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# The readmission rates in patients with versus those without diabetes mellitus at an urban teaching hospital

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ABSTRACT

*Objective:* We examined the 30-day hospital readmission rates and their association with the admission diagnosis and the length of stay (LOS) in patients with diabetes versus those without diabetes mellitus (DM) in an urban teaching hospital.

*Methods:* In this retrospective study, we compared the 30-day readmission rates in patients with DM ($n = 16,266$) versus those without DM ($n = 86,428$) at an urban teaching hospital between January 1, 2013, and September 30, 2015. In individuals with a secondary diagnosis of DM, we analyzed the relationship between readmission rates and the ten most common Medicare Severity Diagnosis Related Groups (MS-DRGs). Additionally, we examined the relationship between the LOS and readmission rates in patients with diabetes and those without DM.

*Results:* The 30-day readmission rates adjusted for age and gender were higher in patients with DM compared to those without DM (15.3% vs. 8.4%, respectively, <0.001). The increased risk of readmissions was present both in patients with a primary or a secondary diagnosis of DM. For the secondary diagnosis of DM, statistically significant difference was present for two out of the ten most common DRGs (DRG # 313 [chest pain], and # 392 [esophagitis, gastroenteritis, and miscellaneous digestive disorders], $p = 0.045$ and 0.009, respectively). There was a direct correlation between LOS and readmission rates in both patients with diabetes and those without DM ($p < 0.001$ for both).

*Conclusions:* The 30-day readmission rates are higher in patients with DM compared to patients without DM. DM is an independent risk factor for hospital readmissions. The readmission rates correlate directly with LOS in both patients with diabetes and those without DM.



## 1. Introduction

According to the 2014 Center for Disease Control and Prevention (CDC), National Diabetes Statistics Report,[1] 29.1 million (or 9.3%) of the US population have diabetes mellitus (DM). This number is expected to rise dramatically due to population growth, aging, urbanization and increasing prevalence of obesity and physical inactivity.[2] Furthermore, patients diagnosed with DM have approximately 2.3 times higher annual per capita medical health care expenditures compared to patients without DM. The DM-related annual costs have been steadily increasing in the US from $174 billion in 2007 to $245 billion in 2012, with about 43% of these expenses associated with hospitalization.[3] The studies which assessed the characteristics of hospital readmissions in patients with DM[4,5] or interventions that may decrease readmission rates[6] are limited.

The Centers for Medicare and Medicaid Services (CMS)[7] define '*readmission*' as admission to a hospital within 30-days of discharge from either the same or a different hospital. Identifying patients with higher readmission risk is of primary importance to improve the quality of care and the outcomes for patients with DM.

In this study, we examined the 30-day readmission rates in a cohort of 102,694 patients with a primary or a secondary diagnosis of DM versus those without DM. We also reviewed the association between 30-day readmission rate and the primary admission diagnosis for the cases with a secondary diagnosis of DM and the relationship between 30-day readmission rates and the length of stay (LOS) in patients with diabetes versus those without DM.

Précis: In a cohort of 102,694 patients, we found that 30-day readmission rates are higher in patients with diabetes vs. those without, regardless of age and gender, and readmission rates increase with prolonged length of stay.

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## 2. Material and methods

### 2.1. Data source: hospital billing system

#### 2.1.1. The study cohort

We compared the 30-day readmission rates in patients with diabetes versus those without DM ($n = 16{,}447$ and $n = 86{,}415$, respectively). We identified all admissions with a primary or secondary diagnosis of DM to Northwell Health/Lenox Hill Hospital between January 01, 2013 and September 30, 2015, using the following primary or secondary International Classification of Diseases, 9th Revision (ICD-9) diagnosis codes: 249.00–249.91, 250.00–250.93, 790.2, or 251.2. We used these dates to include only ICD-9 codes as the Northwell Health System, and Lenox Hill Hospital started to use ICD-10 codes after September 30, 2015. We excluded the patients with the following diagnosis codes: psychiatry (Medicare Severity Diagnosis Related Groups [MS DRGs] 880–887) and chemical dependency (MS DRGs 894–897) as the study was limited to readmission due to medical or surgical reasons. We also excluded the patients with the following diagnosis codes: rehabilitation (MS DRGs 945–946); false labor (Principal ICD-9 Code 644.10); and deaths (discharge disposition: 'Expired').

Readmissions were counted if they occurred within 30-days following the date of discharge for the index admission. The analysis was conducted by patient. The first admission was accepted as the index admission. A readmission was identified as another admission within 30 days of the discharge date of the index admission (regardless of how many times the patient was readmitted in the 30-day period). Therefore, the denominator was the number of index admissions and the numerator was the number of times an index admission resulted in a readmission within 30 days. An admission beyond 30 days after the date of discharge for the index admission was counted as a new index admission.

#### 2.1.2. Data elements and statistical analysis

We calculated the readmission rates as the number of readmissions for any cause within 30 days after the discharge date divided by the number of discharges, expressed as a percent. We used a logistic regression model to explore the effect of diabetes, sex, and age on readmission rates. We performed chi-square analysis to assess an association between readmission rates and length of stay, diagnoses, DM status, age category, and gender. LOS was grouped into what we considered meaningful categories so we could see how readmission rates varied between these discrete categories. This grouping enabled us to use chi-square analysis. The lines in Fig. 2 were generated using linear regression. Although LOS is a skewed variable, linear regression is robust to violations of the normality assumption with the large sample size we used, so we feel its use was justified. We used a chi-square to test whether there were differences between the readmission rates of patients with diabetes and those without DM within each DRG. We did not use the logistic regression: with 10 DRGs, this would have required using many terms to account for the main effects of DRG, DM, and then the interaction terms. This approach would also be harder to interpret than a direct comparison between DM and non-DM within each DRG. Moreover, the sample sizes were big enough to detect any clinically meaningful difference between patients with diabetes and those without DM. Case Mix Index (CMI) was defined as the "Service Intensity Weight" which is a relative measure of resources necessary to treat patients assigned to a DRG. We performed a *t*-test to compare the mean age of patients with diabetes versus those without DM.

## 3. Results

### 3.1. Patient characteristics

The final cohort consisted of a total of 102,694 patients, with 16,266 of these patients with DM. Characteristics of all admissions are shown in Table 1. The mean age of the patients was 65.7 years for those with DM and 57.6 years for those without DM ($p < 0.001$). Out of the total number of patients, 53.9% of the patients with DM were above 65 years old whereas only 32.5% of the patients without DM were above 65 years old ($p < 0.001$). The percentage of male to female patients was 53.1% and 46.9% among those with DM and 41.9% and 58.1% in patients without DM ($p < 0.001$).

### 3.2. Readmission rates

Between January 2013 and September 2015, 13.7% patients with DM and 8.1% patients without DM were readmitted within 30 days after the index admission ($p < 0.001$). Readmission rates were higher in the patients with DM regardless of their age ($p < 0.001$) or gender ($p < 0.001$). We found that diabetes had a persistent effect on readmission rate when controlling for sex and age using a logistic regression model. A patient with DM was found to have 2.47 times the odds of readmission compared to a patient without DM while controlling for the variables above ($p < 0.001$). Patients ≥65 years old had odds of readmission 2.37 times higher than patients <65 years old, and males had 1.55 times greater odds than females ($p < 0.001$). The increased risk of readmissions was found in patients with both primary and secondary diagnosis of DM, with readmission rates in patients with the primary diagnosis of DM higher than in patients with the secondary diagnosis of DM (16.5% vs. 13.6%, respectively, $p = 0.02$) (Fig. 1).

We additionally analyzed the readmission rates when adjusted for DM, age, and gender, with each variable adjusted for the other. For example, the DM vs. non-DM rates were adjusted for age and gender. We found the readmission rates of 15.3% vs. 8.4% in patients with diabetes versus those without DM ($p < 0.001$), adjusted for age and gender. The adjusted readmission rates for gender were 11.3% vs. 7.9%, male vs. female ($p < 0.001$). The adjusted readmission rates for age were 14.1% in patients ≥65 years old and 7.3% in patients <65 years old ($p < 0.001$) (see Table 2A). We also report risk adjusted readmission rates for each DM, age, and gender combination in Table 2B. In patients with DM, the adjusted readmission rate was 12.7% in the male patients who were <65 years-old whereas it was 23.0% in the male patients ≥65 years-old ($p < 0.001$). In patient with DM, the adjusted readmission rate was 9.4% in the female patients who were <65 years-old whereas it was 17.1% in the female patients ≥65 years-old. In patients without DM, the adjusted readmission rate was 8.2% in the male patients who were <65 years-old whereas it was 14.9% in the male patients ≥65 years-old. In patient without DM, the adjusted readmission rate was 6.1% in the female patients who were <65 years-old whereas it was 11.0% in the female patients ≥65 years-old ($p < 0.001$). The *p*-values are the same as for the non-adjusted data (Table 2A and B).

We further analyzed the readmission rates in the individuals with a secondary diagnosis of DM in relation to their primary admission diagnosis for ten of the most common DRGs for the study sample (Table 3). The difference in readmission rates reached a statistically significant level only for two out of the ten most common DRGs (DRG # 313 [chest pain], and # 392 [esophagitis, gastroenteritis, and miscellaneous digestive disorders], $p = 0.045$ and 0.009, respectively). The difference for DRG # 871 (Septicemia or Severe Sepsis without Mechanical Ventilation 96+ Hours with Major Complications and Comorbid Conditions) approched significance level ($p = 0.057$) (Table 3).

We showed a significant correlation between readmission rates and LOS in both patients with diabetes and those without DM ($R^2 = 0.6$ and 0.5, respectively, $p < 0.001$ for both) (Fig. 2). Patients with DM had a significantly higher LOS compared to the patients without DM (overall LOS: 5.4 vs. 4.1, respectively, $p < 0.001$). The CMI was similar in the patients with diabetes and those without DM (an average of 1.8 vs. 1.7, respectively, $p$ = NS). The mean LOS for the patients with DM for readmitted vs. non-readmitted groups was $7.1 \pm 8.8$ days vs. $5.2 \pm 7.6$ days, respectively ($p < 0.001$), and for patients without DM it was $6.1 \pm 17.8$ days vs. $3.9 \pm 5.7$ days, respectively ($p < 0.001$). The patients

**Table 1**
Characteristics of Patients Admitted to the Hospital.

| Characteristic (all patients) | 1° Dx. of DM $N = 823$ (0.8%) | 2° Dx. of DM $N = 15{,}443$ (15.0%) | w/DM (all) $N = 16{,}266$ (15.8%) | w/o DM $N = 86{,}428$ (84.2%) | N (total) 102,694 (100%) | $p$ value (w/DM vs. w/o DM) |
|---|---|---|---|---|---|---|
| Mean age ± SD (y) | 58.6 ± 16.28 | 66.1 ± 13.7 | 65.7 ± 14.1 | 57.6 ± 25.1 | | <0.001 |
| Gender | | | | | | |
| Male, n (%) | 505 (61.4%) | 8140 (52.7%) | 8645 (53.1%) | 36,233 (41.9%) | 44,878 (43.7%) | <0.001 |
| Female, n (%) | 318 (38.6%) | 7303 (47.3%) | 7621 (46.9%) | 50,195 (58.1%) | 57,816 (56.3%) | <0.001 |

Abbreviations: Dx.: diagnosis, SD: standard deviation, w/: with, w/o: without, y: years.

with DM had a higher LOS for both the readmitted and non-readmitted subgroups compared to the patients without DM ($p < 0.001$). Adjusted LOS analysis did not significantly affect the means on the significance level.

## 4. Discussion

Although 9.3% of the US population (29.1 million Americans) has officially been diagnosed with DM, this number reaches 25% among hospitalized patients.[1,4] We found that the readmission rates were higher in a patient with DM compared to those without DM (13.7% vs. 8.1%, respectively, $p < 0.001$). These results were similar after the readmission rates were adjusted for DM, age, and gender (15.3 vs. 8.4, respectively, $p < 0.001$) and are in agreement with previous studies (14.4–22.7% vs. 8.5–13.5%).[4,6]

Jiang et al. showed that >30% of the people with DM have multiple readmissions.[8] The possible reasons behind the higher readmission rates in patients with DM are likely associated with multiple disease-related (the diagnosis of DM, $HbA_{1c}$ levels, severity and number of comorbid conditions, or treatment options) and non-disease-related (socio-demographic factors, such as age, gender, location, access to health care system, type of insurance, etc.) variables.[4,6,9] Regarding the effects of the individual variables on readmission rates, the results of previous studies are contradictory for many of these variables.[4,6,9]

We found that significantly increased readmission rates were present in patients with primary compared to the secondary diagnosis of DM (16.5% and 13.6% respectively; $p = 0.02$), with both of these being significantly higher than the readmission rates in patients without DM (8.1%, $p < 0.001$). We speculate that the increased readmission rate in the primary diagnosis vs. the secondary diagnosis group can be due to the extreme metabolic abnormalities (such as diabetic ketoacidosis, hyperglycemic hyperosmolar state or severe hypoglycemia) in the primary diagnosis group. These problems may be associated with a number of variables such as newly diagnosed DM, recent medication changes, non-compliance, or advanced diabetes with complications. A brief hospitalization may not be sufficient to address all of these issues effectively. Reducing readmission rates in patients with primary diagnosis of DM may require close follow-up, education, and clinical management which begin soon after discharge. Prospective studies are needed to uncover the causes of the readmission rate difference between the patients with the primary and secondary diagnosis of diabetes and to explore interventions that could reduce readmission rates in the primary diagnosis group.

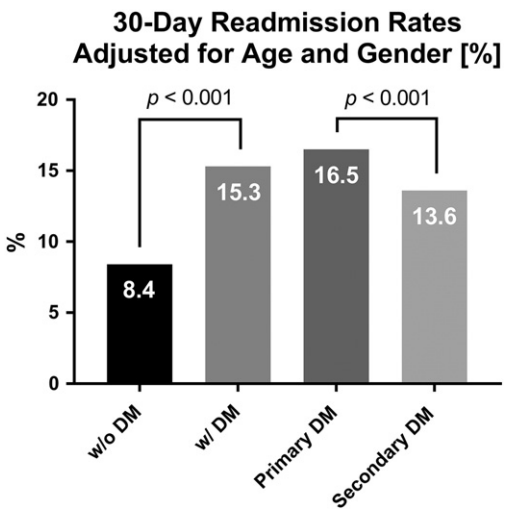


**Fig. 1.** The 30-day readmission rates in the patients with and without diabetes mellitus (DM). The 30-day readmission rates were significantly higher in patients with DM compared to those without DM (15.3% vs. 8.4% respectively, $p < 0.001$), and in patients with the primary diagnosis of DM compared to those with the secondary diagnosis of DM (16.5% vs. 13.6%, respectively, $p = 0.02$).

In our study, the increase in readmission rates for patients with the secondary diagnosis of DM reached a statistically significant level only among two out of the ten most common DRGs (DRG # 313 [chest pain] and # 392 [esophagitis, gastroenteritis, and miscellaneous digestive disorders]). The readmission rate came close to statistical significance for DRG # 871 (septicemia or severe sepsis) (Table 3). Rubin et al. showed that depression, gastroparesis, nephropathy, and anemia are significant predictors of early rehospitalization.[4] Eby et al. demonstrated in patients with DM a significant association between readmission rates and increased comorbidities, particularly sepsis, end-stage renal disease, cerebrovascular disease, hypertension and congestive heart failure.[5] It is possible that the top ten MS-DRGs and their relation to readmission rates may change depending on multiple variables including geographic location, study period, type of the health care system, patient population, etc.

In our study, diabetes had the largest and independent effect on readmission when controlling for sex and age. A patient with DM was found to have 2.47 times the odds of readmission compared to a patient without DM while controlling for other variables. The readmission rates were significantly higher in patients who were above 65 years old

**Table 2**
Risk Adjusted Readmission Rates.

| A. The adjusted readmission rates for diabetes mellitus (DM), age, and gender; each variable is adjusted for the other | | | |
|---|---|---|---|
| DM | Yes | No | $p$ value |
| | 15.3% | 8.4% | <0.001 |
| Sex | Male | Female | |
| | 11.3% | 7.9% | <0.001 |
| Age | ≥65 | <65 | |
| | 14.1% | 7.3% | <0.001 |

| B. The adjusted readmission rates for each DM, age, and gender combination | | | | |
|---|---|---|---|---|
| DM | Sex | Age | Adjusted readmission rates | $p$ value |
| Y | M | <65 | 12.7% | <0.001 |
| Y | M | ≥65 | 23.0% | |
| Y | F | <65 | 9.4% | <0.001 |
| Y | F | ≥65 | 17.1% | |
| N | M | <65 | 8.2% | <0.001 |
| N | M | ≥65 | 14.9% | |
| N | F | <65 | 6.1% | <0.001 |
| N | F | ≥65 | 11.0% | |

**Table 3**
The Ten Most Common Medicare Severity Diagnosis Related Groups for Patients with a Secondary Diagnosis of DM.

| Top 10 MS-DRGs | w/DM | | | w/o DM | | | *p* value |
|---|---|---|---|---|---|---|---|
| | Readm. | D/C | RRs % | Readm. | D/C | RRs % | |
| 247: Perc. CV. Proc. w Drug-Eluting Stent w/o MCC | 94 | 1280 | 7.3 | 191 | 2687 | 7.1 | 0.788 |
| 470: Major Joint Replacement or Reattachment of LE w/o MCC | 18 | 651 | 2.8 | 71 | 3571 | 2.0 | 0.205 |
| 287: Circulatory d/o Except AMI, w Card Cath. w/o MCC | 50 | 385 | 13.0 | 119 | 990 | 12.0 | 0.624 |
| 313: Chest Pain | 30 | 329 | 9.1 | 71 | 1184 | 6.0 | 0.045 |
| 392: Esophagitis, GE. & Misc. Digest. d/o w/o MCC | 49 | 310 | 15.8 | 192 | 1792 | 10.7 | 0.009 |
| 871: Septicemia or Severe Sepsis w/o MV 96+ hr. w/o MCC | 55 | 304 | 18.1 | 141 | 1030 | 13.7 | 0.057 |
| 621: O.R. Procedures for Obesity w/o CC/MCC | 20 | 302 | 6.6 | 65 | 1135 | 5.7 | 0.558 |
| 292: HF & Shock w CC | 67 | 252 | 26.6 | 110 | 484 | 22.7 | 0.245 |
| 251: Perc. CV. Proc. w/o Coronary Artery Stent w/o MCC | 16 | 239 | 6.7 | 34 | 724 | 4.7 | 0.227 |
| 603: Cellulitis w/o MCC | 28 | 239 | 11.7 | 97 | 1061 | 9.1 | 0.223 |

Abbreviations: CA, Coronary Artery; CCs, Complications and Comorbid Conditions; CV, cardiovascular; D/C, discharge; d/o, disorders, DM, Diabetes Mellitus; GE, Gastroenteritis; HF, Heart Failure; LE: lower extremities; MCCs, Major Complications and Comorbid Conditions; MI, Myocardial Infarction; MS-DRGs, Medicare Severity Diagnosis Related Groups; MV, Mechanical Ventilation; OR, Operating Room; Readm., readmissions; RRs, readmission rates; w, with; w/o, without.

compared to the patients between the age of 18 and 65. Additionally, males had significantly higher odds of readmission than females. Eby et al. reported a significant association between readmission rates and increasing age and higher readmission rates in male patients compared to female patients with DM.[5] Strack et al. examined the relationship between demographic and readmission rates in a large retrospective study and showed that three different age intervals (0–30, 30–60 and 60–100 years) show distinct readmission rates which are increasing with age. However, the authors did not observe a difference in the readmission rates between genders.[10] Similarly, Donnan et al. reported a strong association between increased readmission rates and age in the large database analysis. In a retrospective study, Rubin et al. concluded that the male gender, but not advanced age, was a significant predictor for rehospitalizations.[4] Large prospective studies may be necessary to draw more definitive conclusions about the effects of age and gender on readmission rates.

We showed a significant correlation between LOS and readmission rates in both patients with diabetes and those without DM ($R^2 = 0.60$ and 0.56, respectively, $p < 0.001$ for both). However, patients with DM had a significantly higher LOS compared to those without DM (overall

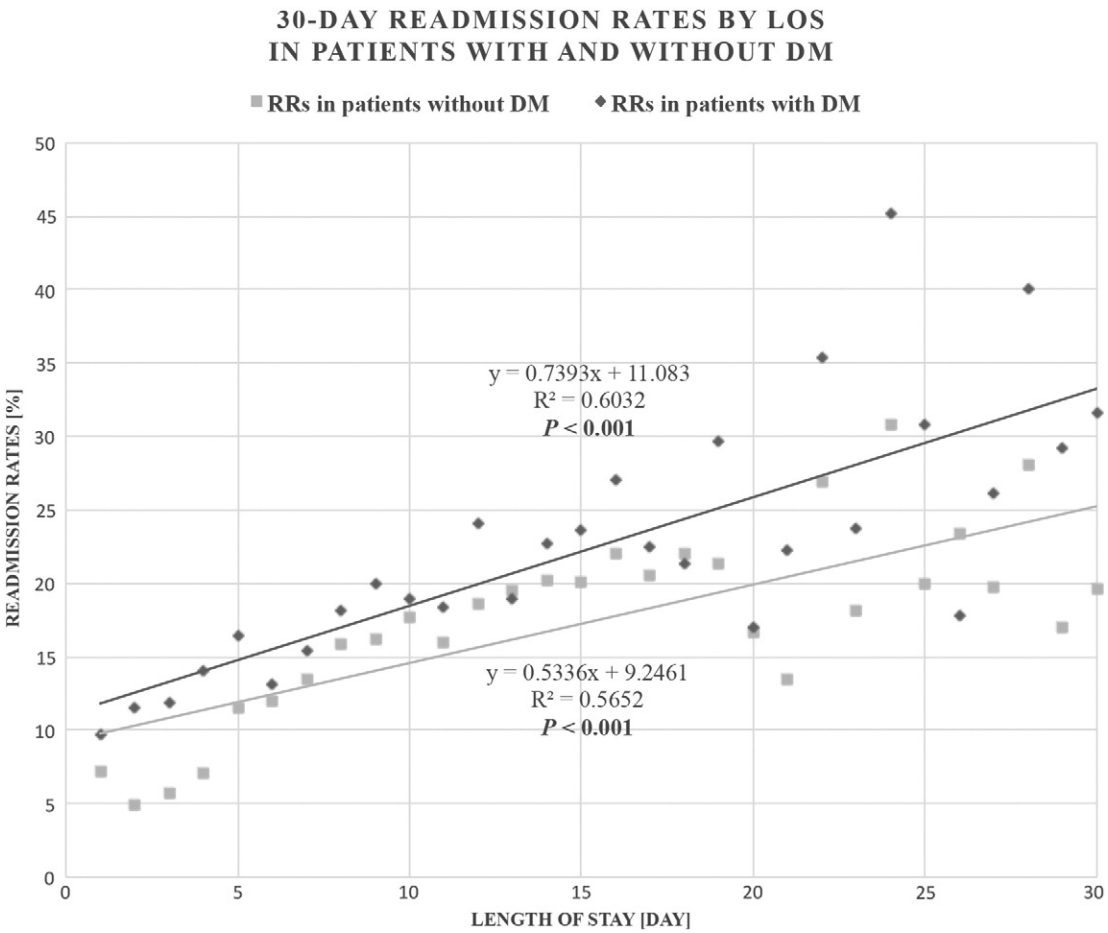


**Fig. 2.** The 30-day readmission rates by the length of stay (LOS) in the patients with and without diabetes mellitus (DM). There was a significant correlation between readmission rates and LOS in both patients with and those without DM ($R^2 = 0.6$; overall LOS: 5.4 days; mean LOS: 7.1 ± 8.8 days vs. $R^2 = 0.5$; overall LOS: 4.1 days; 3.9 ± 5.7, respectively, $p < 0.001$ for all measurements). The patients with DM had a significantly higher LOS for both the readmitted and non-readmitted subgroups compared to those without DM ($p < 0.001$).

LOS: 5.4 vs. 4.1 days, respectively, $p < 0.001$) (Fig. 2). In a study of medical admissions to Veterans Affairs Hospitals, Kaboli and et al.[11] reported that the readmission rates did not increase for the five most common diagnoses despite a decrease in LOS over 14 years. On the contrary, the authors showed a 3% relative increase in the readmission rates for every additional day beyond the average LOS. Similarly, Healy and et al.[12] showed increasing 30-day readmission rates in patients with increasing LOS which they associated with the greater severity of illness. In a retrospective study, Hasan and et al.[13] demonstrated that LOS of more than two days was associated with higher readmission rates. Thus, at this point, there is no consensus in the literature on the association between the readmission rates and LOS.

Our study has a number of limitations. First, the study was conducted at a single urban hospital, so readmissions to other hospitals (if any) were not counted. This limitation may have reduced our estimate of the true readmission rates across the hospital in both patients with diabetes and those without DM. Second, as a retrospective study, this study is a subject to bias in patient selection, data accuracy, and patient follow-up. Third, the hospital billing system data did not include detailed clinical information about the patients' medical condition(s) that may impact LOS or readmission rates. We did not adjust for multiple comparisons among the DRGs because we were concerned about the reduction of power with the number of comparisons. Despite these limiting factors, the robust sample size of patients ($n = 102{,}694$) involved minimizes the limitations above.

Our data support the limited studies which reported higher readmission rates in patients with DM compared to those without DM. Ours appears to be one of the largest studies which assessed multiple aspects of the readmission rates in the same cohort. These aspects included the association between the readmission rates and the demographic characteristics of our population; primary vs secondary diagnosis of DM; LOS; and the top ten most common admission DRGs. Assessing multiple aspects of readmission rates in the same study with a large cohort of patients helps define the most affected target groups. This, in turn, will help to develop better strategies for decreasing readmission rates in patient with DM.

## 5. Conclusions

We conclude that 30-day readmission rates are higher in patients with DM compared to patients without DM regardless of age and gender; readmission rates are significantly higher in male patients and patients >65 years old. The increased risk of readmission for patients with DM was found to be present in patients with both primary and secondary diagnosis of DM, but readmission rate was higher in patients with the primary diagnosis of diabetes. In the cases of secondary diagnosis of DM, the readmission rate difference reached statistically significant level in patients with DM compared to those without DM for two out of the ten most common DRGs (DRG # 313 [chest pain], and # 392 [esophagitis, gastroenteritis, and miscellaneous digestive disorders] and reached close to significant level for DRG # 871 (Septicemia or Severe Sepsis). The readmission rates are increased with prolonged LOS in both patients with diabetes and those without DM. Prospective studies are needed to derive more definitive conclusions about the individual variables which may have an effect on readmission rates and the measures which may reduce readmission rates in patients with DM.

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