Association of Decision Support for Hospital Discharge Disposition With Outcomes

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ABSTRACT

OBJECTIVES: To assess the association of a clinical decision support (CDS) algorithm for hospital discharge disposition with spending, readmissions, and postdischarge emergency department (ED) use.

STUDY DESIGN: A retrospective study in a cohort of fee-for-service Medicare patients 65 years or older linked to a database of patients receiving CDS.

METHODS: We evaluated (1) patients whose discharge disposition was concordant with the CDS recommendation versus those whose disposition was not and (2) patients receiving CDS for discharge disposition versus those not receiving CDS, regardless of concordance. Outcomes were spending over a 90-day episode, 90-day readmissions, and postdischarge ED utilization not associated with a readmission.

RESULTS: Analysis of concordant versus discordant cases showed decreased spending for concordant cases ($860 savings; 95% CI, $162-$1558; *P* = .016), a decrease in readmissions (adjusted odds ratio [OR], 0.920; 95% CI, 0.850-0.995; *P* = .038), and no change in rate of postdischarge ED use (adjusted OR, 0.990; 95% CI, 0.882-1.110; *P* = .858). Analysis of patients receiving CDS versus not receiving CDS showed no significant difference in spending ($221 savings; 95% CI, –$115 to $557; *P* = .198), ED use (adjusted OR, 0.959; 95% CI, 0.908-1.012; *P* = .128), or readmission rate (adjusted OR, 1.004; 95% CI, 0.966-1.043; *P* = .840).

CONCLUSIONS: Following the recommendation of a CDS algorithm for hospital discharge disposition was associated with lower spending, fewer readmissions, and no change in ED use over a 90-day episode of care.

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Spending on postacute care accounts for a substantial portion of overall healthcare costs and is growing faster than other spending categories.[1,2] For conditions like pneumonia, chronic obstructive pulmonary disease, heart failure, and joint replacement, Medicare spends nearly as much in the 30 days after discharge as it does during hospitalization.[3] Moreover, postacute costs are associated with large geographic variation across the United States, with three-fourths of all regional variation in Medicare spending attributable to postacute care spending.[4]

Achieving the judicious, appropriate use of resources following hospitalization can be a critical success factor for organizations participating in full risk capitation and in payment models such as accountable care organizations and bundled payments. Additionally, Medicare spending per beneficiary—a measure of spending encompassing the 30 days subsequent to hospitalization—is publicly reported and tied to financial incentives for all US Inpatient Prospective Payment System hospitals as part of Hospital Value-Based Purchasing and is a component of the physician payment formula under the Merit-based Incentive Payment System.[5]

Despite growing pressure for hospitals to develop a systematic approach to using postacute care for all patients, most published studies examining such approaches address a single diagnosis, such as stroke or joint replacement; describe a method that may be too complex and time-consuming for widespread use; or rely on information that is unavailable early in the hospitalization, when factors influencing discharge destination may be modified.[6-12]

We sought to build a clinical decision support (CDS) algorithm to assist hospital discharge planning teams in identifying the most appropriate discharge care level while avoiding untoward effects such as increases in readmissions, emergency department (ED) use, and overall spending. To assess the algorithm, as a convener in CMS' Bundled Payments for Care Improvement initiative (BPCI),[13] we accessed Medicare claims data for acute hospitalizations and the subsequent 90-day period.

We evaluated the effect of the algorithm on spending, 90-day readmissions, and postdischarge 90-day ED use in cases in which discharge disposition was concordant or discordant with the algorithm's recommendation and in which the algorithm was or was not used (regardless of concordance).

TAKEAWAY POINTS

Following the recommendation of a clinical decision support (CDS) algorithm for hospital discharge disposition was associated with lower spending and reduced readmissions with no change in emergency department (ED) use.

- A CDS algorithm incorporating cognition, ambulation, activities of daily living, capable caregiver availability, skilled therapy needs, and skilled nursing needs was evaluated in 15,887 patients participating in Medicare's bundled payment program.
- Following the algorithm's recommended level of care (home vs home with home health agency vs postacute facility) was associated with an $860 decrease in spending, fewer readmissions, and unchanged postdischarge ED use over a 90-day episode compared with those patients for whom the recommended level of care was not followed.
- The judicious use of postacute care resources by the hospital discharge team can be enhanced by using a CDS algorithm.

METHODS

Setting

The setting of this study was acute hospitalization and the 90-day period following discharge, encompassing patient care in the home, home with a home health agency (hereafter written simply as home health agency), and postacute facility (including skilled nursing facilities, inpatient rehabilitation facilities, and long-term acute care hospitals).

Instrument

We developed a proprietary CDS tool incorporating an algorithm to help teams determine an appropriate level of care following hospital discharge. Inputs to the algorithm were ambulatory status; ability to perform activities of daily living; cognitive status; availability of a capable caregiver; postacute physical, occupational, and speech therapy needs; and postacute skilled nursing needs. In developing the CDS tool, we reviewed the literature to identify patient-level factors to serve as the basis of decision support.[14-19] Caregiver support was also recognized as critical to effective discharge planning.[20-24] We convened experts in home health, postacute facility care, and hospital care in a series of working sessions to finalize factors driving a decision to discharge patients to 1 of 3 options. Other potentially informative factors, including comorbidities, polypharmacy, environmental factors (eg, stairs, home modifications), and social determinants, were intentionally omitted to increase the tool's ease of use. After assessing the tool for user requirements and reproducibility of results across users, we created a scoring system based on the identified inputs that yielded a recommendation for 1 of 3 postdischarge care intensity levels: home, home health agency, or postacute facility.

A pilot was then conducted, using an analysis of 1537 BPCI patients to whom the CDS tool was retrospectively applied. This pilot yielded a proposal that made recommendations as follows (results shown as pilot vs controls): More patients go home or to a home health agency (home, 50.6% [95% CI, 47.7%-53.6%] vs 36.1% [95% CI, 32.8%-39.5%]; home health agency, 32.5% [95% CI, 29.1%-35.1%] vs 26.0% [95% CI, 16.8%-24.4%]), and fewer go to a postacute facility (16.9% [95% CI, 13.1%-20.8%] vs 43.3% [95% CI, 40.2%-46.5%]). The tool's performance was then evaluated using risk-adjusted regression models created to predict the rate of 90-day readmissions for patients discharged to home, a home health agency, and a postacute facility. These rates were compared with observed 90-day readmissions and found to be not statistically different across the 3 discharge dispositions: home (32.4% [95% CI, 30.4%-34.4%] vs 32.8% [95% CI, 29.5%-36.0%]), home health agency (33.1% [95% CI, 31.1%-35.1%] vs 32.0% [95% CI, 27.5%-36.4%]), and postacute facility (33.3% [95% CI, 31.4%-35.3%] vs 31.7% [95% CI, 28.7%-34.7%]).[25]

Subsequently, the algorithm was embedded in the convener's proprietary software platform used by bundled payment program operating personnel to identify and manage patients during the bundle episode. These users—personnel at the convener's BPCI episode–initiating hospitals—were trained in the use of the tool, which involved a webinar, a user's manual, and targeted face-to-face and remote individualized education and support. Training addressed how and when to populate the components of the algorithm and also the importance of creating a process to discuss the tool's inputs and recommendation with the interdisciplinary discharge team, including the patient/surrogate decision maker. Although all episode-initiating hospitals were encouraged to use the tool, only a subset did so, which was at the discretion of the organizations' leadership.

Data: Medicare

All Part A and Part B claims for the convener's population of fee-for-service Medicare BPCI patients encompassing acute hospitalization and the subsequent 90-day period occurring between January 1, 2016, and March 31, 2017, were accessed. After deleting claims with incomplete information, there were 148,385 episodes available for analysis. During the same time period, a subset of 15,887 patients in this population were tested using the CDS tool. Our analytic data set consists of Medicare claims data on 132,498 episodes that did not receive the CDS tool and Medicare claims data plus CDS testing results for the 15,887 episodes that did receive the CDS tool.

For each episode, we examined the following outcomes: allowed payment amounts (spending), discharge disposition (home, home health agency, or postacute facility), readmission within 90 days, and postdischarge ED visits not associated with a readmission within 90 days of hospital discharge.

Propensity Model

We used propensity modeling with inverse probability weighting (IPW) for each analysis[26,27]; propensity to follow the CDS

TABLE 1. Patient Characteristics in CDS-Concordant and CDS-Discordant Groups

	Concordant With CDS	Discordant With CDS	*P*
n	10,218	5669	
Age in years, median (IQR)	78.60 (71.87-85.91)	80.01 (72.84-87.12)	<.001
Length of stay in days, median (IQR)	4.00 (2.00-5.00)	4.00 (3.00-6.00)	<.001
Female, n (%)	6008 (58.8)	3517 (62.0)	<.001
Dual enrolled, n (%)	1732 (17.0)	1139 (20.1)	<.001
Disposition, n (%)			<.001
Home	4604 (45.1)	1876 (33.1)	
Home health agency	1781 (17.4)	1484 (26.2)	
Postacute facility	3833 (37.5)	2309 (40.7)	
Race, n (%)			<.001
Unknown	92 (0.9)	36 (0.6)	
White	8790 (86.0)	4767 (84.1)	
Black	888 (8.7)	591 (10.4)	
Other	155 (1.5)	78 (1.4)	
Asian	144 (1.4)	84 (1.5)	
Hispanic	120 (1.2)	95 (1.7)	
North American Native	29 (0.3)	18 (0.3)	
Complications, n (%)			<.001
Diagnosis code does not indicate CC/MCC presence or absence	688 (6.7)	380 (6.7)	
No CC	3883 (38.0)	1983 (35.0)	
With CC	2205 (21.6)	1178 (20.8)	
With CC/MCC	74 (0.7)	33 (0.6)	
With MCC	3368 (33.0)	2095 (37.0)	

CC indicates comorbid complication; CDS, clinical decision support; IQR, interquartile range; MCC, major comorbid complication.

recommendation was used in the concordant versus discordant analysis, and propensity to use the test was used in the intention-to-treat (ITT) analysis (tested vs untested). We used logistic regression for both propensity models. The following variables were included as independent variables: length of stay, race, sex, dual-enrolled status (binary), prior system utilization (the number of days spent as a hospital inpatient in the year prior to the index hospitalization), entered through the ED, clinical episode name, Medicare Severity Diagnosis Related Group tier (no comorbid complication, comorbid complication, major comorbid complication), and primary diagnosis code. In all analyses, we used IPW to compute average treatment effect among the treated (ATT) estimates. Although these variables were all selected a priori without first examining their relationship to the probability of testing, most of them are significantly associated with it.

Statistical Approach

We performed 2 analyses of the effect of the CDS tool's use on patient outcomes: concordant versus discordant and tested versus untested.

Concordant Versus Discordant

Concordant was defined as discharge disposition agreeing with the CDS tool's recommendation, whereas *discordant* was defined as discharge disposition disagreeing with the recommendation. We used IPW regression (spending) and logistic regression (ED use and readmissions) to test for the effect of agreeing with the CDS tool recommendation on outcomes.

Within this analysis, we also examined the impact of more intense and less intense levels of care. In an attempt to control for hospital-level differences, we performed a post hoc analysis of CDS-concordant versus CDS-discordant cases, showing results for when the hospital is controlled for as a main effect.

A *more intense* level of care is defined as either (1) the CDS tool recommends home and the actual disposition was either home health agency or postacute facility or (2) the CDS tool recommends home health agency and the actual disposition was postacute facility. A *less intense* level of care is defined as either (1) the CDS tool recommends postacute facility and the actual disposition was either home health agency or home or (2) the CDS recommends home health agency and the actual disposition was home. In these models we included the impact of more or less intense levels of care on the outcomes.

Tested Versus Untested

The second analysis consisted of tested versus untested cases. Tested cases received the CDS tool, whereas untested cases did not receive the CDS tool. This was an ITT analysis, examining outcomes independent of whether the CDS tool recommendation was followed. This analysis reflects the expectation that the decision of discharge disposition is based on a merging of clinical expertise and the CDS tool recommendation, with responsibility for the final decision resting with the discharge planning team and patient/caregiver.

We acknowledge that in actual use, providers may not apply the CDS tool to all patients, nor do we expect that everyone in the population will receive the test. Therefore, we used a propensity model to estimate the ATT, or the effect of the test on the outcome of those who received it.

Federal common rule[28] provides an exemption from institutional review board requirements when the purpose is to study, evaluate, or otherwise examine a public benefit or a service program—in this case, CMS' BPCI program. The contractor signed a data use agreement stating that all data were securely and solely used for the purposes of this study.

RESULTS

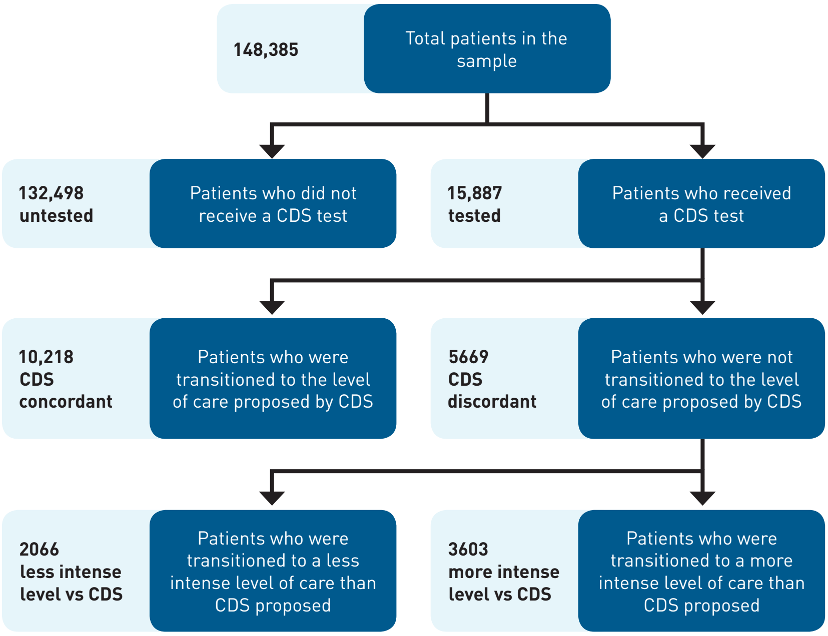
In general, compared with patients found to be discordant, those who were concordant were about 1 year younger, had shorter lengths of stay, were less likely to be women, were less likely to be dual enrolled, and had lower rates of major complications. Concordant patients were also less likely to be sent to home health agencies and postacute facilities and were more likely to go home (**Table 1**).

Adjustment for differences in concordant versus discordant patients using IPW resulted in the 2 groups being similar in all categories (**eAppendix Table 1A** [eAppendix available at **ajmc.com**]).

There were 148,385 patients in the sample in total. Of the 15,887 who received CDS, 10,218 were CDS concordant and 5669 were CDS discordant. Of the latter group, 2066 were discharged to a less intense level of care than what the CDS proposed and 3603 were discharged to a more intense level of care (**Figure 1**).

Episode spending was $860 less (95% CI, $162-$1558; $P = .016$), 90-day readmissions were lower (adjusted odds ratio [OR], 0.920; 95% CI, 0.850-0.995; $P = .038$), and ED use was unchanged (adjusted OR, 0.990; 95% CI, 0.882-1.110; $P = .858$) for concordant compared with discordant cases (**Figure 2**). A post hoc analysis, controlling for the hospital as a main effect, showed episode spending to be $934 less (95% CI, $247-$1621; $P = .008$), 90-day readmissions lower (adjusted OR, 0.916; 95% CI, 0.846-0.992; $P = .031$), and ED use unchanged (adjusted OR, 0.997; 95% CI, 0.887-1.120; $P = .957$) for concordant versus discordant cases.

FIGURE 1. Flow Diagram of All Patients, Patients Receiving CDS, CDS Concordance, and CDS Discordance (more intense and less intense levels of care)



CDS indicates clinical decision support.

More Intense and Less Intense Levels of Care

When concordant cases were compared with discordant cases discharged to more intense levels of care, concordance was associated with decreased spending ($4802; 95% CI, $3896-$5709; $P < .001$), decreased readmission rates (adjusted OR, 0.834; 95% CI, 0.757-0.920; $P < .001$), and unchanged ED use (adjusted OR, 0.956; 95% CI, 0.832-1.096; $P = .517$). Results of the adjusted analysis of concordant versus discordant cases discharged to less intense care suggest that concordance was more expensive ($6417; 95% CI, $5551-$7283; $P < .001$), with no changes in readmission rates (adjusted OR, 1.086; 95% CI, 0.951-1.240; $P = .222$) or ED use (adjusted OR, 1.086; 95% CI, 0.893-1.319; $P = .410$) (**Figure 3**).

Disposition to Home, Home Health Agency, and Postacute Facility

Recommended rates for disposition to home, home health agency, and postacute facility were 41.5%, 29.6%, and 28.9%, respectively, whereas actual disposition rates among the tested population were 40.8%, 20.6%, and 38.7% (**Table 2**). Compared with actual, the CDS tool recommended fewer patients be sent to a postacute facility and more patients be sent to a home health agency than was observed. Approximately the same proportion of patients were sent home (40.8%) as were recommended (41.5%). Conversely, more patients received a recommendation to go to a home health agency (29.6%) than was observed (20.6%), and fewer received a postacute facility recommendation (28.9%) than was observed (38.7%). The overall rate of concordance with the CDS recommendation was 64%. Table 2 shows the numbers of patients for each combination of disposition and recommendation.

Tested Versus Untested Populations and Outcomes

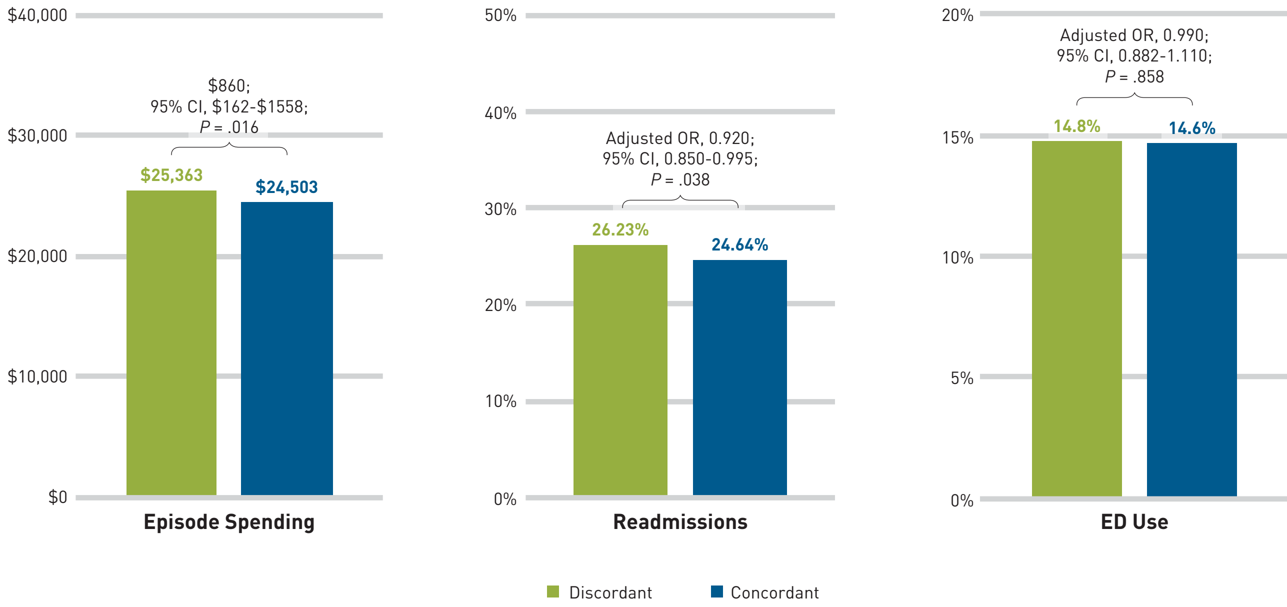
Overall, there was no difference in age between the tested and untested populations. However, the tested were less likely to be white, were more likely to be female, had longer lengths of stay, and had higher rates of dual enrollment. See **eAppendix Table 1B** for the rate of testing split across a selection of demographic variables.

The IPW-adjusted ITT analysis showed decreased spending among those tested, but it was not statistically significant ($221 savings; 95% CI, −$115 to $557; $P = .198$). There was also no difference among those tested in ED use (adjusted OR, 0.959; 95% CI, 0.908-1.012; $P = .128$) or readmission rates (adjusted OR, 1.004; 95% CI, 0.966-1.043; $P = .840$) (see the **eAppendix Figure**).

DISCUSSION

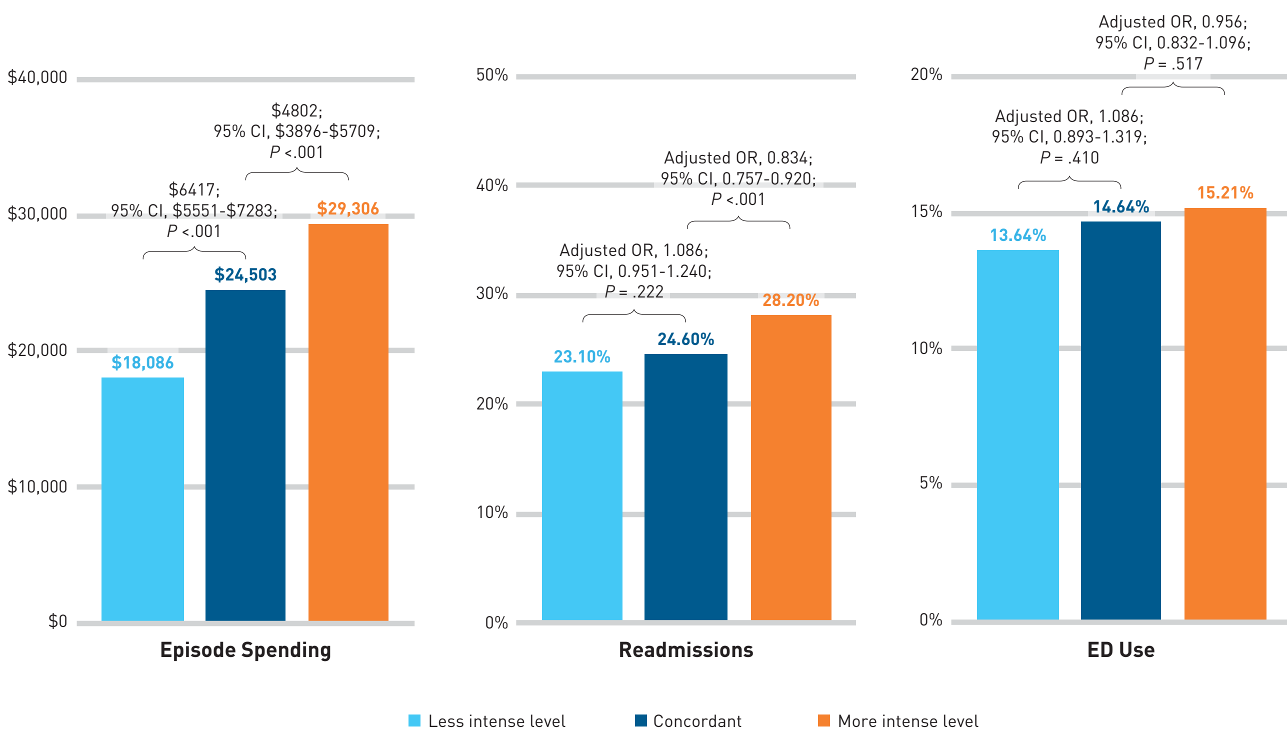
We tested a CDS tool for post–hospital discharge destination and found that following its recommendation was associated with reduced spending and readmissions, with no change in ED use, over the course of an episode encompassing a hospitalization and the ensuing 90-day postdischarge period for patients participating in the Medicare bundled payment program. For cases that were

FIGURE 2. Comparison of Spending, Readmissions, and ED Use for CDS-Concordant Versus CDS-Discordant Cases



CDS indicates clinical decision support; ED, emergency department; OR, odds ratio.

FIGURE 3. Comparison of Spending, Readmissions, and ED Use in CDS-Concordant Versus CDS-Discordant (more intense and less intense levels of care) Cohorts



CDS indicates clinical decision support; ED, emergency department; OR, odds ratio.

discharged to a more intense care level than the recommendation, associated spending and readmissions were greater, whereas ED use was unchanged. For cases discharged to less intense care than recommended, spending was reduced, whereas readmissions and ED use were unchanged.

Because of the observational nature of the study, it is difficult to definitively state the reasons for lower spending or readmission reductions when following the tool's recommendation. It is possible that the recommendation-concordant group—who went home more often and to postacute facilities less often (Table 1)—recovered more successfully because they were in the home environment. The hazards of postacute facilities (eg, falls, delirium, infection, poor nutrition, decreased mobility, deconditioning[29,30]) may play a role in increased readmissions and ED use, although the evidence on the impact of home care versus alternative locations on health outcomes is inconclusive.[31] Alternatively, in select patients, such as those undergoing elective total joint replacement, a home discharge has been associated with lower readmissions.[32]

Similarly, the reasons for findings associated with less intense and more intense discharge decisions are speculative. It is conceivable that for many patients, receiving less intense posthospital care than the tool recommends is in actuality the appropriate care level, thus explaining why spending is lower and readmissions and ED use were no different from those of the recommendation-concordant group. For patients receiving more intense care, which may in part be driven by patient/caregiver preferences, one may argue that higher spending and readmissions are explained by patient factors; however, the propensity model was designed to adjust for such factors.

For patients discharged to a less intense level of care than recommended, because readmissions and ED use were unchanged in that group, it is likely that if the discharge team's judgment supports the decision to discharge to a less intense level, such a decision is safe and appropriate. Conversely, if a more intense level of care is felt to be required, the team should consider this study's findings of higher readmissions and ED use and carefully consider the purported benefits of the decision.

The results of the study also showed that in the comparison of cases receiving CDS tool testing—regardless of whether the recommendation was followed—versus no testing, there was no statistically significant change in spending and no change in readmission rate or ED use. It is likely that providers were selective about who received the tool, namely that those tested had longer hospital lengths of stay and higher rates of dual enrollment, suggesting they may be sicker and more likely in need of additional care after discharge. This is relevant because even with the propensity model, it is difficult to adjust for all the differences between the tested and untested, yet the potentially sicker tested group did not have worse outcomes.

TABLE 2. Number of Patients in the Cohort for Each Combination of Discharge Disposition and Clinical Decision Support Recommendation

		Recommendation			
		Home	Home health agency	Postacute facility	Disposition totals
Discharge disposition	Home	4604	1312	564	40.8%
	Home health agency	1294	1781	190	20.6%
	Postacute facility	694	1615	3833	38.7%
Recommendation totals		41.5%	29.6%	28.9%	

It should be stated that the intention of the CDS tool is to inform the discharge planning team's evaluation regarding the factors influencing discharge destination, with a final decision arrived at with input from the patient/caregiver and the judgment of the team. Discussion and evaluation by the team of the tool's data elements—including measures of independence, availability of a capable caregiver, and postacute needs—along with other details of each particular case can form the basis of a structured process yielding a final decision. The adoption of such a process for evaluating patients' postdischarge destination may help hospitals looking to improve the precision with which various postacute services and settings are recommended.

Limitations

The study was limited to the use of observational data. Thus, if there are unmeasured confounders associated with the decision to follow the CDS tool's recommendation, or to use the tool at all, there may be uncorrected bias in the results. Because providers may exercise discretion as to who receives the CDS tool, selection bias may be a significant factor in differences between the tested and untested groups. Also, the study used only Medicare Part A and Part B claims data in its outcomes analysis. It is possible that clinical data would have improved the propensity model and increased the relevance of the outcomes. It is also possible that there were differences in spending not reflected in Part A and Part B claims, such as out-of-pocket spending or that associated with supplemental insurance, that were not measured.

The population in the study was limited to patients 65 years or older. We cannot rule out the possibility that the impact of the test will differ among younger patients. Moreover, the analysis of recommendation concordance is confounded by the fact that providers' discharge decisions are potentially affected by the tool's recommendations.

CONCLUSIONS

This study demonstrated an association between concordance with a CDS algorithm and decreased 90-day episode spending and readmissions, with no adverse effect on postdischarge ED visits. The study is an example of an innovative approach to care redesign under a bundled payment model. Because bundled payments create an incentive to critically evaluate decisions affecting discharge destination, the development and implementation of the CDS tool can be viewed as a result of a new payment incentive. ■

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eAppendix

eAppendix Table 1A. Patient Characteristics in CDS Concordant and CDS Discordant Groups – Inverse Probability Weighted

Reweighting according to our propensity model leads to substantially similar values for all of our control variables. Note that we do not present absolute counts in this table because the reweighting is arbitrary up to a scalar multiple.

Variable	Concordant w/ CDS	Discordant w/ CDS (weighted)	p
age (median [IQR[a]])	78.6 [71.87, 85.91]	78.71 [71.92, 86.2]	0.275
Length of Stay	4 [2,5]	4 [3,6]	0.247
SEX			0.959
Female	58.80%	58.84%	
Male	41.20%	41.16%	
Dual Enrolled			0.406
0 (No)	83.05%	82.51%	
1 (Yes)	16.95%	17.49%	
RACE			0.824
Asian	1.41%	1.40%	
Black	8.69%	8.81%	
Hispanic	1.17%	1.26%	
North American Native	0.28%	0.28%	
Other	1.52%	1.46%	
Unknown	0.90%	0.86%	
White	86.02%	85.92%	
Complications			0.678
Diagnosis code does not indicate CC[b]/MCC[c] presence or absence	6.73%	6.92%	
No complications	38%	37.44%	
W CC[b]	21.58%	21.57%	
W CC[b]/MCC[c]	0.72%	0.79%	
W MCC[c]	32.96%	33.28%	

a – interquartile range, b – comorbid complications, c – major comorbid complications

eAppendix Table 1B. Patient Characteristics in CDS Tested and CDS Untested Groups

	CDS Tested	CDS Untested	p
N	15887	132498	
age (median [IQR[a]])	79.10 [72.19, 86.38]	78.95 [72.05, 86.24]	0.205
Length of Stay (median [IQR[a]])	4.00 [3.00, 6.00]	3.00 [2.00, 5.00]	<0.001
Female (%)	9525 (60.0)	77739 (58.7)	0.002
Dual enrolled (%)	2871 (18.1)	22557 (17.0)	0.001
disposition (%)			<0.001
home	6480 (40.8)	64016 (48.3)	
home health agency	3265 (20.6)	24790 (18.7)	
post-acute facility	6142 (38.7)	43692 (33.0)	
RACE (%)			<0.001
Unknown	128 (0.8)	976 (0.7)	
White	13557 (85.3)	114925 (86.7)	
Black	1479 (9.3)	11236 (8.5)	
Other	233 (1.5)	1377 (1.0)	
Asian	228 (1.4)	1376 (1.0)	
Hispanic	215 (1.4)	2174 (1.6)	
North American Native	47 (0.3)	434 (0.3)	
complications (%)			0.031
Diagnosis code does not indicate CC[b]/MCC[c] presence or absence	1068 (6.7)	9337 (7.0)	
no complications	5866 (36.9)	49252 (37.2)	
W CC[b]	3383 (21.3)	26847 (20.3)	
W CC[b]/MCC[c]	107 (0.7)	900 (0.7)	
W MCC[c]	5463 (34.4)	46162 (34.8)	

a – interquartile range, b – comorbid complications, c – major comorbid complications

eAppendix Figure. Comparison of Spending, Readmissions and ED Use in CDS Tested vs. Untested