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Intensive Care Unit Admission, Mechanical Ventilation, and Mortality Among Patients With Type 1 Diabetes Hospitalized for COVID-19 in the U.S.

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Abstract

OBJECTIVE—To assess whether risk of severe outcomes among patients with type 1 diabetes mellitus (T1DM) hospitalized for coronavirus disease 2019 (COVID-19) differs from that of patients without diabetes or with type 2 diabetes mellitus (T2DM).

RESEARCH DESIGN AND METHODS—Using the Premier Healthcare Database Special COVID-19 Release records of patients discharged after COVID-19 hospitalization from U.S. hospitals from March to November 2020 (N = 269,674 after exclusion), we estimated risk differences (RD) and risk ratios (RR) of intensive care unit admission or invasive mechanical ventilation (ICU/MV) and of death among patients with T1DM compared with patients without diabetes or with T2DM. Logistic models were adjusted for age, sex, and race or ethnicity. Models adjusted for additional demographic and clinical characteristics were used to examine whether other factors account for the associations between T1DM and severe COVID-19 outcomes.

RESULTS—Compared with patients without diabetes, T1DM was associated with a 21% higher absolute risk of ICU/MV (RD 0.21, 95% CI 0.19–0.24; RR 1.49, 95% CI 1.43–1.56) and a 5% higher absolute risk of mortality (RD 0.05, 95% CI 0.03–0.07; RR 1.40, 95% CI 1.24–1.57), with adjustment for age, sex, and race or ethnicity. Compared with T2DM, T1DM was associated with a 9% higher absolute risk of ICU/MV (RD 0.09, 95% CI 0.07–0.12; RR 1.17, 95% CI 1.12–1.22), but no difference in mortality (RD 0.00, 95% CI −0.02 to 0.02; RR 1.00, 95% CI 0.89–1.13). After adjustment for diabetic ketoacidosis (DKA) occurring before or at COVID-19 diagnosis, patients with T1DM no longer had increased risk of ICU/MV (RD 0.01, 95% CI −0.01 to 0.03) and had lower mortality (RD −0.03, 95% CI −0.05 to −0.01) in comparisons with patients with T2DM.

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CONCLUSIONS—Patients with T1DM hospitalized for COVID-19 are at higher risk for severe outcomes than those without diabetes. Higher risk of ICU/MV in patients with T1DM than in patients with T2DM was largely accounted for by the presence of DKA. These findings might further guide recommendations related to diabetes management and the prevention of COVID-19.

Patients with diabetes hospitalized for coronavirus disease 2019 (COVID-19) infection, the majority of whom have type 2 diabetes mellitus (T2DM), have higher risk of intensive care unit (ICU) admission and death than those without diabetes (1–5). Population-based studies in the U.K. have reported increased risk of critical care unit–treated or fatal COVID-19 in patients with either T1DM or T2DM, with greater odds observed among those with T1DM (6,7). However, the difference in risk between patients with T1DM and T2DM was not significant (7).

In the U.S., high rates of diabetic ketoacidosis (DKA) and poor glycemic control have been reported among cohorts of patients with T1DM hospitalized for COVID-19 (8–11). A study of 40 patients with T1DM hospitalized for COVID-19 at Vanderbilt University Medical Center reported higher odds of hospitalization or severe illness as compared with patients without diabetes (12). However, at the time of writing, there is no nationwide study of COVID-19 severity among patients with T1DM compared with those without diabetes in the U.S. Previous studies have been limited by small sample sizes of patients with T1DM and COVID-19, limiting the ability to analyze mortality in patients with T1DM, or by inadequate comparison groups. Given differences in health care systems, payment structures, population demographics, patient profiles, and variance in severe acute respiratory syndrome coronavirus 2 viral subtypes between the U.S. and the U.K., a nationwide analysis of the impact of COVID-19 on patients with T1DM in the U.S. is warranted (13) Furthermore, whether COVID-19 severity is greater in patients with T1DM than in patients with T2DM is unclear, and no studies in the U.S. have directly compared whether COVID-19 severity differs across diabetes subtype.

Using Premier Healthcare electronic medical records, we examined the risk of ICU admission or invasive mechanical ventilation (ICU/MV) and of death among patients with T1DM hospitalized for COVID-19 in the U.S. compared with that among patients without diabetes or among those with T2DM also hospitalized with COVID-19. We also assessed whether demographic, clinical, or hospital characteristics account for differences in COVID-19 severity in patients with T1DM compared with patients without diabetes or with T2DM. We hypothesized that COVID-19 severity may differ by diabetes type.

RESEARCH DESIGN AND METHODS

Patients and Settings

The Premier Healthcare Database Special COVID-19 Release (PHD-CSR) (release date 19 January 2021; Premier, Charlotte, NC) includes discharge records for adult and pediatric patients from >1,000 nongovernmental, teaching, and community hospitals representing ~25% of U.S. hospital admissions (14). Discharge records are for patients who were discharged from the hospital or died. The present analysis included discharge records from 842 hospitals that contributed data for COVID-19 patients discharged during

March–November 2020. COVID-19 patients were identified through ICD-10, Clinical Modification (ICD-10-CM) discharge diagnosis codes U07.1 during April–November 2020 and B97.29 during March–April 2020 as either a primary or secondary diagnosis (15). The first hospitalization with a COVID-19 discharge diagnosis was defined as the index hospitalization.

Study Variables

Main Exposure—The main exposures included the diagnosis of T1DM for comparison with groups with the categories no diabetes or T2DM. Diabetes diagnosis codes, medications, and laboratory results from any encounter from January 2019 to the index COVID-19 hospitalization were used to determine diabetes status. Most patients with diabetes had codes present at admission (T1DM, 91.8%; T2DM, 92.9%). Previous visits with diabetes codes were available for 48.0% of patients with T1DM and 42.4% of patients with T2DM. Patients were classified as having T1DM or T2DM with a tiered algorithm approach, as described in Fig. 1. This approach is based on an algorithm developed by Klompas et al. (16) that uses a combination of majority T1DM ICD-10-CM codes of all a patient's T1DM or T2DM codes (>50% T1DM codes), glucagon prescription, no prescription of a noninsulin antidiabetes drug (excluding metformin), negative C-peptide results, presence of autoantibodies associated with diabetes, and prescription of urine acetone test strips. Schroeder et al. (17) externally validated this algorithm and found the requirement for majority T1DM diagnosis codes alone had a positive predictive value (PPV) of 96.4%, whereas a modified algorithm, excluding urine acetone strips, had PPV of 95.1%. The use of >50% T1DM diagnosis codes alone has previously been shown to have high sensitivity, specificity, and PPV (all >90%) for studies in youth (18–20). As the present data set lacks laboratory results for the majority of patients and medication data mostly come from inpatient settings where treatment is often restricted to insulin, we chose to first apply the simplified criterion of >50% T1DM ICD-10-CM codes in order to increase the sensitivity of T1DM identification. First, we classified individuals as having T1DM if >50% of T1DM (E10.XX) or T2DM (E11.XX) ICD-10-CM codes were T1DM. Second, among patients with overlapping T1DM and T2DM codes not classified as T1DM in the first tier, or those without ICD-10 codes for T1DM or T2DM, the additional criterion with laboratory results was applied (negative C-peptide result or positive autoantibody result). For our purposes, we considered C-peptide results negative if <6 ng/mL, a cutoff associated with diagnosis of T1DM (13,21). Finally, those with any other diabetes, E08.XX (diabetes from underlying condition), E09.XX (drug- or chemical-induced diabetes), E13.XX (other specified diabetes), O24.31X (unspecified preexisting diabetes in pregnancy), O24.32 (unspecified preexisting diabetes in pregnancy), O24.33 (unspecified preexisting diabetes in the puerperium), O24.8XX (other preexisting diabetes in pregnancy, childbirth, or puerperium), and O24.9XX (unspecified diabetes in pregnancy/childbirth/puerperium), were excluded from the no diabetes group. As a sensitivity analysis, the full modified Klompas algorithm (17) was applied to the entire sample, which assigns T1DM on the basis of any of the following three criteria *1*) >50% T1DM codes and no dispensing of a noninsulin antidiabetes drug (excluding metformin), *2*) >50% T1DM codes and a dispensing for glucagon, and *3*) negative C-peptide result or positive diabetes autoantibody result.

Outcomes—A severe COVID-19 outcome was defined as either ICU/MV or death on the basis of hospital records. ICU/MV was coded with use of the PHD-CSR charge master records. Mortality was defined as expired in the hospital or expired in hospice care, with use of PHD-CSR patient discharge records.

Covariates—Information on demographic and clinical characteristics of COVID-19 patients was extracted from PHD-CSR patient discharge records. The presence of selected underlying conditions linked with diabetes or with COVID-19 severity was identified with use of Clinical Classifications Software Refined (CCSR) categories based on all encounters for the cohort from January 2019 through the index hospitalization (22). Categories marked as “nonchronic” were excluded by the Chronic Condition Indicator (23). Underlying medical conditions were defined by aggregation of the chronic ICD-10-CM codes into a smaller number of meaningful categories (i.e., hypertension CIR007, CIR008; disorders of lipid metabolism, END008; coronary atherosclerosis and other heart disease, CIR011; chronic kidney disease [CKD], GEN003; obesity, END009; neoplasms, all CCSR categories starting with “NEO”; chronic obstructive pulmonary disease, RSP008; and DKA, E10.1 or E11.1).

Statistical Analysis

Descriptive analysis of demographic and clinical characteristics is shown by diabetes status. For examination of differences in proportions among diabetes groups, logittransformed CIs were estimated at an a level of 0.05. The percentage of individuals who received ICU/MV treatment or who died was examined by age-group and diabetes diagnosis. For the purpose of estimating the outcome of ICU/MV, we excluded 8,272 patients who died without being in the ICU/MV. Multivariable logistic regression models were used for estimation of absolute risk difference (RD) and risk ratio (RR) of ICU/MV or mortality among patients with T1DM compared with patients without diabetes or patients with T2DM hospitalized for COVID-19. When the T1DM group was compared with no diabetes and T2DM groups, patients with T2DM and those without diabetes were excluded, respectively. Models for ICU/MV had final sample sizes of 154,179 and 109,056 for the no diabetes and T2DM reference groups, respectively. Models for mortality had sample sizes of 158,831 and 112,692 for the no diabetes and T2D reference groups. RD were estimated with Stata’s postestimation command adjrr, which builds on the margins command (24). RD represents the actual RD in outcomes between T1DM and no diabetes or T2DM; RR represents the ratio of risk for ICU/MV or mortality in T1DM and no diabetes or T2DM. RD is estimated as a probability, but we present it as a percentage in the text for clarity (e.g., an RD of 0.25 is equivalent to 25% increased absolute risk). Given the high risk of outcomes based on the selected exposures, we chose to present RR instead of odds ratio (OR) (24). However, for comparison with previous publications, ORs are presented in Supplementary Table 2. Models were clustered on hospital identifier and included covariates for age, sex, and race or ethnicity (model 1). Continuous age was included as linear and quadratic terms to account for nonlinear associations. Additional adjustments controlled for admission month, payer type, hospital census region, and hospital area (urban, rural) (model 2) and selected underlying conditions (model 3). All statistical analyses were conducted by with Stata (version 16.1; StataCorp, College Station, TX). This activity was reviewed by Centers for Disease Control and Prevention (CDC), and its conduct was consistent with applicable

federal law and CDC policy (Code of Federal Regulations [C.F.R.] and U.S. code [U.S.C.]): 45 C.F.R. part 46, 21 C.F. R. part 56, 42 U.S.C. section [Sect.] 241 (d), 5 U.S.C. Sect. 552a, and 44 U.S.C. Sect. 3501 et seq.

RESULTS

T1DM Algorithm Results

Among 269,674 patients with COVID-19 in the final cohort, 41.8% had a diagnosis of either T1DM (n = 1,849) or T2DM (n = 110,843) (Fig. 1). Of 271,581 patients discharged during March–November 2020, 1,907 were excluded as having only ICD codes for other diabetes. A limited number of T1DM patients had information on C-peptide (0.04%) or diabetes autoantibodies (0.03%). C-peptide levels <6 ng/mL were reported for 12 patients with T1DM (0.65%), 8 patients with T2DM (0.01%), and 0 patients without diabetes. Autoantibodies associated with diabetes were present for 15 patients with T1DM (0.81%), 7 patients with T2DM (0.01%), and 0 patients without diabetes. Among the eight patients identified as having T1DM through application of the verified Klompas algorithm, three had C-peptide levels <0.6 ng/mL and five had detectable autoantibodies associated with diabetes. One-half of them (n = 4) had overlapping T1DM and T2DM ICD-10 codes (≤50% T1DM codes), and one-half (n = 4) did not have any T1DM or T2DM ICD-10 codes.

The most commonly reported medication was insulin. At the COVID-19 visit, insulin was dispensed to 86.5% of patients with T1DM, 78.4% of patients with T2DM, and 12.9% of patients without diabetes. From January 2019 through the index hospitalization, insulin was dispensed to 35.3%, 22.0%, and 1.3% of patients with T1DM, T2DM, and no diabetes, respectively. Among the noninsulin antidiabetes drugs (16.1% T2DM, 4.3% T1DM, 0.3% no diabetes), the most commonly reported from January 2019 through the index hospitalization were metformin (9.4% T2DM, 2.8% T1DM, 0.2% no diabetes), dipeptidyl peptidase 4 inhibitors (3.7% T2DM, 1.1% T1DM, <0.1% no diabetes), and sulfonylureas (5.7% T2DM, 1.1% T1DM, <0.1% no diabetes). Glucagon was rarely dispensed, as expected in nonendocrinological practices (4.0% T1DM, 1.5% T2DM, 0.5% no diabetes).

Demographic, Clinical, and Hospital Characteristics

Overall, median age was 64 years, 51.6% patients were male, and 47.9% were non-Hispanic White. The highest percentage of patients overall came from the South (45.2%) and from urban hospitals (88.7%). Patients with T1DM were younger than those without diabetes or with T2DM and more likely to have Medicaid (Table 1). Compared with patients without diabetes, those with T1DM more frequently were non-Hispanic Black (24.6% vs. 17.6%) and had higher prevalence of some underlying conditions (i.e., disorders of lipid metabolism, 49.1% vs. 34.1%; CKD, 36.3% vs. 14.9%; heart disease, 24.6% vs. 16.7%). Compared with patients with T2DM, those with T1DM more frequently were non-Hispanic White (49.6% vs. 43.9%), more likely to have DKA (45.7% vs. 4%), and less likely to have additional underlying conditions, except for CKD, of which there was a similar prevalence (36.3% vs. 34.8%). DKA was present on admission in 37.3% of patients with T1DM and 3.2% of patients with T2DM. The percentage of patients with DKA within each age category decreased with age and was higher for patients with T1DM than patients with

T2DM within each age category (e.g., 0–17 years, 74.6% DKA in patients with T1DM vs. 24.6% DKA in patients with T2DM, and ≥75 years, 10.3% DKA in patients with T1DM vs. 1.3% DKA in patients with T2DM) (Supplementary Table 1). Among patients with T1DM, 60.2% required ICU/MV treatment, whereas this percentage was lower among those without diabetes (43.6%) or among those with T2DM (54.8%) (Table 1).

Age Distribution of COVID-19 Outcomes

Age distribution of outcomes by diabetes status is shown in Fig. 2. Among patients with T1DM, the largest proportion of outcomes occurred among persons aged <50 years, whereas the opposite was observed among patients with T2DM or among those without diabetes.

Risk of ICU/MV

Age-, sex-, and race- or ethnicity-adjusted absolute risk of ICU/MV among patients with T1DM was 21% (95% CI 0.19–0.24; absolute risk 65% vs. 44%) higher than among those without diabetes (Fig. 2 and Supplementary Table 2) and did not change with further adjustments for demographic and clinical characteristics (Supplementary Fig. 1). Absolute risk of ICU/MV was 9% (95% CI 0.07–0.12) higher than among T2DM patients; however, additional adjustment for DKA reduced this difference to 1% (95% CI −0.01 to 0.03; absolute risk 56% vs. 55%) (Fig. 3 and Supplementary Table 2). The age-, sex-, and race- or ethnicity-adjusted RR for ICU/MV among patients with T1DM was 1.49 (95% CI 1.43–1.56) in comparison with patients without diabetes and 1.17 (95% CI 1.12–1.22) in comparison with patients with T2DM (OR 2.48, 95% CI 2.23–2.76, and 1.47, 95% CI 1.32–1.64, respectively (Fig. 3 and Supplementary Table 2). Additional adjustments marginally reduced the point estimates relative to no diabetes; however, DKA fully accounted for the higher risk in comparisons with T2DM (RR 1.02, 95% CI 0.98–1.06).

Risk of Mortality

The age-, sex-, and race- or ethnicity-adjusted absolute risk of death among patients with T1DM was 5% higher (95% CI 0.03–0.07; absolute risk 17% vs. 12%) than among those without diabetes (Fig. 3 and Supplementary Table 2) but not significantly different from that among patients with T2DM (Fig. 3). In fact, after the presence of DKA was accounted for among patients with diabetes, absolute mortality was 3% lower (95% CI −0.05 to −0.01; absolute risk 16% vs. 18%) among those with T1DM than among those with T2DM (Fig. 3 and Supplementary Table 2). The age-, sex-, and race- or ethnicity-adjusted RR for mortality was 1.40 (95% CI 1.24–1.57) in comparison with no diabetes (OR 1.54, 95% CI 1.31–1.81) (Fig. 3 and Supplementary Table 2) and slightly but not significantly lower with additional adjustments (Supplementary Fig. 2). Relative to mortality among patients with T2DM, DKA adjustment reduced mortality in patients with T1DM by 15% (RR 0.85, 95% CI 0.75–0.96) (Fig. 3).

Overall, however, patients with T1DM represented <1% of hospitalizations and those with T2DM represented 41%; most patients did not have diabetes. The absolute percentage of deaths was lowest among patients with T1DM (9.6%) and highest among those with T2DM (18.5%).

Sensitivity Analysis

With application of the full modified Klompas algorithm (17) we identified 180 fewer patients with T1DM (n = 1,669 T1DM; n = 111,189 T2DM). Age-, sex-, and race- or ethnicity-adjusted estimated risks of ICU/MV or death in patients with T1DM compared with patients without diabetes or with T2DM were similar, with no difference in significance (Supplementary Table 3).

CONCLUSIONS

Patients with T1DM hospitalized for COVID-19 and discharged during March–November 2020 were at significantly higher adjusted risk for ICU/MV treatment and experienced significantly higher mortality than patients without diabetes hospitalized for COVID-19. After adjustment for age, sex, and race or ethnicity, patients with T1DM had 65% absolute risk of ICU/MV and 17% absolute risk of death, which were 21% and 5% higher, respectively, than the absolute risk in patients without diabetes. Patients with T1DM had 9% higher absolute risk of ICU/MV, but no difference in mortality, compared with patients with T2DM.

After history of DKA was accounted for, patients with T1DM had similar risk of ICU/MV and lower risk of mortality in comparison with patients with T2DM. DKA among T1DM patients hospitalized for COVID-19 accounted for 89% of the absolute RD (from 9 to 1%) of ICU/MV in comparison with patients with T2DM, regardless of demographic and other comorbid conditions. Adjustment for DKA reduced the RD for mortality in patients with T1DM compared with T2DM (from 0% to −3%). Indeed, DKA was the single most powerful predictor of the RD in outcomes between those with T1DM and those with T2DM. Nearly one-half of patients with T1DM had a history of DKA–most being present at admission for COVID-19 hospitalization (82% of DKA codes). It is possible that the threshold for hospital admission among the population with T1DM, who are younger, was lower than for the older populations of patients without diabetes or with T2DM, which is supported by the high rates of DKA at admission. A bidirectional relationship between COVID-19 infection and diabetes (25), delayed access to medical care during the lockdown, or both, may exacerbate the risk and severity of DKA among patients with known (8,9,11) or new-onset T1DM (8). Increased rates of DKA have been reported among patients with newly diagnosed T1DM during the pandemic in both patients with and patients without COVID-19, suggesting that delays in seeking care have exacerbated problems related to diabetes (8).

Published data from the U.S. on COVID-19 severity and mortality among patients with T1DM are limited and inconsistent because of the small number of hospitalizations and the lack of consistent data on nonhospitalized COVID-19 patients (6,7,12,26–31). A small prospective U.S. study of 40 COVID-19–positive patients with T1DM reported a nearly fourfold higher odds of hospitalization and a threefold higher odds of severe illness or death in comparison with patients without diabetes, after adjustment for demographic and clinical differences (12). The same study indicated a similar adjusted risk of these outcomes among COVID-19–positive patients with T2DM compared with those with no diabetes but provided no direct comparisons with T1DM (12). Another U.S. study of pediatric ICU patients

across 48 states reported increased duration of high-flow nasal cannula and intubation among patients with T1DM and COVID-19 but provided no sample size for T1DM and no comparison group (29).

The largest studies outside the U.S. are from the U.K., which similarly reported greater risk of COVID-19 severity in patients with T1DM than in those without diabetes (6,7). In-hospital mortality in England was 3.5-fold higher among patients with T1DM compared with those with no diabetes, after adjustments for age, sex, social deprivation, ethnicity, and geographic region (6). After further adjustment for previous hospital admissions for cardiovascular disease, the OR was reduced to 2.9 but still significant. Higher risk of death was reported among Black and Asian patients than among White patients with T1DM (6,32). A similar study of hospital discharge and mortality registration data in Scotland reported 2.4-fold higher age- and sex-adjusted odds of composite fatal or critical care unit–treated COVID-19 among patients with T1DM compared with those without diabetes (7). After an additional adjustment for diabetes duration, T1DM was not associated with higher risk of COVID-19 severity in comparison with T2DM. Previous hospitalizations for DKA were associated with threefold increased odds of severe outcomes among patients with diabetes, although models were not adjusted for other previous comorbidities, as in the current study. The measures of association in the studies from the U.K. (OR 2.4–3.5) are greater than the 1.5-fold increased risk reported here for ICU/MV or 1.4-fold increased risk for death for patients with T1DM compared with patients without diabetes. The present estimated ORs were greater than risk ratios but also still lower than in U.K. studies. However, this comparatively lower risk is expected, as the denominator in the current study is people hospitalized for COVID-19, whereas the studies from the U.K. used population-based denominators. The U.S. does not have a nationwide surveillance system similar to that in the U.K.; thus, we are unable to assess risk of COVID-19 severity among all people with diabetes. However, the current study 1) demonstrates that for those hospitalized, having T1DM confers an additional risk and 2) provides useful information for health care providers in hospital settings.

By contrast, a Belgian study found no data indicating increased COVID-19 hospitalization or mortality among 2,336 patients with T1DM compared with the general population, with only 5 patients with T1DM having COVID-19 (27). Similarly, a nationwide, multicenter, observational study in France found a comparable prevalence of the composite outcome of MV or death by day 7 among 56 patients with T1DM or 2,373 patients with T2DM hospitalized for COVID-19 (31). However, these studies are limited by small sample sizes of patients with T1DM and COVID-19, thus precluding detection of associations with severe outcomes.

The findings of this report are subject to several limitations. First, COVID-19 cases were identified by ICD-10-CM diagnostic codes alone, which may misclassify cases. However, COVID-19 coding in the PHD-CSR shows high sensitivity and specificity with molecular testing (33). Second, ICD-10-CM diagnostic codes may not accurately capture diabetes diagnosis or type and may vary by hospital system. The absence of laboratory data also limits accurate identification of DKA and inclusion of covariates (e.g., HbA_{1c}, blood glucose) that may affect COVID-19 outcomes. Although use of the ratio of T1DM

to all T1DM and T2DM ICD-10-CM codes has been shown to have high accuracy in multiple studies (17–20), it is an imperfect measure and may have poor performance (34). Furthermore, patients with undiagnosed diabetes with uncontrolled blood glucose may be at increased risk of COVID-19 severity but were included in the no diabetes group, which may bias toward the null. Third, due to a lack of laboratory data, we are unable to further assess severity of COVID-19 at admission or adjust for biochemical indicators of COVID-19 severity at hospital admission. It is possible that the threshold for admission in patients with T1DM is higher and that this sample represents more severe cases of COVID-19 in comparison with those of patients without diabetes or with T2DM. Fourth, longer diabetes duration may account for higher ICU/MV among those with T1DM compared with those with T2DM (7); however, the present data lack information on diabetes duration. Finally, this study is based on observational data and cannot determine causality.

The current findings suggest that patients with T1DM hospitalized for COVID-19 are at higher risk of ICU/MV and mortality compared with patients without diabetes. We found that 46% of patients with T1DM had a history of DKA, mostly related to the COVID-19 admission. After we accounted for history of DKA, patients with T1DM had similar risk of ICU/MV and significantly lower mortality rate than patients with T2DM. Knowledge of risk among patients with T1DM and associated demographic factors can guide clinical care and resource allocation in a hospital setting, as well as diabetes management and COVID-19 prevention measures. Public health messaging could emphasize risk of COVID-19 severity among people with T1DM.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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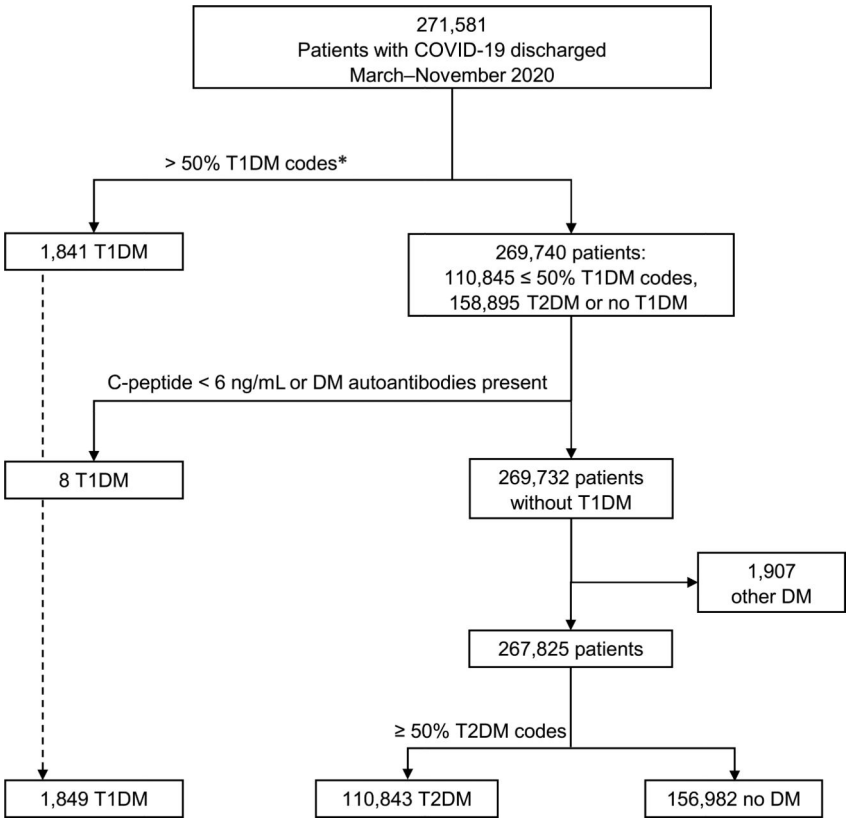

Figure 1—.

Identification of diabetes diagnosis among patients hospitalized with COVID-19 in the U.S., discharged March–November 2020. DM, diabetes mellitus. *If >50% of the patient's T1DM or T2DM diabetes ICD-10-CM codes were T1DM, the patient was categorized as having T1DM.

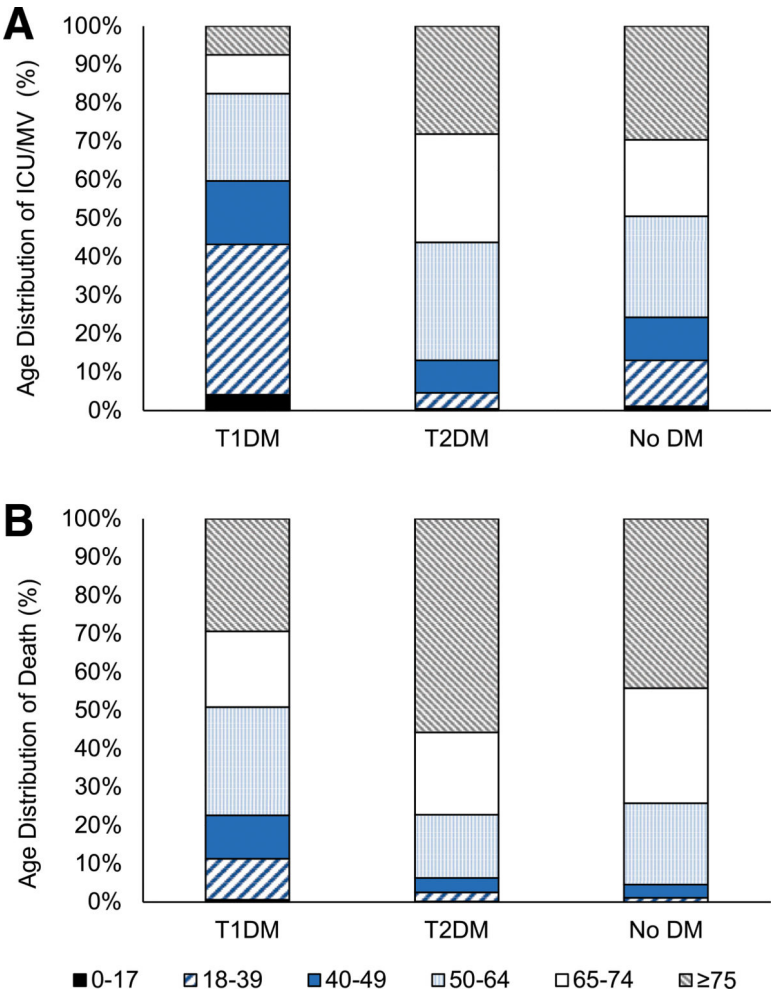

Figure 2—.

Age distribution (in years) by diabetes status of patients with COVID-19 who received ICU/MV treatment (A)ordied(B). DM, diabetes mellitus.

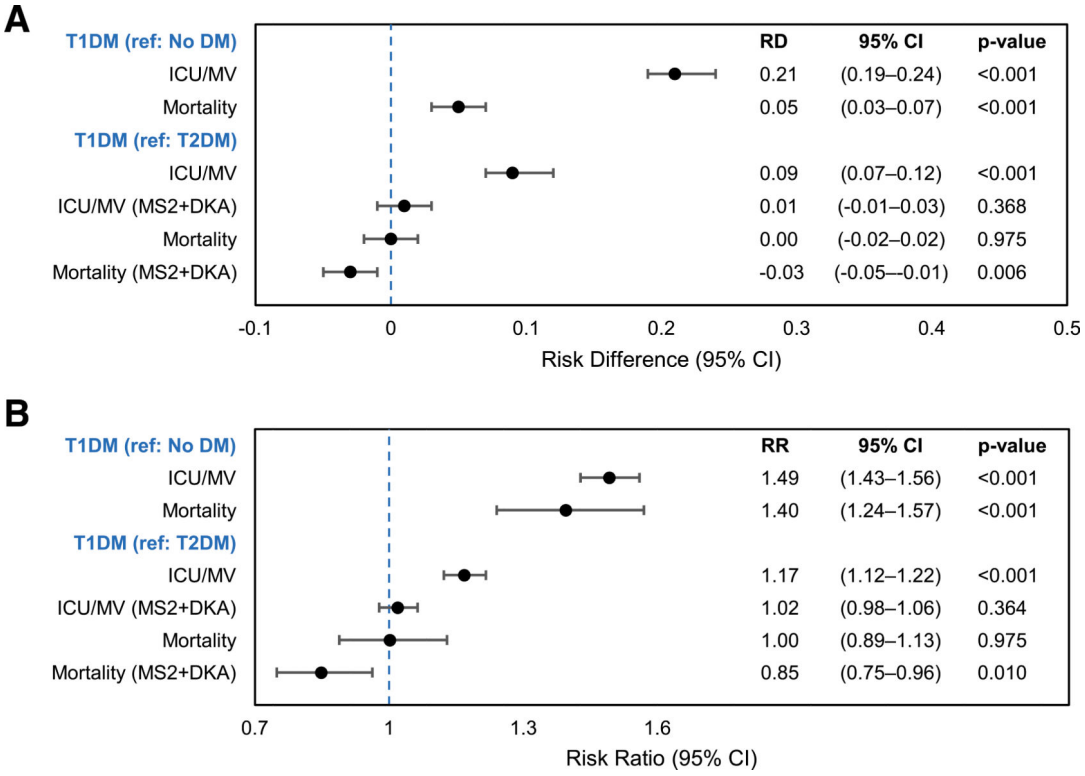

Figure 3—.

Adjusted absolute RDs (A) and risk ratios (RR) B) for(ICU/MV and mortality among 269,674 patients hospitalized with COVID-19 in the U.S., discharged March–November 2020. Each estimate represents results from a separate model, clustered on hospital identifier and controlling for age, sex, and race/ethnicity (model set 1); model set 2 additionally controls for payer type, census region, hospital area (urban, rural), admission month, and DKA. DM, diabetes mellitus; MS2, model set 2; ref, referent.

Table 1—

Demographic and clinical characteristics of patients hospitalized with COVID-19, by diabetes diagnosis—PHD-CSR, U.S., discharged March–November 2020

	Total (*N* = 269,674)		T1DM (*N* = 1,849)		T2DM (*N* = 110,843)		No diabetes (*N* = 156,982)	
	n	**% (95% CI)**	***n***	**% (95% CI)**	***n***	**% (95% CI)**	***n***	**% (95% CI)**
Sex								
Male	139,266	51.6 (51.5–51.8)	940	50.8 (48.6–53.1)	59,149	53.4 (53.1–53.7)	79,177	50.4 (50.2–50.7)
Female	130,223	48.3 (48.1–48.5)	909	49.2 (46.9–51.4)	51,630	46.6 (46.3–46.9)	77,684	49.5 (49.2–49.7)
Unknown	185	0.1 (0.1–0.1)	0	0.0 (0.0–0.0)	64	0.1 (0.0–0.1)	121	0.1 (0.1–0.1)
Age, years[§]								
0–17	2,570	1.0 (0.9–1.0)	71	3.8 (3.1–4.8)	57	0.1 (0.0–0.1)	2,442	1.6 (1.5–1.6)
18–39	32,638	12.1 (12.0–12.2)	697	37.7 (35.5–39.9)	4,994	4.5 (4.4–4.6)	26,947	17.2 (17.0–17.4)
40–49	28,352	10.5 (10.4–10.6)	290	15.7 (14.1–17.4)	9,832	8.9 (8.7–9.0)	18,230	11.6 (11.5–11.8)
50–64	73,573	27.3 (27.1–27.5)	435	23.5 (21.6–25.5)	33,918	30.6 (30.3–30.9)	39,220	25.0 (24.8–25.2)
65–74	57,514	21.3 (21.2–21.5)	200	10.8 (9.5–12.3)	29,973	27.0 (26.8–27.3)	27,341	17.4 (17.2–17.6)
≥75	75,027	27.8 (27.7–28.0)	156	8.4 (7.3–9.8)	32,069	28.9 (28.7–29.2)	42,802	27.3 (27.0–27.5)
Race/ethnicity								
White, non-Hispanic	129,086	47.9 (47.7–48.1)	917	49.6 (47.3–51.9)	48,706	43.9 (43.6–44.2)	79,463	50.6 (50.4–50.9)
Black, non-Hispanic	54,180	20.1 (19.9–20.2)	455	24.6 (22.7–26.6)	26,085	23.5 (23.3–23.8)	27,640	17.6 (17.4–17.8)
Hispanic	52,184	19.4 (19.2–19.5)	297	16.1 (14.5–17.8)	21,596	19.5 (19.3–19.7)	30,291	19.3 (19.1–19.5)
Other, non-Hispanic	26,995	10.0 (9.9–10.1)	152	8.2 (7.1–9.6)	11,769	10.6 (10.4–10.8)	15,074	9.6 (9.5–9.7)
Unknown	7,229	2.7 (2.6–2.7)	28	1.5 (1.0–2.2)	2,687	2.4 (2.3–2.5)	4,514	2.9 (2.8–3.0)
Underlying conditions								
Essential or secondary hypertension	136,577	50.7 (50.5–50.8)	812	43.9(41.7–46.2)	67,233	60.7(60.4–60.9)	68,532	43.7(43.4–43.9)
Disorders of lipid metabolism	125,105	46.4 (46.2–46.6)	908	49.1 (46.8–51.4)	70,628	63.7 (63.4–64.0)	53,569	34.1 (33.9–34.4)
Obesity	85,335	31.6 (31.5–31.8)	467	25.3 (23.3–27.3)	45,461	41.0 (40.7–41.3)	39,407	25.1 (24.9–25.3)
CKD	62,577	23.2 (23.0–23.4)	671	36.3 (34.1–38.5)	38,598	34.8 (34.5–35.1)	23,308	14.9 (14.7–15.0)
Coronary atherosclerosis and other heart disease	62,000	23.0 (22.8–23.1)	455	24.6 (22.7–26.6)	35,335	31.9 (31.6–32.2)	26,210	16.7 (16.5–16.9)
COPD and bronchitis	27,997	10.4 (10.3–10.5)	132	7.1 (6.1–8.4)	13,809	12.5 (12.3–12.7)	14,056	9.0 (8.8–9.1)

	Total (*N* = 269,674)		T1DM (*N* = 1,849)		T2DM (*N* = 110,843)		No diabetes (*N* = 156,982)	
	n	**% (95% CI)**	***n***	**% (95% CI)**	***n***	**% (95% CI)**	***n***	**% (95% CI)**
Neoplasms	18,875	7.0 (6.9–7.1)	105	5.7 (4.7–6.8)	8,061	7.3 (7.1–7.4)	10,709	6.8 (6.7–6.9)
DKA	5,279	2.0 (1.9–2.0)	845	45.7 (43.4–48.0)	4,434	4.0 (3.9–4.1)	0	0.0 (0.0–0.0)
Present at admission	4,195	1.6 (1.5–1.6)	690	37.3 (35.1–39.5)	3,505	3.2 (3.1–3.3)	0	0.0 (0.0–0.0)
Payer type								
Medicare	132,683	49.2 (49.0–49.4)	608	32.9 (30.8–35.1)	63,032	56.9 (56.6–57.2)	69,043	44.0 (43.7–44.2)
Commercial	68,764	25.5 (25.3–25.7)	530	28.7 (26.6–30.8)	23,612	21.3 (21.1–21.5)	44,622	28.4 (28.2–28.6)
Medicaid	40,048	14.9 (14.7–15.0)	491	26.6 (24.6–28.6)	14,226	12.8 (12.6–13.0)	25,331	16.1 (16.0–16.3)
Charity/indigent/self-pay	14,619	5.4 (5.3–5.5)	143	7.7 (6.6–9.0)	4,929	4.5 (4.3–4.6)	9,547	6.1 (6.0–6.2)
Other	13,560	5.0 (4.9–5.1)	77	4.2 (3.3–5.2)	5,044	4.6 (4.4–4.7)	8,439	5.4 (5.3–5.5)
Admission month								
2019–February	267	0.1 (0.1–0.1)	0	0.0 (0.0–0.0)	112	0.1 (0.1–0.1)	155	0.1 (0.1–0.1)
March–April	65,803	24.4 (24.2–24.6)	378	20.4 (18.7–22.3)	27,002	24.4 (24.1–24.6)	38,423	24.5 (24.3–24.7)
May–June	45,571	16.9 (16.8–17.0)	326	17.6 (16.0–19.4)	18,802	17.0 (16.7–17.2)	26,443	16.8 (16.7–17.0)
July–August	70,662	26.2 (26.0–26.4)	478	25.9 (23.9–27.9)	29,805	26.9 (26.6–27.2)	40,379	25.7 (25.5–25.9)
September–November	87,371	32.4 (32.2–32.6)	667	36.1 (33.9–38.3)	35,122	31.7 (31.4–32.0)	51,582	32.9 (32.6–33.1)
Hospital area								
Urban	239,205	88.7 (88.6–88.8)	1,629	88.1 (86.5–89.5)	97,783	88.2 (88.0–88.4)	139,793	89.1 (88.9–89.2)
Rural	30,469	11.3 (11.2–11.4)	220	11.9 (10.5–13.5)	13,060	11.8 (11.6–12.0)	17,189	11.0 (10.8–11.1)
Hospital census region								
South	121,947	45.2 (45.0–45.4)	800	43.3 (41.0–45.5)	51,344	46.3 (46.0–46.6)	69,803	44.5 (44.2–44.7)
Northeast	54,964	20.4 (20.2–20.5)	355	19.2 (17.5–21.1)	21,710	19.6 (19.4–19.8)	32,899	21.0 (20.8–21.2)
Midwest	60,478	22.4 (22.3–22.6)	471	25.5 (23.5–27.5)	23,965	21.6 (21.4–21.9)	36,042	23.0 (22.8–23.2)
West	32,285	12.0 (11.8–12.1)	223	12.1 (10.7–13.6)	13,824	12.5 (12.3–12.7)	18,238	11.6 (11.5–11.8)
Severity markers								
ICU/MV	126,271	48.3 (48.1–48.5)	1,095	60.2 (58.0–62.5)	58,736	54.8 (54.5–55.1)	66,440	43.6 (43.4–43.9)
Mortality	39,843	14.8 (14.6–14.9)	177	9.6 (8.3–11.0)	20,540	18.5 (18.3–18.8)	19,126	12.2 (12.0–12.3)

Data are percentages of column totals and 95% CI unless otherwise specified. Patients admitted to the hospital prior to 2019 are included in the 2019–February category. COPD, chronic obstructive pulmonary disease.

[§]Median age by patient category: all, 64 years (interquartile range 50–76); T1DM, 45 years (30–61); T2DM, 67 years (56–76); and no diabetes, 67 years (56–76).