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HOSPITAL MANAGEMENT OF DIABETES (GE UMPIERREZ, SECTION EDITOR)

Hospital Readmission of Patients with Diabetes

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Abstract Hospital readmission is a high-priority health care quality measure and target for cost reduction. Despite broad interest in readmission, relatively little research has focused on patients with diabetes. The burden of diabetes among hospitalized patients, however, is substantial, growing, and costly, and readmissions contribute a significant portion of this burden. Reducing readmission rates of diabetic patients has the potential to greatly reduce health care costs while simultaneously improving care. Risk factors for readmission in this population include lower socioeconomic status, racial/ethnic minority, comorbidity burden, public insurance, emergent or urgent admission, and a history of recent prior hospitalization. Hospitalized patients with diabetes may be at higher risk of readmission than those without diabetes. Potential ways to reduce readmission risk are inpatient education, specialty care, better discharge instructions, coordination of care, and post-discharge support. More studies are needed to test the effect of these interventions on the readmission rates of patients with diabetes.

Keywords Hospital readmission · Inpatient diabetes · Transitional care · Transitions of care · Risk factors · Discharge support

Introduction

Hospital readmission is a high-priority health care quality measure and target for cost reduction, particularly within 30 days of discharge (30-day readmission, aka early readmission) [1–3]. Despite the broad interest in readmission, relatively little research has focused specifically on readmission of patients with diabetes [4–6]. The burden of diabetes among hospitalized patients, however, is substantial, growing, and costly, and readmissions contribute a significant portion of this burden. Reducing readmission rates among patients with diabetes has the potential to greatly reduce health care costs while simultaneously improving care. Recent research has provided some insight into the risk factors for readmission and the barriers to reducing readmission risk, as well as ways to mitigate that risk.

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Why Should We Care About Readmission Among Diabetic Patients?

Many believe readmission rates reflect the quality of health care delivery, although this is debated [7]. Starting October 1, 2012, the Centers for Medicare and Medicaid Services began to decrease payments to hospitals that have greater-than-expected 30-day readmission rates under the Hospital Readmission Reduction Program established by the Patient Protection and Affordable Care Act, reflecting an effort to motivate improvements in care while reducing costs [8]. In the current era of major health care reform, there is growing interest in hospital readmissions. There has been an exponential rise in the past decade of PubMed-cited articles published in this area, from less than 100 annually in the 1980s to 1379 in 2013 [9].

Despite interest in readmissions, few studies have focused on readmissions among patients with diabetes [4–6]. There were only 85 publications listed on PubMed containing the search terms “hospital, readmission, and diabetes” in 2013 [9],

and many of these publications are not relevant to this topic. The lack of attention paid to readmission of diabetic patients may reflect the fact that less than 2 % of hospital discharges annually list a *primary* diagnosis of diabetes [10]. This statistic, however, belies the reality that the burden of diabetes among hospitalized patients is substantial, growing, and costly. Patients with diabetes currently represent about 9 % of the US population [11], but they account for approximately 25 % of hospitalizations (over eight million per year) [10, 12, 13]. The number and proportion of hospitalized patients with diabetes has increased steadily over the past two decades [10, 12, 14], mirroring the increasing incidence and prevalence of diabetes in the general population [11, 15]. While the overall 30-day readmission rate of hospitalized patients is 8.5–13.5 % [16, 17], the 30-day readmission rate of diabetic patients is 14.4–22.7 % [18–22]. Estimates of readmission rates beyond 30 days after hospital discharge are even higher, with over 26 % of diabetic patients being readmitted within 3 months and 30 % within 1 year [18, 19] In 2012, costs associated with the hospitalization of diabetic patients in the USA were $124 billion, of which an estimated $25 billion was attributable to 30-day readmissions assuming a 20 % readmission rate [12, 20]. Therefore, reducing 30-day readmissions of patients with diabetes has the potential to greatly reduce healthcare costs while simultaneously improving care. A modest 5 % reduction in the 30-day readmission rate would result in 82,754 fewer admissions per year based on Agency for Healthcare Research and Quality Nationwide Inpatient Sample data from 2012, translating into an estimated annual cost savings of $1.2 billion [10, 20]. These data and the widespread interest in health care reform have prompted recent calls for more research on how to prevent readmissions in this important group of patients [4, 5, 21].

In order for readmissions to be prevented, they must first be understood. A good understanding of the causes and risk factors for readmission is crucial. Readmission risk reduction interventions are more likely to be effective if they are informed by a solid understanding of the factors contributing to readmission risk. However, these interventions (discussed below) require human and financial resources. The resource requirements of interventions combined with the substantial prevalence of diabetes among hospitalized patients make interventions that attempt to reduce readmissions among all patients with diabetes impractical. Resources should therefore be focused on the highest-risk patients. Such high-risk patients do indeed exist. The Urban Diabetes Study, which included 291,752 discharges of diabetic patients in Philadelphia, PA, found that 10.5 % of the patients were discharged at least five times over 8 years. This group of high utilizers accounted for 64 % of all the discharges during the study period [22].

Risk Factors for Readmission Among Patients with Diabetes

30-Day Readmission

Studies of readmission risk factors among patients with diabetes can be grouped into those that focused on readmission within 30 days and those that examined readmission over longer time periods. Risk factors for 30-day readmission based on studies of at least 2000 patients are presented in Table 1 [22–25, 26•, 27•, 28••, 29, 30]. The following factors are associated with an increased risk of 30-day readmission and have been reported by at least two studies: male gender, comorbidity burden, hospital length of stay, government insurance vs. private or no insurance, emergent or urgent vs. elective admission, recent prior hospitalization, and being discharged against medical advice. Factors that are associated with an increased risk of 30-day readmission but have only been reported by one study or in abstract form include lower education level, being unemployed, living in an urban area vs. a remote rural area, lower income, receiving inpatient nutrition support, increased serum creatinine, lower serum hematocrit, being discharged with home health care or to another institution, the number microvascular or macrovascular diabetes complications, failing to recognize and document a diagnosis of diabetes, and, counterintuitively, having outpatient follow-up within 30 days of discharge. It is possible that sicker patients were more motivated to obtain follow-up than healthier patients and thus were more likely to be readmitted. There are conflicting data on the associations of age, race, ethnicity, proximity to the hospital, and A1c with 30-day readmission.

The few studies exploring an association of A1c with 30-day readmission deserve a comment. A recently published single-center retrospective cohort study of 2265 hospitalized diabetic patients with an A1c >9 % did not find an independent association of baseline admission A1c with 30-day readmission [26•]. In contrast, a single-center retrospective cohort study of 1949 hospitalized patients with type 2 diabetes in a Boston-area primary care network found that the subgroup of patients with an admission A1c ≥8 % had an approximately 20 % lower odds of 30-day readmission for each 1 % increase in A1c [31•]. In further contrast, a retrospective cohort study of 880 diabetic and non-diabetic patients who underwent coronary artery bypass surgery found that a preoperative A1c >6 % was associated with a roughly twofold increase in the odds of readmission within 30 days after surgery [32]. Lastly, a retrospective cohort study of nearly 70,000 inpatients with diabetes found that merely measuring the A1c was associated with a decreased risk of 30-day readmission among patients with a primary diagnosis of diabetes but not those with other primary diagnoses [29]. This suggests that greater attention to diabetes reflected by A1c measurement may improve outcomes among patients hospitalized for diabetes. The

Table 1 Risk factors for 30-day readmission of patients with diabetes

Risk factor	Effect, if statistically significant [reference]								
	[23]	[24]	[25]	[26•]	[22]	[27•]	[28••]	[29]	[30]
Sociodemographics									
Male vs. female gender	+	−			+	+			+
Increasing age		−			−	NS		NS	+
Black vs. white		NS	NS	NS	+	+	+		
Hispanic vs. white			+		−				
Less than college vs. college graduate						+	+		
Disabled vs. employed						+	+ +		
Retired vs. employed							+ +		
Unemployed vs. employed							+		
Lower income county		+							
Home zip code <5 miles from hospital				NS			+		
Remote rural vs. urban residents		− −							
Insurance: Private vs. Medicare					−				
Insurance: Private vs. none				NS		+	+		
Insurance: Medicaid vs. none				+					
Insurance: Medicare vs. none				NS	+				
Insurance: Medicaid vs. private							+		
Hospital-related									
Number of prior hospitalizations					+				
Discharge within 30 days prior to admission						+ +			
Urgent or emergent vs. elective admission					+		+	+	
Admission serum creatinine, mg/dl						+	+		
Admission hematocrit, per 5 %						−	−		
Length of stay	+	+		+	+	NS		+	
Discharge with intravenous catheter vs. self-care				+ +					
Discharge against medical advice					+	+			
Diabetes-related									
Microvascular complications, per diagnosis							+		
Macrovascular complications, per diagnosis							+		
DM dx not coded, had prior dx vs. coded, had prior dx			+						
Pre-admission glucocorticoid							+		
Pre-admission insulin						+	+		
Therapy intensification on discharge									
Inpatient diabetes education				− −					
A1c, %				NS					
Other									
Pre-admission statin							+		
Comorbidity burden	+	+			+ +				+
Outpatient follow-up within 30 days		+ +							

− odds ratio (OR) 0.75–0.99 or not provided, − − OR<0.75, + OR 1.01–2.00, + + OR>2.00, *DM* diabetes mellitus, *dx* diagnosis, *NS* not statistically significant

association of A1c with 30-day readmission therefore remains unclear and may depend on the level of glycemic control and reason for hospitalization.

Most of the studies noted above used administrative databases to explore readmission risk factors or were not designed to identify reasons for readmission per se. In an effort to broaden the understanding of 30-day readmission among patients with diabetes, we performed a qualitative study [33•]. Based on thematic analysis of semi-structured interviews of adult inpatients with diabetes who were readmitted within

30 days of hospital discharge, we identified five themes that contribute to readmission risk: (1) poor health literacy, i.e., lack of knowledge about diabetes and discharge instructions, (2) health system failure of the hospital discharge process and post-discharge support, (3) failure of factors that were expected to be protective, such as following the discharge instructions, being aware of medication changes upon discharge, and having help and social support at home, (4) social determinants of health impeding care, and (5) loss of control over illness. Most of the patients reported needing help with transportation, medications, and food. Patients generally denied actively exacerbating their condition prior to readmission and believed that being readmitted was out of their control. These findings suggest several points of intervention that will be discussed below.

Predicting Early Readmission Risk

While the work by other groups discussed thus far provides some insight into 30-day readmission risk factors for diabetic patients, none provides the ability to identify individual high-risk patients at the point of care. We therefore developed the Diabetes Early Readmission Risk Index (DERRI), which is a multivariable logistic regression model that predicts the risk of all-cause 30-day readmission among hospitalized patients with diabetes [28••]. The DERRI is based on a retrospective cohort of 17,595 adult patients with diabetes discharged between 2004 and 2012. Out of the 43 variables examined, there were 13 statistically significant predictors of 30-day readmission retained in the model (included in Table 1). The DERRI has good discriminatory ability (C-statistic 0.72) and is adequately calibrated (Hosmer-Lemeshow goodness-of-fit test $p=0.41$). Early readmission risk in the highest tertile was 40 %, accounting for 58 % of all early readmissions. This early readmission risk index may be useful for targeting discharge support resources to those at higher risk.

Readmission Beyond 30 Days After Discharge

Not surprisingly, there is considerable overlap among risk factors for 30-day readmission of patients with diabetes and readmission more than 30 days after discharge, including higher comorbidity burden, public versus private insurance, lower income, length of stay, diabetes-related complications, and renal disease [18, 19, 26•, 34, 35]. While data on the effect of race and ethnicity on 30-day readmission were mixed, multiple studies have shown that African American and Hispanic patients are at greater risk of readmission after 30 days than Caucasians [18, 26•, 34]. In contrast to 30-day readmission, patients living in urban areas are more likely to be readmitted after 30 days than rural patients [18, 36].

As with the data on 30-day readmission, the effect of glycemic control on later readmission is unclear. There is some evidence to support the hypothesis that poor glycemic control contributes to long-term readmission risk. First, a high A1c is associated with an increased risk for hospitalization for any-cause and cardiovascular disease [37–39]. Second, insulin therapy post-discharge is associated with a lower risk of readmission at 1 year. In a study of patients with type 2 diabetes who used insulin before and during hospitalization, patients who continued insulin after discharge had lower risks of all-cause and diabetes-related readmission within 12 months compared to patients who did not continue the insulin [40]. A companion study of insulin-naïve type 2 diabetes patients with baseline A1c levels ≥8 % who initiated insulin during hospitalization found a trend for an association between insulin continuation and lower risk of readmission [41]. Among the subgroup of patients, however, with a baseline A1c ≥9 %, insulin continuation was significantly associated with a lower risk of all-cause (adjust hazard ratio [HR] 0.58 [0.36–0.93] 95%CI) and diabetes-related readmission (adjusted HR 0.46 [0.23–0.87] 95%CI).

In contrast to the evidence supporting a role of poor glycemic control in contributing to readmission risk, some data actually suggest that poor glycemia is associated with lower readmission risk. A one-arm pilot trial of individualized diabetes education and phone follow-up in 82 patients with an A1c >9 % found that lower baseline A1c was a weak predictor of readmission at 3 months but not at 6 months [42••]. The same group performed a retrospective analysis of 2069 hospitalized diabetic patients with a baseline A1c >9 % and found that higher A1c was associated with lower risk of readmission within 6 months [26•]. Post hoc analysis revealed that higher A1c was only associated with lower readmission risk among those patients who received inpatient diabetes education, suggesting that patients with the worst glycemic control may stand to gain the most from education. Given the conflicting evidence regarding glycemic control and readmission risk, it is unclear if hyperglycemia is a marker for increased risk or a cause for readmissions. More research is needed to clarify this relationship.

Diabetes as a Risk Factor for Readmission

Patients with diabetes may be at higher risk of readmission than those without diabetes. In a study of 4769 medical patients, diabetes was associated with a statistically significant 40 % increased risk of readmission within 90 days [43]. Diabetes is also associated with an increased risk of readmission in patients hospitalized for cardiac surgery [44, 45], heart failure [46, 47], acute myocardial infarction [48], stroke [49], or liver disease [50]. In contrast, recent studies have not found that diabetes is independently associated with an increased risk of 30-day readmission in medical patients or veterans

[51, 52]. Considered together, these data suggest that the effect of diabetes on readmission risk may vary by length of follow-up and by primary reason for hospitalization.

Barriers to Reducing Readmission Risk of Patients with Diabetes

Having established that the risk of readmission of diabetic patients depends on multiple sociodemographic, medical, and process-related factors, and given the complexity of diabetes management, it is not surprising that multiple barriers to reducing readmission risk exist. Competing medical priorities may overshadow diabetes in the discharge planning process, especially among patients hospitalized for other reasons. For example, a survey of medical charts of diabetic patients at one academic teaching hospital found that 60 % of discharge notes mentioned diabetes, and only 20 % of discharges included a plan for diabetes follow-up [53]. Similarly, in our small qualitative study of readmitted diabetic patients, very few discharge instructions included diabetes-specific information other than medications [33•]. Despite the recommendation to intensify diabetes therapy in poorly controlled patients upon discharge [54], such intervention is often deferred to the outpatient setting [55]. Adding to the complexity of discharge planning, most patients have an inpatient regimen that is very different from their outpatient regimen, in accordance with current guidelines to discontinue non-insulin diabetes medications upon admission [54]. Furthermore, assessment of glycemic control and adjustment of diabetes therapy, especially insulin, should be performed much sooner after discharge than for most other chronic conditions [56••]. Lastly, providers may fail to provide outpatient follow-up within 30 days [55].

In addition to these health system factors, there are several patient-related factors that impede efforts to minimize readmission. Poor health literacy may be of particular importance given that diabetes requires more engagement by patients than many other chronic conditions [33•]. Patients with lower health literacy may not remember or understand their discharge instructions. In addition, misperceptions about diabetes control may persist despite inpatient diabetes education [57]. Poor health literacy, along with lack of financial resources and feeling powerless to control one's health, may contribute to medication nonadherence [33•]. Lack of financial resources, including transportation and health insurance, may impede the ability of patients to keep outpatient follow-up appointments [58]. Inadequate finances may also make it difficult to reach patients by phone, which limits the utility of phone-based interventions [42••, 57]. Although many of these factors apply to hospitalized patients in general, the multiple causes of readmission and barriers to reducing readmission risk of diabetic patients are complex and merit specific consideration.

Strategies for Reducing Readmission Risk of Patients with Diabetes

Although a number of trials have tested strategies to reduce readmission rates in various hospital populations, few have focused on patients with diabetes [59–65]. Rather, most of these studies have enrolled unselected hospitalized patients, those on medical services, the elderly, or those admitted for heart failure or other specific conditions. These trials have shown significant relative reductions in 30-day readmission risk ranging from 30 to 75 %. With one exception, all of the successful studies tested multi-component discharge bundles, suggesting that bundled interventions may realize an additive effect beyond that seen with a single intervention. Common components of these interventions were patient-centered discharge education, peri-discharge coordination of care, and post-discharge support. Whether these strategies could be applied successfully to patients with diabetes is unknown.

Evidence supporting readmission risk reduction interventions specifically in diabetic patients comes from several retrospective and small prospective studies. The data from randomized controlled trials of inpatient diabetes specialty care are mixed. One trial in 179 hospitalized patients with diabetes found that daily rounds by a nurse diabetes educator and an endocrinologist improved inpatient glycemic control and reduced all-cause readmission rates at 3 months from 32 to 15 % (p=0.01) [66]. In contrast, however, a randomized controlled trial in 300 diabetic inpatients found that a diabetes specialist nurse decreased length of stay but did not affect readmission rates at 1 year [67]. Readmissions before 1 year were not assessed in this trial, and it is possible that diabetes specialty care may only affect readmission risk less than 1 year after discharge.

Several studies have examined the effect of inpatient diabetes education on readmissions. A single-center retrospective cohort study in more than 2000 hospitalized diabetic patients with a baseline A1c >9 % found that inpatient diabetes education significantly reduced the risk of 30-day readmission by 44 % and 180-day readmission by 20 % [26•]. In a one-arm pilot trial of inpatient diabetes education and post-discharge phone follow-up in 82 patients with a baseline A1c >9 %, the 180-day readmission rate for uncontrolled hyperglycemia was 3.2 %, down from 28 % of admissions due to hyperglycemia [42••]. Also in support of a beneficial effect of education, another randomized controlled trial of poorly controlled hospitalized patients with diabetes found that pharmacist discharge counseling improved medication adherence during the 150 days after discharge, increased the rate of follow-up visits, and lowered the A1c by 2 %. Although readmissions were not assessed in this study, it suggests some of the ways diabetes education may reduce readmission rates. Lastly, a randomized controlled trial in 65 diabetic patients admitted for hypoglycemia found that inpatient education, adjustment

of medications, and discharge planning significantly reduced the incidence of 30- and 90-day readmissions for hypoglycemia while also reducing length of stay by more than 2 days [68].

In addition to inpatient diabetes specialty care and education, a few studies have explored the effect of intensifying diabetes therapy on readmission rates. A retrospective cohort study of 1949 hospitalized patients with type 2 diabetes found that intensifying diabetes therapy was not associated with 30-day readmission or emergency department visits [31•]. Among medical patients with a baseline A1c ≥8 %, however, intensification of therapy was associated with a statistically significant 77 % lower odds of 30-day readmission/emergency department visits and a 1.8 % lower A1c. Similarly, a retrospective cohort study of insulin naïve patients with type 2 diabetes initiated on insulin during hospitalization reported a trend toward lower 1-year readmission risk for those with baseline A1c levels ≥8 % and a statistically significant lower risk in patients with baseline A1c levels ≥9 % [41]. Likewise, a smaller retrospective cohort study in patients with type 2 diabetes and baseline A1c levels ≥10 % found a similar beneficial effect of diabetes therapy intensification on 90-day readmission rates [69]. Thus, intensification of diabetes therapy upon discharge may reduce readmission risk among poorly controlled patients.

Another strategy for reducing readmission rates is dedicated outpatient support. A pilot randomized controlled trial in 100 diabetic medically indigent patients who lacked primary care reported that follow-up visits in a diabetes transitional care clinic 2 to 5 days after hospital discharge significantly decreased the rate of 90-day diabetes-related readmissions among the subgroup of patients originally admitted for diabetes [56••]. In the entire cohort, the transitional care clinic was associated with a nonsignificant reduction in 90-day readmissions (20 vs. 28 %). Another study focused on diabetes-related readmissions explored the effect of outpatient support provided to 115 patients with type 1 diabetes admitted for diabetic ketoacidosis [70]. In this nonrandomized trial, patients who consented to the intervention received at least four clinic visits annually in a dedicated diabetes treatment unit, monthly phone calls, and 24-h access to a diabetologist by phone. The intervention was associated with a significantly lower rate of readmissions for diabetic ketoacidosis over the 2-year study period, a 3 % lower A1c level, and a lower cost of diabetes-related care. Outpatient diabetes support therefore appears to decrease diabetes-related readmission risk.

Although not formally tested, there are a number of ways to improve the hospital discharge process and potentially reduce readmission risk. Our qualitative study of readmissions discussed above led to the conclusion that better communication of discharge instructions, involving patients more in medication reconciliation and scheduling follow-up appointments, and assessing barriers to following the discharge plan may decrease the risk of readmission [33•]. Discharge instructions should be written clearly at an appropriate reading and health literacy level [4]. Discharge paperwork should also include ways for patients to contact post-hospital care providers and information on follow-up appointments, which are best scheduled prior to discharge. Communication with patients can be optimized with the teach-back method, which has been used successfully for outpatient diabetes care [71]. A summary of strategies to reduce readmission risk among patients with diabetes is presented in Table 2.

Conclusions

Hospital readmission of patients with diabetes is an important health care quality measure and driver of costs. Major risk factors for readmission include lower socioeconomic status, racial/ethnic minority, greater burden of comorbidities, public insurance, emergent or urgent admission, and a history of recent prior hospitalization. Certain hospitalized patients with diabetes may be at higher risk of readmission than those without diabetes. Multiple health system and patient-related barriers to reducing readmission rates exist. A mix of expert opinion and a handful of mostly small studies provide a number of potential strategies for reducing readmission risk, including inpatient education, specialty care, better discharge instructions, coordination of care, and post-discharge support. The diabetes-specific strategies such as diabetes education, intensifying therapy, and outpatient diabetes care tend to be more effective in poorly controlled patients and tend to reduce

Table 2 Potential strategies to reduce readmission risk of diabetic patients

Inpatient diabetes education
For patients who are poorly controlled, new to diabetes or insulin, or have severe hypoglycemia
Inpatient diabetes consultation
For poorly controlled patients or those with a history of readmissions or recent severe hypoglycemia
Intensifying diabetes therapy based on admission A1c
Diabetes discharge instructions
Clearly written at an appropriate reading and health literacy level
Include information on follow-up appointments
Include contact information for providers
Using teach back to optimize patient communication
Follow-up planning
Involving patients in appointment scheduling
Assessing and addressing barriers to adherence
Post-discharge support by phone or outpatient visit within 1 week
Follow-up diabetes outpatient visit within 1 month after discharge

diabetes-related readmission risk more than all-cause readmission risk. Large randomized controlled trials are needed to test the effect of these interventions on readmission rates among patients with diabetes.

Compliance with Ethics Guidelines

Conflict of Interest Daniel J. Rubin has received grant support from Merck for a subcontract for inpatient diabetes research.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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- •• Of major importance

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