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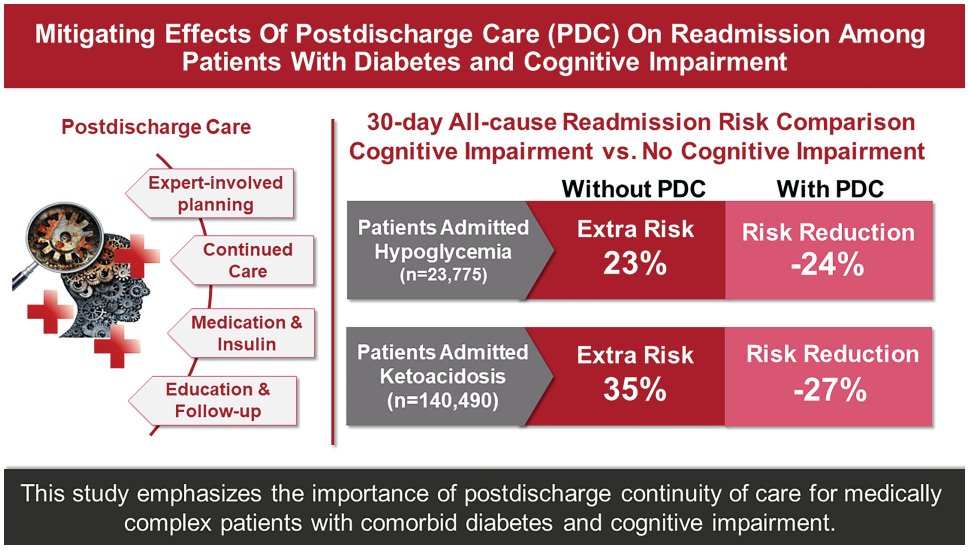

ARTICLE HIGHLIGHTS

- **Why did we undertake this study?**
  Evidence is lacking about whether postdischarge care (PDC) can mitigate the escalated risk of readmission among patients with diabetes and cognitive impairment (CI) due to compromised self-care.
- **What is the specific question we wanted to answer?**
  Does PDC mitigate the excessive readmission risk associated with CI among patients with diabetes admitted due to hypoglycemia and ketoacidosis?
- **What did we find?**
  Using the National Readmission Database, we found CI increased readmission risk in people with diabetes admitted for hypoglycemia and ketoacidosis. However, among patients discharged with PDC, PDC negated this excessive readmission CI-related risk.
- **What are the implications of our findings?**
  PDC is crucial in reducing elevated readmission risks in patients with comorbid diabetes and CI.

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Associations Between Postdischarge Care and Cognitive Impairment–Related Hospital Readmissions for Ketoacidosis and Severe Hypoglycemia in Adults With Diabetes

Yehua Wang,[1,2] Tianze Jiao,[1,2] Matthew R. Muschett,[1,2] Joshua D. Brown,[1,2] Serena Jingchuan Guo,[1,2] Ambar Kulshreshtha,[3] Yongkang Zhang,[4] Almut G. Winterstein,[1,2] and Hui Shao[1,2,3,5]

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ORIGINAL ARTICLE

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OBJECTIVE

Patients with severe hypoglycemia (SH) or diabetic ketoacidosis (DKA) experience high hospital readmission after being discharged. Cognitive impairment (CI) may further increase the risk, especially in those experiencing an interruption of medical care after discharge. This study examined the effect modification role of postdischarge care (PDC) on CI-associated readmission risk among U.S. adults with diabetes initially admitted for DKA or SH.

RESEARCH DESIGN AND METHODS

We used the Nationwide Readmissions Database (NRD) (2016–2018) to identify individuals hospitalized with a diagnosis of DKA or SH. Multivariate Cox regression was used to compare the all-cause readmission risk at 30 days between those with and without CI identified during the initial hospitalization. We assessed the CI-associated readmission risk in the patients with and without PDC, an effect modifier with the CI status.

RESULTS

We identified 23,775 SH patients (53.3% women, mean age 65.9 ± 15.3 years) and 140,490 DKA patients (45.8% women, mean age 40.3 ± 15.4 years), and 2,675 (11.2%) and 1,261 (0.9%), respectively, had a CI diagnosis during their index hospitalization. For SH and DKA patients discharged without PDC, CI was associated with a higher readmission risk of 23% (adjusted hazard ratio [aHR] 1.23, 95% confidence interval 1.08–1.40) and 35% (aHR 1.35, 95% confidence interval 1.08–1.70), respectively. However, when patients were discharged with PDC, we found PDC was an effect modifier to mitigate CI-associated readmission risk for both SH and DKA patients ($P < 0.05$ for all).

CONCLUSIONS

Our results suggest that PDC can potentially mitigate the excessive readmission risk associated with CI, emphasizing the importance of postdischarge continuity of care for medically complex patients with comorbid diabetes and CI.

Cognitive impairment (CI) is a common comorbidity among people with diabetes. In the U.S., the prevalence of CI ranged between 15 and 26% (1–3) compared with

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<10% in the general population (4). A higher prevalence of CI in people with diabetes is largely attributable to dysregulated blood glucose values, hypoglycemic events, and coexistence of other vascular conditions (e.g., hypertension and other metabolic derangements) (5). CI often manifests as deficits in recall and working memory, an inability to concentrate or learn, or challenges in making decisions (6). Individuals with diabetes and comorbid CI were found to have difficulty with self-care (7,8). Activities such as self-monitoring of blood glucose, use of injectable medications, such as insulin, and adherence to medication administration and dietary schedules are cognitively burdensome and may be affected by CI in this population (7), which may cause suboptimal blood glucose control and adverse clinical sequelae such as hypo- and hyperglycemia. Current studies have also found CI is a risk factor for early readmission, extended hospitalizations, and mortality for people with and without diabetes (9,10). Therefore, due to its high prevalence and negative health consequences in this population, CI has been increasingly recognized as an important comorbidity in people with diabetes (11).

Severe hypoglycemia (SH) and diabetic ketoacidosis (DKA) are associated with an increased risk for hospitalization and are potentially life-threatening (12). The incidence rate of hospitalization among Medicare beneficiaries was 612 per 100,000 person-years for SH and 367 per 100,000 person-years for hyperglycemia (13). Because of its chronic etiology, patients are at risk for readmission after discharge, and this risk may be exacerbated among patients with CI and without proper follow-up care (14). The 30-day readmission risk for patients with an index diagnosis of SH and DKA is estimated to be 17% and 16%, respectively (13).

Postdischarge care (PDC) entails interventions delivered following discharge to provide continued medical support to medically complex patients, in part, to prevent hospital readmission (15). For those with diabetes, PDC typically consists of patients' and their families' education, home care, and medication monitoring (16). PDC is a collaborative practice between clinicians, nurses, pharmacists, hospitals, patients and their caregivers, and other supportive services (17). The American Diabetes Association recommends a structured postdischarge plan tailored to each patient's needs (11,18). Those with diabetes and comorbid CI require a structured approach to care that involves a multidisciplinary patient care team due to a compromised ability for self-care and vulnerability to readmission. A proper PDC may be imperative to prevent readmission in this population.

Currently, there is a paucity of empirical evidence on whether PDC may mitigate the elevated risk of hospital readmission associated with CI among individuals with poorly controlled diabetes. This study aimed to fill this knowledge gap by analyzing data from the National Readmissions Database (NRD). We tested two hypothesizes: *1*) whether the absence of PDC after admission for SH or DKA among those with comorbid CI would result in a higher risk of readmission compared with those without comorbid CI and *2*) whether receiving PDC may mitigate this CI-associated excess risk of hospital readmission.

RESEARCH DESIGN AND METHODS

We conducted a retrospective cohort study among U.S. adults aged ≥18 years with a primary diagnosis of SH or DKA at the index hospital admission identified from the NRD between the years 2016 and 2018. The NRD is the largest publicly available all-payer inpatient health care readmissions database in the U.S. and is curated by the Agency for Healthcare Research and Quality. Although deidentified, the NRD links all admissions for a person with all readmissions in a given calendar year and provides a nationally representative sample of hospital readmissions for all ages. The study design is diagrammed in Supplementary Fig. 1.

Study Population

The study included U.S. adults aged ≥18 years who had an ICD-10-Clinical Modification (CM) code indicative of diabetes and had a primary diagnosis of SH or DKA upon the index admission, as indicated by ICD-10-CM code, and were discharged alive between January and November in the year of the index hospitalization. ICD-10-CM codes pertaining to diabetes were identified through the Chronic Conditions Warehouse (CCW) (19). These codes are provided in Supplementary Table 2.

Index hospitalization was defined as the first hospitalization record for a given individual in that year. Those discharged in December were excluded because 30-day readmissions could not be captured for these individuals. Because the NRD database does not capture death after hospital discharge, we also required that patients were at minor or moderate risk of mortality during their index hospitalization.

Study Outcomes

The primary outcome of interest was 30-day all-cause readmission. Time to readmission was calculated as the readmission date minus the index admission date and minus the index admission length of stay.

CI, PDC, and Covariates Measurement

CI was defined by the presence of an ICD-10-CM code in any diagnosis code position during the patient's initial hospitalization record indicative of mild CI, Alzheimer disease, and dementia (including vascular dementia, frontotemporal dementia, mixed dementia, Lewy body dementia, and other dementia), amnesia, delirium, and nervous system degeneration. It was obtained through literature review and clinical expert review (20,21). The code lists are included in Supplementary Table 1.

We defined patients discharged with PDC as individuals discharged to care-providing facilities, such as skilled nursing facilities or intermediate care facilities, or being discharged with home health care. Patients discharged home and to self-care were considered to have no PDC. We used the NRD discharge disposition variable ("DISPUNIFORM") to ascertain the PDC status.

Other covariates included age, sex, primary payer, median household income level, risk of mortality at index discharge, and disease severity at index discharge based on All Patient Refined Diagnosis-Related Group (APR-DRG). The APR-DRG algorithm used in the NRD calculates the Severity of Illness (SOI) scores based on the patient's diagnoses and procedures performed during the hospitalization. SOI is defined as "the extent of organ system loss of function or physiologic decompensation" and is categorized as minor, moderate, major, and extreme (22). SOI scores are calculated using all available information up to and including the discharge date. We also used a validated algorithm to measure the baseline frailty index as a covariate using the diagnosis codes. The algorithm contains 16 conditions

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(arthritis, chronic skin ulcer, CI, congestive heart failure, depression, falls, gout or other crystal-induced arthropathy, impaired mobility, musculoskeletal problems, mycoses, paranoia, Parkinson disease, pneumonia, skin and subcutaneous tissue infections, stroke, and urinary incontinence) to predict the probability of being frail (21).

Also included in the model were hospital characteristics, including the number of hospital beds (small, medium, and large), teaching status (metropolitan nonteaching, metropolitan teaching, and nonmetropolitan hospital), ownership (government nonfederal [public], private not-for-profit [voluntary], and private investor-owned [proprietary]), and urban-rural designation (large metropolitan areas, small metropolitan areas, micropolitan areas, not metropolitan or micropolitan).

Statistical Analysis

Patients initially hospitalized with SH or DKA were analyzed separately as two distinct cohorts. All analyses were conducted using sample weights for national estimates following Healthcare Cost and Utilization Project specifications for using the NRD.

Given that the decision to recommend PDC encompasses a variety of factors—ranging from patient demographics, severity, frailty, and cognitive status to clinical physicians—to optimally address the baseline characteristic difference between those who did and did not receive PDC, we wanted to exhaustively use the full information contained in this database. We therefore used a high-dimensional propensity score (HDPS) analysis. This technique is semiautomated and particularly advantageous as it allows for the automatic identification and prioritization of not just measured confounders but also potential proxies for unmeasured confounders in a large health care database (23,24). We included all diagnosis code positions and all procedure code positions of each patient during their initial admission as the high-dimensional domains into the HDPS algorithm. At the same time, key variables, such as CI status, risk of mortality, frailty, and severity level, were specifically forced into the HDPS algorithm to ensure balanced distribution across the study cohorts. We used the propensity score obtained to construct a population through inverse-probability of treatment weighting (IPTW) with trimming in which patient characteristics were balanced between those who did and did not receive PDC.

The 30-day readmission rate was defined as the number of patients who were readmitted within 30 days after the initial discharge of all patients discharged alive.

We generated Kaplan-Meier survival curves to compare the probability of readmission between the CI and non-CI group, using log-rank testing for comparison. To compare the time to 30-day readmission between the CI and non-CI group, in the IPTW weighted population, we applied a multivariable Cox proportional hazards regression model to calculate the adjusted hazard ratio (aHR) for readmission, adjusting for covariates including patients' demographic information, socioeconomic status, severity, risk of mortality, frailty, and hospital-related variables. PDC was included as an interaction term with CI.

We also conducted a series of sensitivity analyses to examine the findings in different groups, including patients >65 years of age, type 2 diabetes, type 1 diabetes, patients with dementia, and patients with depression. Depression is a common feature of CI (25). Patients with depressive disorders also present with symptoms of memory loss and attention deficiency, which hinder diabetes management (26). Therefore, we added depressive disorder as a proxy and added it into the definition of CI in the sensitivity analysis.

Nonskewed continuous baseline variables are described using mean and SD. Skewed variables are described using median and interquartile range and compared. Categorical variables are reported as counts and percentages.

We conducted all data management and analyses using SAS 9.4 software (SAS Institute, Cary, NC). Data visualization was conducted using R Studio. A two-sided $P < 0.05$ was considered statistically significant.

RESULTS

Patient Characteristics

We identified 23,775 patients hospitalized due to SH and 140,490 patients hospitalized due to DKA; of these, 53.3% of the patients in SH cohort and 45.8% of the patients in DKA cohort were women. The average age was 65.9 ± 15.3 in the SH cohort and 40.3 ± 15.4 in the DKA cohort, and 2,675 (11.2%) and 1,261 (0.9%) had a CI diagnosis at their index hospitalization, respectively (Supplementary Fig. 2).

For both DKA and SH patients, those with CI were older (SH: 78.4 ± 9.3 vs. 64.3 ± 15.2; DKA: 65.6 ± 15.2 vs. 40.1 ± 15.2), more likely to be enrolled in Medicare (SH: 89.6% vs. 63.3%; DKA: 69.3% vs. 15.9%), and more likely to be at moderate risk of mortality (SH: 86.0% vs. 61.5%; DKA: 76.7% vs. 30.7%) (Table 1).

Readmission Rates and PDC

For SH patients, the 30-day crude all-cause readmission rate was 11.0% (95% confidence interval 10.6–11.5) for patients without CI and 11.4% (95% confidence interval 10.2–12.8) for those with CI, with no significant difference between the groups. For DKA patients, the crude readmission rate was 9.4% (95% confidence interval 9.2–9.6) for patients without CI and 14.4% (95% confidence interval 12.4–16.5) for those with CI. See Supplementary Fig. 3 for the Kaplan-Meier curve.

The baseline characteristics comparisons between those who did and did not receive PDC are summarized in Table 2. Patients at an older age, with more severe conditions, and frailer, tend to have a higher likelihood of receiving PDC. We conducted IPTW to balance patient baseline characteristics between those who did and did not receive PDC. After the weighting, all measured sociodemographic variables were balanced (standard mean difference <0.1).

In the PDC-balanced population, we used a Cox proportional hazard model to assess the association between CI and readmission. Patients in a more severe condition at their initial admission tended to have a higher readmission risk. When we adjusted for other included covariates, CI was associated with 23% higher risk of 30-day all-cause readmission among patients with CI compared with patients without CI (aHR 1.23, 95% confidence interval 1.08–1.40). For DKA patients, after adjusting for covariates, we found a 35% increase in the risk of readmission among patients with CI compared with patients without CI (aHR 1.35, 95% confidence interval 1.08–1.70). Other variables associated with increased readmission risk included being discharged with PDC, having more severe conditions and a higher

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Table 1—Baseline characteristics of hypoglycemia and ketoacidosis patients with and without CI

	Patients initially admitted due to SH		Patients initially admitted due to DKA	
	Non-CI (*n* = 21,100)	CI (*n* = 2,675)	Non-CI (*n* = 139,229)	CI (*n* = 1,261)
Female sex	11,110 (52.7)	1,578 (59.0)	63,694 (45.8)	710 (56.3)
Age at admission, years	64.3 ± 15.2	78.4 ± 9.3	40.1 ± 15.2	65.6 ± 15.2
Median annual household income				
$1–24,999	7,607 (36.5)	896 (33.8)	49,127 (35.8)	423 (34.1)
$25,000–34,999	5,461 (26.3)	702 (26.4)	38,311 (27.9)	337 (27.1)
$35,000–44,999	4,483 (21.5)	568 (21.4)	30,914 (22.5)	268 (21.6)
≥$45,000	3,271 (15.7)	489 (18.4)	18,968 (13.8)	214 (17.2)
Primary payer				
Medicare	13,336 (63.3)	2,359 (89.6)	22,083 (15.9)	872 (69.3)
Medicaid	3,440 (16.3)	102 (3.8)	43,560 (31.4)	187 (14.9)
Private insurance	3,136 (14.9)	125 (4.7)	48,802 (35.1)	131 (10.4)
Self-pay, others, no charge	1,154 (5.6)	50 (1.9)	24,426 (17.6)	68 (5.4)
During the initial hospitalization				
Risk of mortality				
Minor likelihood of dying	8,119 (38.5)	373 (14.0)	97,085 (69.8)	294 (23.3)
Moderate likelihood of dying	12,980 (61.5)	2,301 (86.0)	42,141 (30.7)	967 (76.7)
Severity of illness				
Minor loss of function	4,836 (22.9)	639 (23.9)	75 (0.1)	2 (0.2)
Moderate loss of function	11,968 (56.7)	1,686 (63.0)	106,348 (76.4)	926 (73.4)
Major loss of function	4,280 (20.3)	349 (13.1)	32,602 (23.4)	330 (26.2)
Extreme loss of function	15 (0.1)	0 (0)	201 (0.1)	3 (0.2)
Bed size of the hospital				
Small	3,614 (17.1)	463 (17.3)	26,335 (18.9)	254 (20.1)
Medium	6,514 (30.9)	849 (31.7)	41,309 (29.7)	366 (29.0)
Large	10,972 (52.0)	1,363 (51.0)	71,565 (51.4)	641 (50.8)
Control/ownership of the hospital				
Government, nonfederal	2,658 (12.6)	351 (13.1)	18,796 (13.5)	163 (12.9)
Private, not-for-profit	14,285 (67.7)	1,789 (66.9)	100,076 (71.9)	924 (73.3)
Private, investor-owned	4,157 (19.7)	535 (20.0)	20,357 (14.6)	174 (13.8)
Hospital teaching status				
Metropolitan nonteaching	5,842 (27.7)	752 (28.1)	38,132 (27.4)	334 (26.5)
Metropolitan teaching	13,345 (63.2)	1,685 (63.0)	85,195 (61.2)	781 (61.9)
Nonmetropolitan hospital	1,913 (9.1)	238 (8.9)	15,902 (11.4)	146 (11.6)
Hospital urban-rural designation				
Metropolitan areas				
Large (≥1 million residents)	13,109 (62.1)	1,705 (63.7)	73,207 (52.6)	683 (54.2)
Small (<1 million residents)	6,078 (28.8)	732 (27.4)	50,120 (36.0)	432 (34.3)
Micropolitan areas	1,341 (6.4)	165 (6.2)	11,935 (8.6)	102 (8.1)
Not metropolitan or micropolitan	572 (2.7)	73 (2.7)	3,967 (2.8)	44 (3.5)

Data are presented as *n* (%) or mean ± SD. PDC includes being discharged to skilled nursing facilities, intermediate care facilities, or home health care. The risk of mortality and the severity of the condition during the initial hospitalization were measured by the APR-DRG algorithm using all diagnoses and medical procedures from admission to discharge. For disease severity, each level suggests different levels of extents of organ system loss of function or physiologic decompensation.

mortality risk during the initial admission, being admitted to hospitals with a larger number of hospital beds, and being admitted to private hospitals. These variables indicated that patients were in a more severe condition during their first admission, which was associated with a later higher readmission risk. We also found higher income, private insurance, and metropolitan teaching hospital were associated with lower readmission risk, suggesting better socioeconomic status and access to health care resources was associated with reduced readmission risk. The full model output is summarized in Supplementary Table 3.

When the SH group was discharged with PDC, the association of CI and risk of 30-day all-cause readmission became insignificant (aHR 0.93, 95% confidence interval 0.83–1.05). Compared with the patients discharged without PDC (aHR 1.23, 95% confidence interval 1.08–1.40), the CI-associated risk of readmission was reduced by 24% (95% confidence interval 17–31). The interaction term *P* value was 0.001, indicating PDC had a modifying effect on the CI-associated readmission risk. When the DKA group was discharged with PDC, the difference in the risk of readmission between patients with and without CI was not significant (aHR 0.98, 95% confidence interval 0.80–1.20). Compared with the patients discharged without PDC (aHR 1.35, 95% confidence interval 1.08–1.70), the CI-associated risk

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Table 2—Baseline characteristics comparison between those who did and did not receive PDC at baseline, before and after weighting

	Hypoglycemia cohort						Ketoacidosis cohort					
	Before weighting			After weighting			Before weighting			After weighting		
Variables	Received no PDC	Received PDC	SMD	Received no PDC	Received PDC	SMD	Received no PDC	Received PDC	SMD	Received no PDC	Received PDC	SMD
Having CI	6.4	23.0	0.48	11.9	11.9	−0.001	0.5	6.1	0.32	1.0	1.0	−0.001
Female	52.0	58.2	0.13	54.0	53.7	−0.007	45.8	51.3	0.11	46.2	44.3	−0.04
Age at admission, years	63.3 ± 15.2	72.9 ± 12.5	0.69	66.4 ± 18.1	66.5 ± 26.8	0.01	39.4 ± 14.8	54.4 ± 16.4	0.96	40.6 ± 16.1	39.7 ± 57.6	−0.06
Median annual household income			0.02			0.003			−0.02			0.03
$1–24,999	36.2	35.1		36.0	36.0		35.4	37.2		35.5	34.3	
$25,000–34,999	25.9	27.2		26.4	26.5		28.0	26.9		27.9	28.1	
$35,000–44,999	21.5	21.6		21.4	21.1		22.7	21.4		22.6	22.6	
≥$45,000	16.0	16.2		16.2	16.4		13.9	14.6		14.0	14.8	
Primary payer			−0.48			−0.03			−0.70			0.02
Medicare	59.5	83.4		67.2	68.1		14.0	47.0		16.6	16.8	
Medicaid	17.0	8.8		14.5	14.6		30.9	27.3		30.6	30.0	
Private insurance	17.3	5.7		13.5	13.0		37.0	19.7		35.6	35.6	
Self-pay, others, no charge	6.2	2.1		4.8	4.5		18.1	6.0		17.2	17.6	
Risk of mortality during initial hospitalization			0.20			−0.003			0.52			0.01
Likelihood of dying												
Minor	40.4	23.5		35.1	35.2		71.0	46.4		69.1	68.9	
Moderate	59.6	76.5		64.9	64.8		29.0	53.6		31.0	31.4	
Being frail	24.3	50.8	0.57	32.9	33.4	0.01	0.8	9.6	0.40	1.6	1.6	0
Illness severity during initial hospitalization			0.20			0.02			0.52			0.01
Loss of function												
Minor	25.6	16.6		22.7	21.9		0.1	0.1		0.1	0.2	
Moderate	55.8	61.3		57.7	58.2		77.4	60.8		76.0	75.5	
Major	18.5	21.9		19.6	19.8		22.4	38.5		23.7	24.1	
Extreme	0.1	0.1		0.1	0.1		0.1	0.6		0.2	0.2	

Data are presented as the percentage of patients or as the mean ± SD. To assess PDC's effect modification effect on the direct association between CI and readmission, we balanced the characteristics of patients who did and did not receive PDC. We used a HDPS algorithm to predict the probability of receiving PDC. We added patients' baseline age, sex, income, payer, CI status, frailty, severity, risk of mortality, and hospital-related information into the prediction model. We also added patients' diagnosis and procedure codes into the algorithm. With the propensity score of receiving PDC, we used IPTW to balance the patient characteristics between those who did and did not receive PDC. The patients' characteristics are compared before and after weighting. A standard mean difference (SMD) of <0.1 was considered as a good balance.

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Table 3—The aHR of readmission for patients discharged with and without PDC

	Patients initially admitted for SH, aHR (95% confidence interval)	Patients initially admitted for DKA, aHR (95% confidence interval)
Without PDC		
Having CI		
No	Reference	Reference
Yes	1.23 (1.08–1.40)*	1.35 (1.08–1.70)*
With PDC		
Having CI		
No	Reference	Reference
Yes	0.93 (0.83–1.05)	0.98 (0.80–1.20)

The analysis excluded the patients who had a major and extreme likelihood of mortality during the index hospitalization. *Indicates a statistically significant result.

of readmission was reduced by 27% (95% confidence interval 18–36). The interaction term *P* value was 0.034, indicating PDC had a modifying effect on the CI-associated readmission risk. The results are summarized in Table 3.

Sensitivity Analysis

The results of the sensitivity analysis are included in Supplementary Fig. 4. Our findings in the main analyses were consistent in different subgroups, unless those had insufficient power to make the conclusion (e.g., age-group >65 years in the DKA cohort and type 1 diabetes group in the SH cohort). We found the increased readmission risk associated with CI was more pronounced among patients with dementia and in older age-groups. At the same time, we observed more mitigating effects of PDC on the CI-associated extra readmission risk.

CONCLUSIONS

Using a national sample of hospital admissions, we investigated the impact of comorbid CI among individuals with diabetes on hospital readmission rates and the role of PDC in reducing the risk of readmission. We found patients with comorbid CI were more likely to experience hospital readmission within 30 days of discharge if PDC was not provided. The study's findings align with previous research demonstrating an increased risk of readmission associated with CI among community-dwelling adults (9) and Medicare patients with type 2 diabetes (27). Other variables were associated with increased readmission risk such as risk of mortality and severity of illness during the initial hospitalization. We found other variables, such as higher income level and private insurance (vs. Medicare), were associated with lower readmission risk, suggesting that better socioeconomic status and health care resources might play a role in reducing readmission risk. On the other hand, hospitals with a small number of beds (vs. large and medium) and private hospital (vs. government, nonfederal) were associated with a high readmission risk. This could be associated with baseline condition severity. It is more likely that severe and complicated cases were admitted to hospitals with better equipment.

Our study adds to the literature by highlighting the vulnerability of patients with diabetes and CI after the discharge and the importance of PDC in reducing the excessive readmission risk associated with CI among individuals with diabetes (28,29). Organizations including the Centers for Disease Control and Prevention and Centers for Medicare & Medicaid Services (30,31) recommend implementing PDC to prevent readmission risk.

Effective PDC planning and implementation are essential for optimal medication adherence and glucose monitoring, compensating for the limitations in self-management arising from CI, and thus to reduce future readmission (32,33). Also, PDC provides family members an opportunity to be educated about the intricacies of caring for CI patients and to provide potential solutions (34). For an optimal implementation of PDC, it is also necessary to consider efficient communication between different stakeholders—patients, their families, primary care providers, endocrinologists, and neurologists—to ensure consistent and efficient care (35,36). Geriatric specialists should also be involved in the PDC planning. Previous trial evidence has shown a high-quality geriatric assessment is essential for ensuring PDC and reducing future readmission (37). On the other hand, as found in our analysis, higher income level, private insurance, and better medical resources were associated with lower readmission risk, indicating the necessity to account for potential health disparities related to factors including socioeconomic status and race/ethnicity in accessing good health care and PDC of high quality (38).

Additionally, our study underscores the importance of improving the measurement of PDC in future research. We used discharge disposition as a proxy for PDC at discharge. To be noted, the NRD does not provide detailed information on the content and quality of PDC, such as the specific types of PDC services provided, the duration of care, and the frequency of follow-up. Also, it is challenging to evaluate the quality-of-care coordination and communication among health care providers, which is an essential component of effective PDC. Furthermore, the database does not capture whether patients received care from sources outside of the hospital system, such as primary care providers or specialists, which may impact the effectiveness of PDC. Given the complex nature of PDC, there is a need to develop standardized measures that capture the content and quality of PDC services, including care coordination and communication among health care providers. This would enable more precise and accurate evaluation of the effectiveness of PDC in reducing readmission rates and improving patient outcomes.

The strengths of the study included the use of a large and national representative sample. We included both individual sociodemographic information and hospital information to adjust for potential confounders.

Our study also has several limitations to be recognized. First, the algorithm to detect CI could be suboptimal in sensitivity despite a comprehensive literature review and physician input, especially the CI of milder symptoms. Approximately 80% of the CI detected was dementia. According to several cohorts investigating CI prevalences among individuals with diabetes in the U.S. (most of them focusing on the population >65 years), the prevalence ranged between 15 and 26% (1–3). Our dementia prevalence among the hypoglycemia and ketoacidosis cohorts >65 years of age was 22.7 and 16.3%, which was consistent with the existing literature. However, for mild CI symptoms, they could be

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underdocumented since CI is often not noticed and recorded until there are significant impairments in functioning and self-management behaviors (39). Compared with the prospective studies actively investigating mild CI, NRD as a retrospective inpatient admission database is less sensitive to detect these milder cognitive symptoms. Therefore, our findings are more relevant for patients with more severe CI symptoms. Age was thus considered as another factor for the lower CI prevalence in the DKA cohort. The average age was 40 in the DKA cohort compared with 66 in the SH cohort. The lower CI prevalence in NRD also delineated the fact that CI was currently an underdetected diabetes comorbidity. Using neuropsychological evaluations for a more accurate diagnosis in both clinical and research settings is important to comprehensively identify CI in later research settings.

Second, the NRD has a limitation of not tracking postdischarge mortality events. This competing risk prevented us from observing the readmission. Since the patients with CI in both groups tended to be older in age and to have more severe conditions, the risk of postdischarge mortality can be a differential between the patients with and without CI (i.e., due to higher mortality risk, it would be harder for us to observe readmission among the CI group), which could bias our HR estimates toward 1 or even <1. We excluded the patients with major or extreme likelihood of mortality during the index hospitalization and only included the patients with minor or moderate mortality risk, trying to reduce the potential bias.

We also recognize that we assessed only some types of PDC. We found the mitigating effect of PDC on CI-related readmission risk among those discharged to a nursing home and home health care. Future analysis including a more comprehensive PDC spectrum assessing the same topic is warranted. To be noted, patients discharged home could still receive some form of care not captured in the database. If so, our estimation could be conservative, and thus, the real effect could be more significant.

Lastly, some important factors, such as race/ethnicity, drug use, duration of diabetes, previous history of admission, and glycemic indices, were not available in the database for analyses and thus were unable to be adjusted for. Future studies should reassess this question using more detailed and comprehensive data, including postdischarge mortality, for a more definite conclusion.

CONCLUSIONS

Comorbid CI is associated with increased risk for readmission among people with SH or DKA. Our findings highlighted the potential benefit of PDC in mitigating the excessive readmission risk associated with CI. Such interventions serve to reduce unnecessary health care use and expenditures in the form of preventable hospital readmission. Future studies need to enhance the sensitivity of detecting CI and include a more comprehensive range of PDC and assess their benefits in mitigating CI-associated risk.

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