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Comparison of COVID-19 outcomes in patients with Type 1 and Type 2 diabetes: A systematic review and meta-analysis

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Abstract
Background and aims: This systematic review and meta-analysis aimed to evaluate the current evidence available to investigate clinical outcomes between patients with type 1 and type 2 diabetes.

Methods: MEDLINE (Pubmed), Scopus, Web of Science, Cochrane library, Google scholar and Clinical-trials.gov were searched. Randomized controlled trials (RCTs), non-randomized trials, and observational studies were eligible for inclusion. National Institutes of Health Quality Assessment Tool was used to assess the quality. Data were pooled by the Restricted-maximum-likelihood random-effects approach.

Results: Total 11 studies comprising 7690415 individuals were included in this study. The log OR for the pooled data for all-cause mortality rate was -0.71 (95% CI: -1.38 to 0.03). Based on the pooled results, type 1 diabetic COVID-19 patients may have a better prognosis for mortality. There were no significant differences between groups in term of ICU-admission log OR -0.22 (95% CI: -0.81 to 0.37), and hospitalization log OR -0.48 (95% CI: -1.23 to 0.27). Based on our descriptives analyses after adjusting for age and comorbidities, the high-risk group in three studies was type 2 diabetes, and in five studies was type 1. Two studies reported no significant difference between these groups in relevant outcomes.

Conclusion: There were no significant differences in disease severity between type 1 and type 2 diabetes. Based on the unadjusted data available, the mortality rate for people with type 1 diabetes was shown to be lower than that for people with type 2. As data on these subjects is scarce, and the results obtained from studies are heterogeneous, further research with adequate sample sizes is needed to precisely compare the outcomes of COVID-19 between type 1 and type 2 diabetes.

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1. Introduction

World Health Organization (WHO) declared novel Coronavirus Disease 2019 (COVID-19) caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) a pandemic for March 11, 2020 [1]. As a result, its high transmissibility has caused more than 6 million deaths worldwide, and the number continues to increase as new strains emerge [2]. Symptoms of the disease may range from asymptomatic or mild to severe pneumonia, multi-organ failure, acute respiratory distress syndrome (ARDS), and even death [3,4]. Comorbidities are one of many risk factors contributing to the severity of the disease [5]. Studies have established a significant relationship between the risk of mortality in COVID-19 patients and certain comorbidities, including chronic kidney disease (CKD), chronic lung disease, diabetes mellitus (DM), hypertension, aging, immunosuppression, and obesity [6]. An analysis by the Chinese CDC of 72314 patients indicates that diabetes is the second most common cause of death (7.3%) after heart disease (10.5%), which equates to a rate of 2.3% in the general population [7].

Diabetes mellitus (DM) is a chronic disease characterized by glucose dysregulation and severe long-term complications affecting multiple organs. Type 1 diabetes (T1D) and type 2...
diabetes (T2D) are the most prevalent subtypes of diabetes. Nearly half a billion people suffer from DM, making it one of the most important risks for severe COVID-19. Moreover, DM is often associated with other risk factors, including hypertension, nephropathy, obesity, cardiovascular disease (CVD), a proinflammatory and hypercoagulable state that makes the individual more susceptible to hyperglycemia and more severe forms of COVID-19 [8–11]. The prevalence of T1D ranged from 0.15% to 28.98% among COVID-19 patients [12]. The risk of progression to severe COVID-19 and death is more significant in patients with diabetes mellitus (DM) [13]. As a result of the impairment of the immune system caused by DM, an uncontrolled immune response was produced against SARS-CoV-2 [14]. Bidirectional interrelationships between SARS-CoV-2 and DM complications will result in a more complex situation in terms of disease severity.

Due to the high prevalence of diabetes among COVID-19 patients and the special care that is needed during infection, we are concerned about preventing and treating COVID-19 in patients with diabetes. A number of studies have reported an association between diabetes and a higher risk of severe COVID-19; however, it is unclear which types of diabetes are associated with a higher risk of severe disease progression. In order to fill this evidence gap, we conducted a systematic review and meta-analysis to compare T1D and T2D in terms of disease severity.

2. Methods

2.1. Search strategy

We conducted a systematic review and meta-analysis in accordance with the recommendations of the Cochrane Handbook [15]. We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) in this study [16]. Our study protocol is registered at PROSPERO under the number CRD42022319173.

Pubmed/MEDLINE, Scopus, Web of Science, Cochrane library, and Clinicaltrials.gov were assessed by our reviewers (N.S and D.A and M.R and Z.A) who designed a search strategy using the search string: (“COVID-19” [Mesh]) OR (“SARS-CoV-2” [Mesh]) OR “COVID-19” OR “Coronavirus” OR “nCoV” OR “SARS-CoV-2” AND (“Diabetes ” [Mesh]) OR “Diabetes” OR “diabetes mellitus” OR “diabetes mellitus type 1” OR “diabetes mellitus type 2” OR “diabetes type 1” OR “diabetes type 2.” All publications were retrieved up to February 16, 2022. Additionally, we searched the reference sections of other studies for relevant publications. The result was exported to the EndNote X9 program for further screening.

2.2. Study selection and data extraction

Studies recognized as eligible for inclusion included: 1) confirmed COVID-19 patients; 2) patients diagnosed with T1D and T2D; 3) studies evaluating outcomes relevant to this topic; and 4) studies reporting both T1D and T2D infected with SARS-CoV-2. We included randomized controlled trials (RCTs), non-randomized trials, and observational studies. We excluded case reports, case series, non-English articles, and studies that involved patients <18 years old and pregnant women. Additionally, studies that focused on only one type of diabetes (for instance, studies focused exclusively on T2D) were excluded. Two reviewers independently reviewed the titles and abstracts (N.S and D.A), then the full texts in EndNote. All disagreements were resolved via discussion with a third reviewer to reach an agreement (AS). Data were extracted from text, tables, figures, graphs, and supplementary materials into an excel spreadsheet. Two reviewers (N.S and A.S.) independently extracted author/year, country, study type, population, duration, number of patients in each trial, as well as outcome data.

2.3. Quality assessment

Two reviewers (M.T and A.S) independently evaluated the included studies using the NIH risk of bias checklist [17]. The checklist included 14 questions designed to assess the quality of observational cohort and cross-sectional studies. The studies with 10 or more yeses are rated as “Good”, 7–9 yeses as “Fair”, and fewer than 7 yeses are rated as “Poor”.

2.4. Outcome measure

The meta-analysis outcomes were all cause mortality, hospitalization, and ICU admission rates for COVID-19 patients with T1D compared to COVID-19 patients with T2D.

2.5. Data synthesis and analysis

In this study, data were pooled by the Restricted-maximum-likelihood random-effects approach since the indicators were designed to vary across studies, and there was some variation between the studies. A log odds ratio (log OR) was calculated to summarize the overall effects of outcomes. A p-value of <0.05 was considered significant for the effect estimate. The I² statistic was used to assess study heterogeneity, with I² values of <50%, 50–75%, and >75%, respectively, indicating low, moderate, and high levels of heterogeneity. Although I² is the most commonly used measure of heterogeneity, the I² value increases as the number of trials increases. This makes it challenging to compare I² across analyses. Therefore, we report both I² and Tau for each analysis. Publication bias was assessed using funnel plots inspection and Egger’s regression test for funnel plot asymmetry. To evaluate the effect of individual studies on the pooled results, we conducted a leave-one-out sensitivity analysis. A sub-group analysis was conducted for both the adjusted and unadjusted data. We used Stata version 16 statistical software (Stata Corp, College Station, TX, USA) for the quantitative synthesis.

3. Results

A total of 2419 initial studies were identified, and 638 duplicates were removed (Fig. 1). After screening the titles and abstracts, 39 full-text articles were reviewed, and 11 studies were included.

3.1. Characteristics and quality of included studies

Most of the studies were conducted in European countries, including Austria (n = 1), Sweden (n = 1), Scotland (n = 1), France (n = 1), England (n = 4), and Turkey (n = 1). Two studies were conducted in the United States (n = 2). The studies considered were all observational, and eight of them had a sample size of more than 1000 patients. Detailed characteristics of each study is provided in Table 1. On the basis of the NIH checklist, the quality of included studies was evaluated as Good/Fair and none was rated Poor. Most of the studies did not provide additional information about blinding outcome assessors to the participants’ exposure status or assessing the exposure in more than one study.

3.2. Mortality

A total of eight studies, including 7379184 COVID-19 patients with T1D or T2D, reported a mortality rate in their studies (Fig. 2-A) [18–25]. Log OR for the pooled data was −0.71 (95% CI: −1.38 to −0.03) with high heterogeneity (I² = 98%, Tau = 0.67). Based on the pooled results, T1D COVID-19 patients may have a better prognosis for mortality. Our analysis of subgroups using adjusted/
unadjusted data revealed a pooled log OR of $-0.95$ (95% CI: $-1.41$ to $-0.48$) for unadjusted data and $0.83$ (95% CI: $0.41$ to $1.25$) for adjusted data (Fig. 3-A). According to the sensitivity analysis performed using the leave-one-out method, the overall effect would be substantially altered if any study were excluded (except for the study by Demirci et al. [26] (Fig. 4-A). Upon examination of funnel plots and Egger’s regression test ($p = 0.43$), there was no evidence of publication bias (Fig. 5-A).

### 3.3. ICU admission

There have been six studies reporting rates of hospitalization for T1D or T2D, including 1422426 patients with COVID-19 (Fig. 2-B) [19,22–24,27]. Pooled log OR was $-0.22$ (95% CI: $-0.81$ to $0.37$) with high heterogeneity ($I^2 = 88\%$, $\tau = 0.39$). The pooled results indicate that there was no difference between T1D and T2D in patients with COVID-19. Based on subgroup analyses of adjusted/unadjusted data, we found a pooled log OR of $-0.52$ (95% CI: $-0.97$ to $-0.06$, $I^2 = 72\%$) for unadjusted and $0.60$ (95% CI: $0.20$ to $0.99$) for adjusted data (Fig. 3-B). A sensitivity analysis using the leave-one-out method showed that the overall effect was substantially altered when the study by Demirci et al. was omitted [26] (Fig. 4-B). According to the funnel plot and Egger’s regression test ($p = 0.33$), there is no publication bias (Fig. 5-B).

### 3.4. Hospitalization

A total of six studies, including 1112951 COVID-19 patients with T1D and T2D, reported hospitalization rates (Fig. 2-C) [19,22–24,28,29]. We calculated the pooled log OR to be $-0.48$ (95% CI: $-1.23$ to $0.27$) with high heterogeneity ($I^2 = 97\%$, $\tau = 0.78$) between the groups. It was found that there was no difference between COVID-19 patients with T1D and T2D. Subgroup analysis based on adjusted and unadjusted data shows a pooled log OR of $-0.93$ (95% CI: $-1.65$ to $-0.21$, $I^2 = 96\%$) for unadjusted data and $0.43$ (95% CI: $-0.01$ to $0.87$) for adjusted data (Fig. 3-C). When the leave-one-out method was used, the overall effect was not substantially altered when any single study was omitted (Fig. 4-C). Upon examination of the funnel plot and Egger’s regression test ($p = 0.0533$), there was no evidence of publication bias (Fig. 5-C).

### 3.5. Descriptive synthesis for outcomes after adjustment

The majority of the studies included in our quantitative synthesis that provided the necessary information for our synthesis were data from registries without any adjustment for age or other comorbidities between T1D and T2D patients with COVID-19 disease. In their own studies, however, they have reported their results after further adjustment as well as their unadjusted results. As a result of adjusting for age and comorbidities, the high-risk group in three studies was T2D, five studies were T1D, and two studies reported no significant difference between these groups in relevant outcomes.

### 4. Discussion

To the best of our knowledge, this is the first systematic review and meta-analysis comparing the severity of COVID-19 between
| Author/Year | Country | Type of study | Duration | Population | Total patients | Age | T1D Total | T1D Age | T1D Co-morbidity | T2D Total | T2D Age | T2D Co-morbidity | Final results | Quality |
|------------|---------|---------------|----------|------------|----------------|-----|-----------|---------|-----------------|-----------|---------|-----------------|--------------|---------|
| Sourij [18]/2020 | Austria | Combined prospective and retrospective multicenter cohort study | From April to June 2020 | Hospitalized people aged 18 years or older with a confirmed positive throat swab for SARS-CoV-2 and a confirmed diagnosis of type 1 diabetes, type 2 diabetes or prediabetes | 238 | 71.1 ± 12.9 | 11 | N.A. | N.A. | 180 | N.A. | N.A. | No significant differences for mortality between people with T1D and T2D. | Fair | |
| Rawshani, [19]/2021 | Sweden | Retrospective case control cohort study | Till January 1, 2020 | Adult patients (>18) with type 1 and type 2 diabetes with at least one registration in the NDR between January 1, 1998 and January 1, 2020, and who were alive on Jan 1, 2020 | 456,615 | N.A. | 44639 | 42.60 ± 16.56 | Coronary heart disease: 3490 Acute myocardial infarction: 1736/ Stroke: 1357 Heart failure: 1474 Valvular disease: 528/ Atrial fibrillation: 1212/Hypertension: 15474/ Chronic obstructive pulmonary disease: 489/Dementia: 243/ Asthma: 2965 Alcoholism: 2651 Substance abuse: 3726/Schizophrenia: 399/Renal disease: 160, Immune disease or on immunosuppressants: 629, N.A. | 411976 | 66.05 ± 13.24 | Coronary heart disease: 85814 Acute myocardial infarction: 42581/ Stroke: 35793 Heart failure: 44215 Valvular disease: 15278/Atrial fibrillation:56522/Hypertension: 228441/ Peripheral arterial disease: 15904 Chronic obstructive pulmonary disease: 21210/Dementia: 10834/Asthma: 26936 Alcoholism: 16785 Substance abuse: 29018/Schizophrenia: 8963/Renal disease: 35382/Cancer: 81715 Any heart disease: 93891, Asthma or chronic lower airway disease: 93704, Neurological and dementia (excluding epilepsy): 1390, Liver disease: 160, Immune disease or on immunosuppressants: 629, N.A. | Increased risk for Good T2D after adjustment, T1D did not show an excess risk for outcomes after adjustment; reassuringly for this group, there were very few deaths and admissions into intensive care. | Good |
| McGurnaghan, [27]/2021 | Scotland | Cohort study | From March to July 2020 | Total population of Scotland, including all people with diabetes who were alive 3 weeks before the start of the pandemic in Scotland (estimated Feb 7, 2020) | 5,463,300 | 66-7 | 34 383 | 44.5 (29.7,58.3) | Any heart disease: 4847, Asthma or chronic lower airway disease: 8704, Neurological and dementia (excluding epilepsy): 1390, Liver disease: 160, Immune disease or on immunosuppressants: 629, N.A. | 275 960 | 68.4 (59.1,76.9) | Any heart disease: 92891, Asthma or chronic lower airway disease: 93704, Neurological and dementia (excluding epilepsy): 13460, Liver disease: 2698, Immune disease or on immunosuppressants: 3161, N.A. | Adjusted odds Good ratio of patients with fatal or critical care unit-treated COVID-19 in T1D was higher comparing T2D. | Good |
| Lasbleiz (28)/2020 | France | Retrospective monocentric observational cohort study | From March to April 2020 | COVID-19 diagnosis confirmed biologically (by SARS-CoV-2 PCR test) and/or radiologically (ground-glass opacity and/or crazy paving on chest computed | 344 | 62.1 ± 14.0 | 20 | 40.1 ± 15 | N.A. | 324 | 63.5 ± 13 | N.A. | Most of T1D patients were managed as out-patients. After adjustment, patients with T2D always had a much greater risk of being hospitalized than T1D. | Good | |
tomography scan) and a personal history of diabetes or newly diagnosed diabetes on admission (glycosylated hemoglobin HbA1c ≥ 6.5% during hospitalization).

| Study                                | Country     | Study Type               | Study Period                          | Patients                          | Gender | Age (Mean) | BMI (Mean) | HbA1c (Mean) | Smoking | Hypertension | Diabetic Complications | COVID-19-Related Mortality |
|--------------------------------------|-------------|--------------------------|---------------------------------------|-----------------------------------|--------|------------|------------|--------------|---------|--------------|------------------------|---------------------------|
| Kempegowda [20], 2021                | England     | Retrospective cohort study | From March to May 2020                | 88 patients treated              | N.A.   | 5.3        | 30.9       | N.A.          | 15      | 63           | T2D were more likely to need ICU with higher mortality rates comparing T1D. | Fair                      |
| Holman [21], 2020                    | England     | Population-based cohort study | Till May 11, 2020                      | People with diagnosed diabetes who were registered with a general practice | 3138410 | N.A.       | 46.6 (SD 19.6) | N.A.          | 264     | 390          | Previous myocardial infarction: 3095/ Previous stroke: 3160/ Previous heart failure: 6825/Any cardiovascular or renal morbidity: 31 790/ a recent history of one or more prescriptions for antihypertensive drugs: 115 660/ Hypertension:13/ Asthma: 2/ Taking any antihypertensive medication: 25 | Good                      |
| Gregory [22], 2021                  | United States | Prospective cohort study | From March to August 2020               | Case subjects with COVID-19 across a regional health care network of 137 service locations | 6451   | N.A.       | 37 (table 2)  | N.A.          | 273     | 58           | Hypertension:194/ Asthma: 28/ Taking any antihypertensive medication:269 | Good                      |
| Gao [23], 2021                      | England     | Prospective, community-based, cohort study | From January to April 2020             | Individuals aged 20–99 years who were registered at a general practice (GP) that contributes to the QResearch database and had available BMI data | 6910695 | 44 248     | N.A.       | N.A.          | 577 246 | N.A.         | N.A.                                      | Good                      |
| Demirci [26], 2022                  | Turkey      | Nationwide retrospective cohort                     | From March to May 2020                 | Patients with confirmed (PCR positive) COVID-19 infection between 11 March through May 30, 2020 | 149,671 | N.A.       | 41         | 33,478        | Smoking: 29/ Hypertension: 110/ Dyslipidaemia: 80/ Obesity: 5/ Asthma,COPD: 57/ Chronic kidney disease:43/ Coronary artery disease (CAD):65/ Cancer: 8/ Microvascular complications: 77/ Macrovascular complications: 73/ Taking RAS blocker: 78 | 41                         |

(continued on next page)
Various reports from around the world indicate that the prevalence of diabetes among hospitalized COVID-19 patients can reach as high as 20% [30]. Further, epidemiological studies suggest that diabetes is more prevalent among individuals with severe disease and is associated with a higher mortality rate [31]. Furthermore, patients with diabetes are more likely to acquire infections such as lower respiratory tract infections due to impaired immune function, including a lack of proper phagocytosis by neutrophils, macrophages, and monocytes [32]. Hyperglycemia is also associated with an increased risk of severe infections [33]. Therefore, patients with diabetes are at greater risk of developing more severe forms of the disease and even death. Together, these factors result in higher COVID-19 morbidity and mortality, placing a great burden on healthcare systems and other aspects of people’s lives. Considering public health perspectives, with the emergence of new variants and their rapid spread, the number of patients admitted to hospitals, especially intensive care units, has grown dramatically. As such, it is crucial to establish protocols that prioritize patients based on their estimated risk of severe disease and death. Special attention should be paid to patients with conditions associated with more severe outcomes, such as older age, diabetes, hypertension and obesity, as they are more likely to suffer complications. As a result of this condition, COVID-19 can be prevented through improved social distancing and personal protective equipment, enhanced patient vigilance, and a lower threshold for testing, hospitalization, and intensive care for patients with diabetes.

Both T1D and T2D are the most prevalent types of diabetes mellitus. Although both groups are at risk of severe outcomes, there are differences between them as two pathophysiologically distinct conditions. In COVID-19 patients with both types of diabetes, the mortality rate is associated with age, male gender, cardiovascular disease (CVD), renal impairment, obesity, and underweight [34]. BMI could be a determining factor when comparing these two subtypes since it is more prevalent among patients with T2D. According to Trieu et al., elevated BMI is evident among patients with T1D compared to T2D patients. Good G. The National Diabetic Registry, SARS-CoV-2: Severe Acute Respiratory Syndrome Coronavirus 2. N.A.: Not Applicable. PCR: Polymerase Chain Reaction. DKA: Diabetic ketoacidosis. Intensive Care Unit (ICU): Critical Care Unit. BMI: Body Mass Index. COVID-19: Coronavirus Disease 2019. RAS: Renin Angiotensin System. GP: General Practice. CAD: Coronary Artery Disease.
Fig. 2). Forest plots showing the results of meta-analyses for comparing COVID-19 outcomes in patients with type 1 and type 2 Diabetes. A) The rate of mortality was significantly lower in patients with type 1 diabetes, B) No significant difference was observed in terms of ICU admission between type 1 and type 2 diabetes, C) No significant difference was observed in terms of hospitalization between type 1 and type 2 diabetes.
Fig. 3). Sub-group meta-analysis based on adjusted/unadjusted data available for age, sex, and comorbidities. Most of the included studies only reported OR/RR after adjustment, therefore, large amount of data in meta-analysis are unadjusted for possible confounders. A) Mortality, B) ICU admission, C) Hospitalization. Yes: adjusted data; No: unadjusted data.
lower risk for these outcomes among patients with T2D, whereas the risk was the same for patients with T1D [34].

According to the English national audit cohort, compared to individuals without diabetes, the odds ratios for COVID-19 deaths in the hospital were 3.51 in T1D patients and 2.03 in T2D patients [28]. Due to limitations associated with the datasets used in the study, confounding factors such as hypertension, CKD, BMI, and smoking status were not adjusted [25]. A matched case-control study from Scotland reported ORs of 2.75 and 1.60 for T1D and T2D, respectively [27]. Lasbleiz et al. reported a much higher hospitalization risk for T2D patients after adjusting for age and BMI, whereas T1D patients may be reassured [28].

In Gregory et al.’s study, the odds of hospitalization and more severe disease were similar between T1D patients and T2D patients [22]. According to Demirci et al., a nationwide cohort study was conducted with 149,671 patients who tested positive for COVID-19 [26]. They found that despite adjusting for age, gender, and microvascular and macrovascular complications, patients with T1D had a threefold greater risk of ICU admission and mortality than people with T2D. They described the scarcity of data regarding T1D due to the low prevalence of T1DM, the younger age of T1DM patients compared to T2DM patients, and the fact that elders are at a greater risk of becoming affected by COVID-19. They concluded that these two subtypes of diabetes mellitus are entirely different in their clinical outcomes based on their findings. In addition, the different immune dysfunction and pathophysiology may be contributing to the higher mortality rate associated with T1D [26]. COVID-19 mortality has an inverse relationship with eGFR [30]. As eGFR values may change after taking anti-diabetic medications, there is concern that the use of these drugs may impact mortality rates.

5. Strengths and clinical relevance

Our study has several strengths. This is the first systematic review and meta-analysis to examine COVID-19 severity differences between T1D and T2D. We conducted a comprehensive database search in order to obtain the most comprehensive results and accurate conclusions. The analysis of each outcome was also based on at least five studies. Additionally, most of the studies included measured and differentiated the level of baseline characteristics that may vary in amount or level, such as HbA1c. These findings may have implications for clinical practice and public health policies. While chronic hyperglycemia is the primary cause of diabetes...
mellitus, type 1 and type 2 diabetes differ in terms of their pathophysiology, preventive methods, age of onset, management, and epidemiological characteristics. As a result, the approaches needed to treat these two types of diabetes differ. It is beneficial for us to identify which type of diabetes leads to more severe forms of COVID-19 in order to determine the preventive measures needed to reduce the number of affected individuals and further complications associated with concurrent COVID-19 infection. Specifically tailored education and management can be provided to patients with each type of diabetes to achieve this objective.

The fact that T2D is more prevalent and develops at an older age than T1D indicates that the disease severity in patients with these two types of diabetes warrants special consideration for prevention and management. Furthermore, management of T1D is based on insulin therapy. On the other hand, the management of T2D includes a variety of anti-diabetic medications, which may cause different side effects, increasing the risk of alterations to the health status of patients. Diabetic ketoacidosis (DKA) is a severe acute metabolic condition characterized by acidosis, ketosis, and hyperglycemia that occurs more frequently among patients with type 1 diabetes [36]. It is important to assess the risk of severe disease for patients who are more vulnerable to DKA as this is a life-threatening condition. We found that both types of patients have the same risk of developing severe disease; therefore, there is no need to prioritize these two patient types when it comes to providing health care services.

6. Limitations

As our study was subject to several limitations, its results should be interpreted with caution. Most of the analyzed studies were cohort studies, so they may be prone to bias related to their retrospective nature. The populations of the included studies were clinically heterogeneous. For example, one study included pediatric patients, while others included adult patients. In addition, some studies included very few participants, whereas others were national studies including large numbers of participants. The timing of the studies and the region in which they were conducted may have affected the results, as there were a number of differences between included studies. Furthermore, the heterogeneity of the results obtained from the studies is high; however, meta-analyses based on observational studies are often highly heterogeneous [37]. Lastly, it should be noted that most of our quantitative synthesis includes unadjusted data for age, gender, and other comorbidities due to the fact that confounding factors such as elderly age, cardiovascular disease, hypertension, and obesity are associated with severe COVID-19 and increased mortality.

We conclude, based on our results, that there are no significant differences between T1D and T2D in terms of severity of the disease. The mortality rate for people with T1D was observed to be lower than that for people with T2D based on the unadjusted data available. As data on these subjects is scarce, and the results obtained from studies are heterogeneous, further research with adequate sample sizes is needed to precisely compare the outcomes of COVID-19 between T1D and T2D.

Author contributions

Arman Shafiee: Conceptualization, Investigation, Project administration, Writing- original draft, Writing-review & editing.
Mohammad Mobin Teymouri Athar, Mahmoud Nassar: Investigation, Writing- original draft, Writing-review & editing.
Niloofar Seighali, Dilya Aminzade, Payam Fattahi, Maryam Rahmannia, and Zahra Ahmadi: Conceptualization, Investigation, Writing- original draft.

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Ethics approval

Not applicable.

Data availability

Data sharing is available by contacting corresponding author.

Declaration of competing interest

No Conflict of interest.

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Not applicable.

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