 (Ref)	1 (Ref)
Pancreatitis	66 (3.1)	2.97 (0.42, 2.97)	3.60 (0.02, 3.6)	2.49 (0.7, 2.49)
Malignancy	1,458 (68.1)	1.77 (0.92, 1.77)	3.33 (0.66, 3.33)	1.3 (0.82, 1.3)

Model adjusts for patient preoperative risk factors, indication for operation, and the occurrence of complication occurring before hospital discharge. Odds ratios compare each discharge destination with the reference category of discharge to home. Odds ratios are considered statistically significant if the 95% CI does not include the value 1. Open abdominal aortic aneurysm repair is excluded from this table because all operations were performed for the same indication.

HHC, home health care; IRF, inpatient rehabilitation facility; OR, odds ratio; SNF, skilled nursing facility; UC, ulcerative colitis.

Appendix 3. Preoperative Risk Factors as Predictors of Discharge to Post-Acute Care

Preoperative risk factors	Colectomy, OR (95% CI)			Pancreatectomy, OR (95% CI)			Abdominal aortic aneurysm, open, OR (95% CI)		
	SNF	IRF	HHC	SNF	IRF	HHC	SNF	IRF	HHC
Age category, y									
65–74	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
75–84	3.76 (3.19, 4.43)	3.57 (2.61, 4.89)	1.60 (1.43, 1.78)	4.83 (3.45, 6.75)	3.71 (2.16, 6.38)	1.52 (1.27, 1.82)	3.86 (2.79, 5.35)	4.69 (2.82, 7.80)	1.91 (1.47, 2.49)
>84	16.79 (13.74, 20.53)	8.19 (5.49, 12.21)	3.20 (2.71, 3.78)	10.05 (5.76, 17.54)	9.29 (3.80, 22.72)	1.57 (0.97, 2.56)	8.89 (4.96, 15.92)	6.28 (2.13, 18.51)	2.23 (1.24, 4.04)
Sex									
Female	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
Male	0.56 (0.49, 0.64)	0.78 (0.60, 1.01)	0.75 (0.68, 0.83)	0.68 (0.49, 0.95)	1.09 (0.64, 1.84)	1.06 (0.87, 1.31)	0.44 (0.32, 0.60)	0.79 (0.48, 1.28)	0.77 (0.57, 1.04)
ASA category									
I and II	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
III	2.10 (1.78, 2.47)	2.18 (1.54, 3.09)	1.38 (1.23, 1.54)	1.03 (0.65, 1.66)	1.58 (0.52, 4.78)	0.75 (0.53, 1.05)	1.42 (0.62, 3.27)	0.87 (0.27, 2.79)	0.73 (0.41, 1.29)
IV and V	3.36 (2.54, 4.45)	3.99 (2.41, 6.63)	1.71 (1.34, 2.19)	2.46 (1.2, 5.04)	5.63 (1.45, 21.92)	0.81 (0.4, 1.61)	1.38 (0.57, 3.36)	0.68 (0.16, 2.82)	0.55 (0.26, 1.14)
Functional status									
Independent	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
Partially dependent	4.68 (3.70, 5.92)	4.69 (3.23, 6.81)	1.91 (1.50, 2.43)	6.05 (2.66, 13.76)	10.25 (2.78, 37.83)	2.85 (1.30, 6.23)	4.86 (1.92, 12.28)	1.83 (0.37, 9.04)	2.74 (1.29, 5.82)
Comorbidities									
0	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
1	1.28 (1.04, 1.59)	0.75 (0.50, 1.11)	1.34 (1.15, 1.55)	1.31 (0.87, 1.97)	1.28 (0.44, 3.73)	1.13 (0.86, 1.48)	1.41 (0.84, 2.35)	1.47 (0.65, 3.32)	1.37 (0.85, 2.19)
2	1.64 (1.32, 2.06)	0.94 (0.62, 1.41)	1.52 (1.30, 1.80)	2.09 (1.36, 3.21)	2.34 (0.89, 6.17)	1.16 (0.86, 1.55)	1.62 (0.88, 2.99)	2.45 (0.94, 6.34)	1.62 (0.94, 2.81)
≥3	2.25 (1.76, 2.88)	1.19 (0.76, 1.85)	2.00 (1.66, 2.41)	2.43 (1.46, 4.04)	2.75 (0.70, 10.79)	1.32 (0.93, 1.87)	2.01 (1.07, 3.77)	4.39 (1.88, 10.24)	1.71 (0.94, 3.13)
Wound class									
I and II	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)	1 (Ref)
III	1.51 (1.20, 1.89)	1.58 (1.05, 2.39)	1.25 (1.04, 1.50)	0.79 (0.39, 1.6)	2.25 (1.13, 4.47)	1.19 (0.74, 1.91)	1.33 (0.53, 3.32)	–	0.26 (0.08, 0.84)
IV	1.79 (1.30, 2.46)	1.89 (1.11, 3.22)	1.20 (0.91, 1.57)	0.38 (0.11, 1.34)	0.29 (0.06, 1.28)	0.79 (0.39, 1.57)	–	–	2.67 (0.16, 44.17)

Model adjusts for patient preoperative risk factors, indication for operation, and the occurrence of complications occurring before hospital discharge. Odds ratios compare each discharge destination with the reference category of discharge to home. Odds ratios are considered statistically significant if the 95% CI does not include the value 1.
HHC, home health care; IRF, inpatient rehabilitation facility; OR, odds ratio; SNF, skilled nursing facility.