

Treatment Success in Adults With Newly Diagnosed Type 2 Diabetes During the COVID-19 Pandemic: A Single-Center Cross-Sectional Study

Ecem Özyaprak Erdem

ecemozyaprak@gmail.com

Dr Lütfi Kırdar Kartal Eğitim ve Araştırma Hastanesi, Istanbul, Turkey

Nazlı Hacıağaoğlu

Dr Lütfi Kırdar Kartal Eğitim ve Araştırma Hastanesi, Istanbul, Turkey

Engin Ersin Şimşek

Dr Lütfi Kırdar Kartal Eğitim ve Araştırma Hastanesi, Istanbul, Turkey

Research Article

Keywords: Type 2 Diabetes, COVID-19, Treatment Adherence, Glycemic Control, Primary Care, HbA1c

Posted Date: October 22nd, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11216915/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background

The COVID-19 pandemic disrupted diabetes diagnosis, monitoring, and continuity of care, potentially affecting treatment outcomes in individuals with newly diagnosed type 2 diabetes. This study aimed to evaluate treatment success and identify factors associated with achieving individualized glycemic targets among adults diagnosed with type 2 diabetes during the COVID-19 pandemic, with consideration of prior COVID-19 infection.

Methods

This single-center cross-sectional study included 211 adults diagnosed with type 2 diabetes after March 2020 and evaluated at a diabetes center in Türkiye between June and September 2023. Clinical, laboratory, treatment, and COVID-19 data were obtained from patient interviews and electronic health records. Treatment success was defined as achievement of individualized HbA1c targets according to the 2022 Turkish Endocrinology and Metabolism Society guideline. After excluding 20 participants who developed COVID-19 following diabetes diagnosis, factors associated with treatment success were evaluated in 191 participants using multivariable Firth penalized logistic regression, with additional models examining comorbidities and concomitant medication use as sensitivity analyses.

Results

Among 191 participants included in the treatment-success analysis, 139 (72.8%) achieved their individualized HbA1c target. In the primary Firth penalized logistic regression model, higher HbA1c at diagnosis was associated with lower odds of treatment success (aOR 0.80, 95% CI 0.66–0.97), whereas longer diabetes duration (aOR 1.06 per month, 95% CI 1.01–1.11) and pharmacological adherence (aOR 6.88, 95% CI 2.83–17.92) were associated with higher odds of success. Prior COVID-19 infection was also associated with higher odds of treatment success (aOR 2.88, 95% CI 1.15–8.04), although this finding should be interpreted cautiously.

Conclusions

Treatment success was primarily associated with baseline glycemic status and pharmacological adherence. The unexpected association between prior COVID-19 infection and higher odds of treatment success should be interpreted cautiously given its sensitivity to model specification. These findings emphasize the importance of treatment adherence and continuity of diabetes care.

BACKGROUND

Diabetes is a rapidly growing global health issue with far-reaching effects, affecting an estimated 529 million people worldwide in 2021, a figure projected to rise to 1.31 billion by 2050¹. WHO reports that diabetes causes blindness, kidney failure, heart attacks, and lower-limb amputations. Additionally, approximately 2 million deaths are attributed to diabetes and diabetes-related kidney disease, while around 11% of cardiovascular deaths are associated with high blood glucose levels. Although diabetes represents a substantial global health burden, it can be effectively managed through lifestyle modifications, early diagnosis, regular follow-up, and appropriate treatment².

Despite advances in diabetes diagnosis and treatment, substantial gaps in disease awareness, treatment, and glycemic control persist worldwide. A recent systematic review and meta-analysis showed that approximately 60% of individuals with diabetes were aware of their condition and 45% received pharmacological treatment, while only 20% achieved adequate glycemic control, with particularly pronounced disparities in low-income countries and rural populations³. Treatment success for diabetes is defined by limiting the blood glucose level at desirable level based on clinical characteristics of patients such as age and coexisting disease profiles⁴. However, effective management of type 2 diabetes extends beyond glycemic control and requires a comprehensive approach addressing multiple cardiovascular risk factors, including hypertension, dyslipidemia, and obesity, to reduce the risk of long-term microvascular and macrovascular complications.⁵

In 2019, the outbreak of SARS-CoV-2, also referred to as COVID-19, originated in Wuhan, China, and rapidly spread globally, resulting in 772,052,752 confirmed cases and 6,985,278 deaths worldwide⁶. In our country, the confirmed case count reached 17,042,722, with 101,492 recorded deaths⁷. Turkey reported its first COVID-19 case on March 11, 2020⁸. The country experienced an initial peak in daily cases on April 29, 2020, with 2,936 cases, and a second peak on December 8, 2020, with 6,593 cases⁷. After the initial peak subsided, restrictions were gradually eased on June 1, 2020, but were subsequently reemployed in various forms on November 18, 2020, as cases rose again⁹. The highest number of daily cases, 111,157, was reported on February 4, 2022, a period when multiple COVID-19 vaccines were available⁹. Nearly three years after the pandemic's onset, the World Health Organization (WHO) declared its end on May 5, 2023¹⁰. Nonetheless, questions remain regarding the potential long-term health impacts of COVID-19 on individuals.

The intersection of these two pandemics has heightened the risk of morbidity and mortality for both diseases, leading researchers to explore their relationship. Numerous studies have shown that most hospitalized COVID-19 patients also had diabetes mellitus, intensifying scrutiny of the association between diabetes and COVID-19^{11, 12}. Most research indicates that diabetes exacerbates the severity of COVID-19^{13, 14}; however, some studies suggest COVID-19 may also directly contribute to the onset of diabetes^{15, 16}.

Although the precise impact of COVID-19 on diabetes onset and management remains unclear, the pandemic profoundly altered both individual lifestyles and the delivery of healthcare services¹⁷.

This study aimed to evaluate treatment success and identify factors associated with achieving individualized glycemic targets among adults diagnosed with type 2 diabetes during the COVID-19 pandemic, with particular consideration of prior COVID-19 infection.

METHODS

Study design and participants

This cross-sectional study aimed to identify differences in patient profiles and disease progression among diabetes mellitus patients who contracted COVID-19 versus those who did not during the pandemic. The study included individuals aged 18 and older who visited the Kaynarca Diabetes Center at Kartal Dr. Lütfi Kırdar City Hospital between June 1 and September 1, 2023, and met specific inclusion criteria. Based on a 95% confidence interval, a 5% margin of error, and an anticipated 10% drop-out rate, 203 patients were targeted, with data collection completed on 211 participants.

Inclusion criteria were age 18 or older, first-time diabetes diagnosis post-March 2020, and accessible health records in the national e-Nabız system. Exclusions included gestational diabetes, inaccessible e-Nabız records, type 1 diabetes, corticosteroid use, and pre-pandemic diabetes diagnoses.

Data collection and definitions

Data on demographics, medical history, and treatment adherence were collected through interviews, with BMI and metabolic syndrome diagnoses assessed using hospital data. HbA1c, FPG, C-peptide levels, and treatment protocols were retrieved from hospital and e-Nabız records. e-Nabız records also confirmed exclusion criteria and provided COVID-19 PCR results and hospitalization details.

Treatment success was defined as achievement of the individualized HbA1c target recommended in the 2022 Turkish Endocrinology and Metabolism Society (TEMED) guideline⁴. HbA1c targets were determined according to patient characteristics, including age and the presence of comorbidities, rather than using a single HbA1c threshold for all participants. Accordingly, each participant was classified as having achieved or not achieved treatment success based on the HbA1c target applicable to their individual clinical profile.

Data were collected using an investigator-completed electronic data collection form (Microsoft Excel). The form included variables specified in the study protocol, as well as information routinely obtained during clinical consultations. Patient-reported information was recorded by the investigator during routine clinical interviews, while additional demographic, clinical, treatment-related, and laboratory data were retrieved from electronic health records. The form was used for systematic data recording and was not administered to participants as a standardized questionnaire. An English-language version of the data collection form is provided as Additional file 3.

Statistical analysis

Statistical analyses were performed using R version 4.3.2. Continuous variables were summarized as mean $\pm$ standard deviation or median (interquartile range), as appropriate, and categorical variables as number and percentage. For the treatment-success analysis, participants who developed COVID-19 after the diagnosis of diabetes were excluded to avoid including an exposure occurring during the treatment and follow-up period, leaving 191 participants for analysis. Continuous variables were compared between treatment-success groups using the Wilcoxon rank-sum test, and categorical variables were compared using Fisher's exact test.

Factors associated with treatment success were evaluated using multivariable Firth penalized logistic regression. Firth penalization was used because complete separation was observed in some treatment-modality categories. The primary model included HbA1c at diagnosis, diabetes duration, pharmacological adherence, treatment modality, and prior COVID-19 infection. Results are reported as adjusted odds ratios (aORs) with 95% confidence intervals (CIs). Additional models including recorded comorbidities or concomitant medication use were examined as sensitivity analyses. All statistical tests were two-sided, and $P < 0.05$ was considered statistically significant.

Use of generative AI

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) for English-language editing, grammar checking, and assistance with the presentation of the statistical analyses. All AI-assisted content was reviewed and edited by the authors, who take full responsibility for the content of the manuscript.

RESULTS

Participant characteristics

The average age of the 211 participants in this study was 51.7 ± 10.09 years, with 37.9% ($n = 80$) identifying as female. Most participants were married (87.2%, $n = 184$), held an education level of primary school or below (55.5%, $n = 117$), were employed (59.7%, $n = 126$), and lived in a nuclear family setting (79.1%, $n = 167$). Among the participants, 42.2% ($n = 89$) were current smokers, while 14.7% ($n = 31$) were former smokers, with an average pack-year history of 12.66 ± 19 among current smokers. Alcohol consumption was reported by 12.8% of participants.

The most common comorbid conditions observed were metabolic syndrome (67.8%, $n = 143$), hyperlipidemia (64.9%, $n = 137$), and obesity (42.2%, $n = 89$). Additionally, 32.7% ($n = 69$) of participants had hypertension, 9.95% ($n = 21$) had coronary artery disease, and 5.69% ($n = 12$) had a psychiatric disorder.

In terms of diabetes-related treatment, 34.1% (n = 72) were using antihypertensive medication, 53.1% (n = 112) were on lipid-lowering drugs, and 19.9% (n = 42) were prescribed anticoagulants.

Anthropometric measures among participants showed an average height of 167.8 ± 9.3 cm. and weight of 84.9 ± 15.5 kg. The average body mass index (BMI) was 30.3 ± 5.4 , and the average waist circumference of 102.9 ± 14 cm. A significant portion of the group, 44.1% (n = 93), was classified as overweight. Since the diabetes diagnosis, an average of 16 ± 11 months had elapsed. Half of the participants (50.2%, n = 106) received their diagnosis at Kartal Dr. Lutfi Kırdar City Hospital Kaynarca Diabetes Center. At diagnosis, the average HbA1c level was 9.4 ± 2.5 , with an average fasting plasma glucose (FPG) level of 203 ± 90.4 mg/dL. During the study, the most recent average HbA1c recorded was 7.2 ± 1.8 , and the average FPG level was 135 ± 55 mg/dL. Additionally, the latest C-peptide level among participants averaged 3.5 ± 9.6 .

Table 1
Demographic and clinical characteristics of the study population (n = 211)

Characteristic	Total (n = 211)
Age, years	51.7 ± 10.1
Male sex	131 (62.1)
BMI, kg/m ²	29.3 (26.5–33.5)
HbA1c at diagnosis, %	8.9 (7.1–11.4)
Fasting plasma glucose at diagnosis, mg/dL	173 (127–263.5)
Diabetes duration, months	14.3 (6.0–25.7)
Prior COVID-19 infection	75 (35.5)
Pharmacological adherence	147 (69.7)
Treatment modality	
OAD	163 (77.3)
Insulin	8 (3.8)
OAD + insulin	33 (15.6)
No medication	7 (3.3)
Hypertension	69 (32.7)
Hyperlipidemia	137 (64.9)
Obesity	89 (42.2)

Additional demographic characteristics, lifestyle factors, comorbidities, and concomitant medication use are presented in Table S1.

Treatment success and associated clinical characteristics

For analyses of treatment success, 20 participants who developed COVID-19 after the diagnosis of diabetes were excluded to avoid including an exposure occurring during the treatment and follow-up period. Accordingly, the treatment-success analysis included 191 participants, of whom 139 (72.8%) achieved their individualized HbA1c target according to the 2022 TEMD guideline and were classified as having achieved treatment success, whereas 52 (27.2%) did not.

Table 2
Clinical and laboratory characteristics according to treatment success (n = 191)

Characteristic	Treatment failure (n = 52)	Treatment success (n = 139)	P value
Age, years	51.5 (42.0–58.3)	52.0 (45.5–58.0)	0.622
Female sex	18 (34.6)	57 (41.0)	0.506
BMI, kg/m ²	27.7 (25.3–34.4)	29.3 (26.9–33.0)	0.160
HbA1c at diagnosis, %	11.0 (9.6–12.0)	8.0 (6.8–10.7)	< 0.001
Fasting plasma glucose at diagnosis, mg/dL	233 (163–302)	154 (124–244)	< 0.001
Diabetes duration, months	9.3 (3.8–19.7)	14.3 (6.8–25.1)	0.006
Pharmacological adherence	20 (38.5)	112 (80.6)	< 0.001
Treatment modality			< 0.001
OAD	22 (42.3)	123 (88.5)	
No medication	0 (0.0)	6 (4.3)	
Insulin	8 (15.4)	0 (0.0)	
OAD + insulin	22 (42.3)	10 (7.2)	
Anticoagulant use	4 (7.7)	33 (23.7)	0.013
Antihypertensive use	20 (38.5)	43 (30.9)	0.388
Prior COVID-19 infection	15 (28.8)	60 (43.2)	0.096
Note: Data are presented as median (interquartile range) or n (%). Continuous variables were compared using the Wilcoxon rank-sum test and categorical variables using Fisher's exact test. BMI, body mass index; OAD, oral antidiabetic drug.			

Factors associated with treatment success

In the treatment-success analysis of 191 participants, those who achieved treatment success had lower HbA1c and fasting plasma glucose levels at diagnosis and a longer duration of diabetes than those who did not achieve treatment success. Pharmacological adherence and treatment modality also differed significantly between the groups. Anticoagulant use was more frequent among participants who achieved treatment success, whereas age, sex, BMI, antihypertensive use, and prior COVID-19 infection did not differ significantly between the groups (Table 2).

In the primary multivariable Firth penalized logistic regression model, higher HbA1c at diagnosis was associated with lower odds of treatment success (aOR 0.80 per 1% increase, 95% CI 0.66–0.97; $P = 0.022$). Longer diabetes duration was associated with higher odds of treatment success (aOR 1.06 per month, 95% CI 1.01–1.11; $P = 0.010$), as was pharmacological adherence (aOR 6.88, 95% CI 2.83–17.92; $P < 0.001$). Compared with OAD therapy, insulin treatment (aOR 0.014, 95% CI < 0.001 –0.135; $P < 0.001$) and combined OAD plus insulin treatment (aOR 0.155, 95% CI 0.050–0.459; $P < 0.001$) were associated with lower odds of treatment success. Prior COVID-19 infection was associated with higher odds of treatment success (aOR 2.88, 95% CI 1.15–8.04; $P = 0.023$) (Table 3).

Table 3
Factors associated with treatment success in the primary Firth penalized logistic regression model (n = 191)

Variable	Adjusted OR	95% CI	P value
HbA1c at diagnosis, per 1% increase	0.80	0.66–0.97	0.022
Diabetes duration, per month	1.06	1.01–1.11	0.010
Pharmacological adherence	6.88	2.83–17.92	< 0.001
Treatment modality			
OAD	Reference	—	—
No medication	0.85	0.07–118.36	0.920
Insulin	0.014	< 0.001 –0.135	< 0.001
OAD + insulin	0.155	0.050–0.459	< 0.001
Prior COVID-19 infection	2.88	1.15–8.04	0.023

Model: likelihood-ratio $\chi^2 = 85.55$, $df = 7$, $P < 0.001$; $n = 191$.

Footnote: OR, odds ratio; CI, confidence interval; OAD, oral antidiabetic drug. Adjusted ORs were estimated using multivariable Firth penalized logistic regression. OAD treatment was used as the reference category. Firth penalization was used because complete separation was observed in some treatment categories.

In sensitivity analyses, the association between prior COVID-19 infection and treatment success remained similar after additional adjustment for recorded comorbidities (aOR 3.34, 95% CI 1.19–10.84; $P = 0.020$). After additional adjustment for concomitant medication use, the point estimate remained in the same direction, but the confidence interval included the null (aOR 2.60, 95% CI 0.97–7.74; $P = 0.059$) (Table S2).

DISCUSSION

Over the past half-century, the prevalence of diabetes has increased approximately fourfold¹⁸. The most important factors behind that trend are obesity¹⁹, urbanization²⁰, population aging²¹, environmental factors^{21, 22} and genetic predisposition²³. Moreover, while the most substantial increase was observed in the regions of low- and middle-income, treatment success was considerably lower in low- and middle-income countries^{3, 24}. This clearly demonstrates how the burden of diabetes disproportionately falls on socioeconomically disadvantaged populations.

The proportion of participants achieving their individualized HbA1c target was relatively high (72.8%)²⁵. This finding should be interpreted in the context of the study population and the definition of treatment success. Participants were evaluated at a dedicated diabetes center, and treatment success was defined according to individualized HbA1c targets rather than a single uniform threshold. Therefore, the observed rate may not be directly comparable with glycemic control rates reported in broader diabetes populations. Moreover, because treatment success was assessed cross-sectionally, the observed target attainment does not necessarily indicate sustained glycemic control over time.

Several studies have also highlighted that the management of diabetes was uniquely affected during the pandemic. Pandemic-related restrictions disrupted screening programs, increased sedentary lifestyles, and led to hesitancy in routine care, all creating specific challenges in diabetes diagnosis and management^{26–28}.

Obesity is the real not-yet-resolved pandemic of modern times. WHO reported in 2022 that 1 in 8 people in the world were living with obesity²⁹. Moreover, higher-than-optimal BMI was associated with 3.7 million deaths from noncommunicable diseases (NCDs), including cardiovascular diseases, diabetes and cancer³⁰.

The COVID-19 pandemic and the associated restrictions are known to have contributed, both directly and indirectly, to the increasing global burden of obesity^{31, 32}. Furthermore, it is suggested that obesity may stand as a factor that may worsen hyperglycemia in COVID-19 cases³³. In the present study, participants with prior COVID-19 infection were more frequently classified as overweight or obese than those without prior infection ($P = 0.030$). However, given the cross-sectional design, the temporal relationship between COVID-19 infection and body weight cannot be established, and this finding should be interpreted cautiously.

A notable finding in our study was the rate of comorbidities, with metabolic syndrome as the most common, followed by hyperlipidemia, obesity, and hypertension. In an earlier study on diabetes comorbidities by Akın S. and Bölük C. at the Kartal Dr. Lütfi Kırdar Internal Medicine Department³⁴, hypertension was the most frequent comorbidity, especially in those with a longer diabetes duration. In contrast, the lower hypertension rate in our study likely reflects our focus on patients diagnosed within the last three years. This suggests the importance of close monitoring to prevent hypertension-related complications in newly diagnosed diabetes patients.

No significant differences were observed in HbA1c, FPG, and C-peptide levels between individuals with and without prior COVID-19 infection. Studies have shown that COVID-19 infection can temporarily raise glycemic levels due to stress and inflammation, but this increase generally does not alter HbA1c levels³⁵. Thus, such fluctuations alone are unlikely to lead to a diabetes diagnosis in those not otherwise at risk. However, the stress associated with COVID-19 could potentially contribute to diabetes onset in those with metabolic or genetic predispositions.

Systematic reviews and meta-analyses indicate a higher likelihood of diabetes diagnosis following COVID-19 infection^{36, 37}. However, most of these studies are either community-based, hospital database-based, or conducted with hospitalized patients, often without specifying diabetes type. Factors like corticosteroid use and socioeconomic status are also generally unstandardized. While it is suggested that COVID-19 might lead to diabetes through pancreatic beta-cell damage³⁸, it remains unclear to what extent this occurs or what type of diabetes may result.

Pandemic restrictions led to specific conditions affecting diabetes diagnosis, monitoring, and treatment³⁹, creating a variation in regular care. In the present study, higher HbA1c at diagnosis was associated with lower odds of treatment success, whereas longer diabetes duration and pharmacological adherence were associated with higher odds of success. Insulin-based treatment was associated with lower odds of success than OAD therapy, although this likely reflects differences in disease severity and treatment indication. Pharmacological adherence emerged as the strongest modifiable factor associated with treatment success. Future studies should investigate whether pandemic-related disruptions in follow-up and diabetes care affected adherence and explore strategies to maintain treatment continuity during future healthcare crises.

Unexpectedly, prior COVID-19 infection was associated with higher odds of treatment success in the primary model (aOR 2.88, 95% CI 1.15–8.04). This association persisted after adjustment for recorded comorbidities but was attenuated after additional adjustment for concomitant medication use (aOR 2.60, 95% CI 0.97–7.74). Therefore, this finding should not be interpreted as a beneficial effect of COVID-19. Differences in clinical characteristics, healthcare contact, or follow-up intensity may have contributed to the observed association, although these factors were not directly measured.

In the expanded sensitivity model, anticoagulant use was associated with higher odds of treatment success. Although anticoagulant therapy was frequently used during the COVID-19 era, this finding

should not be interpreted as a beneficial effect of anticoagulation on glycemic control. Anticoagulant use may instead reflect differences in comorbidity burden, clinical surveillance, or healthcare contact. Thus, this association should be considered exploratory and warrants further investigation.

This study has several limitations. First, its single-center, cross-sectional design and relatively modest sample size limit the generalizability of the findings and preclude causal inference. Some treatment and comorbidity subgroups were small, resulting in sparse data and imprecise estimates despite the use of Firth penalized logistic regression.

Second, treatment success was defined by achievement of individualized HbA1c targets. Although HbA1c remains a central measure of glycemic control, contemporary diabetes management increasingly emphasizes broader outcomes beyond HbA1c alone, including hypoglycemia, glycemic variability, weight management, cardiovascular and renal outcomes, and patient-centered measures^{40, 41}.

Moreover, the cross-sectional assessment reflects target attainment at a particular point in time rather than sustained treatment success over time. Healthcare utilization, follow-up intensity, and screening frequency were not directly measured, limiting our ability to explain the unexpected association between prior COVID-19 and treatment success. This association was also sensitive to model specification and should therefore be interpreted cautiously. Residual confounding from unmeasured clinical and behavioral factors cannot be excluded.

Finally, changes in COVID-19 diagnostic practices during the pandemic may have affected the classification of prior infection.

This study provides a unique contribution to the literature by examining factors influencing treatment success and exploring the relationship between COVID-19 infection and type 2 diabetes in individuals diagnosed and monitored during the pandemic. Notably, the study began after the pandemic had concluded and intentionally excluded participants using corticosteroids, which might otherwise confound results. Its value lies in the detailed assessment of comorbidities, medication histories, lifestyle factors, and sociodemographic characteristics of participants.

CONCLUSION

In conclusion, treatment success in adults diagnosed with type 2 diabetes during the COVID-19 pandemic was strongly associated with pharmacological adherence and baseline glycemic status. Although prior COVID-19 infection showed an unexpected association with treatment success, this finding was sensitive to model specification and should not be interpreted causally. These findings emphasize the importance of early identification, sustained treatment adherence, and continuous follow-up in diabetes care, particularly during periods of healthcare disruption. Given the high prevalence of type 2 diabetes and the need for long-term, accessible care, primary care is particularly well positioned to support regular monitoring, reinforce treatment adherence, and maintain continuity of diabetes management during both routine care and future healthcare crises.

Abbreviations

BMI: Body mass index

CI: Confidence interval

COVID-19: Coronavirus disease 2019

CVD: Cardiovascular disease

FPG: Fasting plasma glucose

HbA1c: Glycated hemoglobin

OAD: Oral antidiabetic drug

OR: Odds ratio

TEMDS: Turkish Endocrinology and Metabolism Society

T2DM: Type 2 diabetes mellitus

Declarations

Ethics approval and consent to participate

The study was approved by the Clinical Research Ethics Committee of Kartal Dr. Lütfi Kırdar City Hospital (Decision No. 2023/514/250/40; 29 May 2023). All procedures involving human participants were performed in accordance with the Declaration of Helsinki and relevant institutional and national ethical guidelines and regulations. Informed consent was obtained from all participants prior to their inclusion in the study.

Consent for publication

Not applicable

Availability of data and materials

The de-identified dataset generated and analyzed during the current study is publicly available in the GitHub repository “DM2-treatment-process”: <https://github.com/EOZYAPRAK/DM2-treatment-process/blob/37dd811c957d4ba9599457ce0b134237f1acc68a/DM2-treatment-process-data.xlsx>. All direct patient identifiers, including names and national identification numbers, were removed from the dataset before public deposition.

Competing interests

The authors declare that they have no financial or non-financial competing interests.

Funding

The authors received no financial support, grants, or other funding for the research, authorship, or publication of this article.

Authors' contributions

The study's conception and design were carried out collaboratively by all authors. Material preparation, data collection, and analysis were performed by EÖE, NH and EEŞ. The first draft of the manuscript was prepared by Ecem Özyaprak Erdem, with all authors providing feedback and revisions on earlier drafts. Each author reviewed and approved the final version of the manuscript.

Acknowledgements

Not applicable

References

1. Ong KL, Stafford LK, McLaughlin SA, et al. Global, regional, and national burden of diabetes from 1990 to 2021, with projections of prevalence to 2050: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet*. 2023;402:203–34.
2. WHO. (2024) Diabetes Fact Sheet.
3. Shahrestanaki E, Mohammadian Khonsari N, Seif E, Baygi F, Ejtahed H-S, Sheidaei A, Djalalinia S, Magliano DJ, Qorbani M. The worldwide trend in diabetes awareness, treatment, and control from 1985 to 2022: a systematic review and meta-analysis of 233 population-representative studies. *Front Public Health*. 2024. <https://doi.org/10.3389/fpubh.2024.1305304>.
4. TEMD Diabetes Mellitus Çalışma ve Eğitim Grubu. Diabetes Mellitus ve Komplikasyonlarının Tanı. Tedavi ve İzlem Kılavuzu.; 2022.
5. Aguilar RB. Evaluating Treatment Algorithms for the Management of Patients With Type 2 Diabetes Mellitus: A Perspective on the Definition of Treatment Success. *Clin Ther*. 2011;33:408–24.
6. WHO. (2023) COVID-19 Dashboard.
7. T.C. Sağlık Bakanlığı. (2022) Genel Koronavirüs Tablosu.
8. ŞİRİN H, ÖZKAN S. COVID-19 Epidemiology: In the World and Turkey. *Kulak Burun Boğaz ve Baş. Boyun Cerrahisi Dergisi*. 2020;28:6–13.
9. Ak S. Derleme TÜRKİYE'DE KAMU SAĞLIK POLİTİKASINDA COVID-19 SÜRECİ. VE SAĞLIK DİPLOMASİSİ ROLÜ; 2023.
10. UN News. WHO Chief Declares End to COVID-19 as a Global Health Emergency. *UN News*; 2023.
11. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. 2020;395:497–506.

12. Grasselli G, Zangrillo A, Zanella A, et al. Baseline Characteristics and Outcomes of 1591 Patients Infected With SARS-CoV-2 Admitted to ICUs of the Lombardy Region, Italy. *JAMA*. 2020;323:1574.
13. İLİN S, KUŞKONMAZ Ş. DİYABET VE COVID – 19. *Ankara Eğitim ve Araştırma. Hastanesi Tıp Dergisi*. 2022;54:471–8.
14. Conte C, Cipponeri E, Roden M. Diabetes Mellitus, Energy Metabolism, and COVID-19. *Endocr Rev*. 2024;45:281–308.
15. Khunti K, Del Prato S, Mathieu C, Kahn SE, Gabbay RA, Buse JB. COVID-19, Hyperglycemia, and New-Onset Diabetes. *Diabetes Care*. 2021;44:2645–55.
16. Nhau PT, Gamede M, Sibiya N. COVID-19-Induced Diabetes Mellitus: Comprehensive Cellular and Molecular Mechanistic Insights. *Pathophysiology*. 2024;31:197–209.
17. Faruqi J, Balasubramanyam A. COVID-19 and diabetes mellitus: a review of the incidence, pathophysiology and management of diabetes during the pandemic. *Expert Rev Endocrinol Metab*. 2023;18:167–79.
18. Ali MK, Pearson-Stuttard J, Selvin E, Gregg EW. Interpreting global trends in type 2 diabetes complications and mortality. *Diabetologia*. 2022;65:3–13.
19. Chandrasekaran P, Weiskirchen R. The Role of Obesity in Type 2 Diabetes Mellitus—An Overview. *Int J Mol Sci*. 2024;25:1882.
20. Tinajero MG, Malik VS. An Update on the Epidemiology of Type 2 Diabetes. *Endocrinol Metab Clin North Am*. 2021;50:337–55.
21. Xu Y, Lu J, Li M, et al. Diabetes in China part 1: epidemiology and risk factors. *Lancet Public Health*. 2024;9:e1089–97.
22. Gong JY, Sajjadi SF, Motala AA, Shaw JE, Magliano DJ. Variation in type 2 diabetes prevalence across different populations: the key drivers. *Diabetologia*. 2025;68:2327–39.
23. Laakso M, Fernandes Silva L. Genetics of Type 2 Diabetes: Past, Present, and Future. *Nutrients*. 2022;14:3201.
24. Dal Canto E, Ceriello A, Rydén L, Ferrini M, Hansen TB, Schnell O, Standl E, Beulens JW. Diabetes as a cardiovascular risk factor: An overview of global trends of macro and micro vascular complications. *Eur J Prev Cardiol*. 2019;26:25–32.
25. Triplitt C. Improving treatment success rates for type 2 diabetes: recommendations for a changing environment. *Am J Manag Care*. 2010;16:S195–200.
26. Franco DW, Alessi J, de Carvalho TR, Kobe GL, Oliveira GB, Knijnik CP, Amaral B, Becker AS, Schaan BD, Telo GH. The impact of a telehealth intervention on the metabolic profile of diabetes mellitus patients during the COVID-19 pandemic - A randomized clinical trial. *Prim Care Diabetes*. 2022;16:745–52.
27. Shen Y, Zhang L, Fan X, Zhou J. Effectiveness of remote continuous glucose monitoring on adverse outcomes among patients with diabetes complicated with COVID-19. *J Diabetes Investig*. 2021;12:1923–4.

28. Haynes SC, Kompala T, Neinstein A, Rosenthal J, Crossen S. Disparities in Telemedicine Use for Subspecialty Diabetes Care During COVID-19 Shelter-In-Place Orders. *J Diabetes Sci Technol.* 2021;15:986–92.
29. World Health Organization. (2025) Obesity and overweight.
30. Brauer M, Roth GA, Aravkin AY, et al. Global burden and strength of evidence for 88 risk factors in 204 countries and 811 subnational locations, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet.* 2024;403:2162–203.
31. Boutari C, Mantzoros CS. A 2022 update on the epidemiology of obesity and a call to action: as its twin COVID-19 pandemic appears to be receding, the obesity and dysmetabolism pandemic continues to rage on. *Metabolism.* 2022;133:155217.
32. Sideli L, Lo Coco G, Bonfanti RC, Borsarini B, Fortunato L, Sechi C, Micali N. Effects of COVID-19 lockdown on eating disorders and obesity: A systematic review and meta-analysis. *Eur Eat Disorders Rev.* 2021;29:826–41.
33. Stefan N, Birkenfeld AL, Schulze MB. Global pandemics interconnected – obesity, impaired metabolic health and COVID-19. *Nat Rev Endocrinol.* 2021;17:135–49.
34. Akin S, Bölük C. Prevalence of comorbidities in patients with type–2 diabetes mellitus. *Prim Care Diabetes.* 2020;14:431–4.
35. Gerganova A, Assyov Y, Kamenov Z. Stress Hyperglycemia, Diabetes Mellitus and COVID-19 Infection: Risk Factors, Clinical Outcomes and Post-Discharge Implications. *Front Clin Diabetes Healthc.* 2022. <https://doi.org/10.3389/fcdhc.2022.826006>.
36. Lai H, Yang M, Sun M, et al. Risk of incident diabetes after COVID-19 infection: A systematic review and meta-analysis. *Metabolism.* 2022;137:155330.
37. Zhang T, Mei Q, Zhang Z, Walline JH, Liu Y, Zhu H, Zhang S. Risk for newly diagnosed diabetes after COVID-19: a systematic review and meta-analysis. *BMC Med.* 2022;20:444.
38. Wu C-T, Lidsky PV, Xiao Y, et al. SARS-CoV-2 infects human pancreatic β cells and elicits β cell impairment. *Cell Metab.* 2021;33:1565–e15765.
39. Khare J, Jindal S. Observational study on effect of lock down due to COVID 19 on HBA1c levels in patients with diabetes: Experience from Central India. *Prim Care Diabetes.* 2022;16:775–9.
40. Stolar MW. Defining and Achieving Treatment Success in Patients With Type 2 Diabetes Mellitus. *Mayo Clin Proc.* 2010;85:S50–9.
41. Kennedy L, Cefalu WT, Richards RJ, Melendez-Ramirez LY. Redefining treatment success in type 2 diabetes mellitus: Comprehensive targeting of core defects. *Cleve Clin J Med.* 2009;76:S39–47.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SupplementaryTableS1AdditionalCharacteristics.docx](#)

- [SupplementaryTableS2SensitivityAnalyses.docx](#)
- [AdditionalFile3InvestigatorCompletedDataCollectionFormENG.docx](#)