Original Research Article

Incidence of diabetes and ischemic heart disease in COVID-19 post pandemic

Amrendra Kumar Singh[1]*, Raj Kamal Choudhary[1], Kumari Ragini[2], Anjum Perwez[1]

[1]Department of Medicine, J. L. N. M. C. Bhagalpur, Bihar, India
[2]Department of Obstetrics and Gynaecology, A. N. M. C. H. Gaya, Bihar, India

*Correspondence:
Dr. Amrendra Kumar Singh,
E-mail: skschinku@gmail.com

ABSTRACT

Background: The long-term effects of COVID-19 pandemic are currently getting more attention. The majority of individuals with COVID-19 report having symptoms for longer than 4 weeks following their initial appearance. after COVID-19 infection, there is worry that cardiovascular conditions and metabolic conditions may be harmed. Aim of the study the incidence of ischaemic heart disease and diabetes mellitus (DM) post COVID 19 pandemic.

Methods: Information for all individuals diagnosed as suffering of COVID-19 were taken at the beginning of the investigation from the health department's release of electronic medical records in February 2021. The main outcomes analysed were first ever documented cardiovascular disorders (CVD) as well as DM diagnoses. The data were then combined for the time periods following the index date (long COVID-19), for five to twelve weeks following the index date (post-acute COVID19), for four weeks after the date of indexing (acute COVID-19), prior to the index date (Pre-index). For COVID-19 patients as well as control subjects, incidence rates with precise Poisson confidence intervals (CIs) were computed.

Results: CVD events was 1362 in COVID-19 study group while it was 131 in control study group at phase corresponding to four weeks after the indexed date. CVD events was 781 in COVID-19 study group while it was 298 in control study group at phase corresponding to five to twelve weeks since the date of indexing. CVD events was 781 in COVID-19 study group while it was 298 in control study group at phase corresponding to five to twelve weeks since the date of indexing. CVD events was 2,134 in COVID-19 study group while it was 298 in control study group at phase corresponding to 13 to 52 weeks since the date of indexing.

Conclusions: Early on after COVID-19 infection, the risk of CVD is elevated, and this risk is elevated for up to three months. However, there does not appear to be a long-term rise in the prevalence of CVD or DM in COVID-19 patients who do not already have these illnesses. This study shows that after COVID-19 infection, the incidence of DM is high for at minimum 12 weeks before it starts to decline

Keywords: Prevalence, CVD, DM, Post COVID-19

INTRODUCTION

The multiple organ systems illness known as Coronavirus disease of 2019 (COVID-19) more universally acknowledged.[1] The severe acute respiratory syndrome Coronavirus 2 (SARS-CoV-2) virus infects the respiratory system and causes host immune reactions that could have systemic implications by activating inflammatory mediators.[2,3] With downregulated response of immune system, irregular platelet aggregation, coagulopathy, endothelial cell malfunction, and thrombosis affecting different methods with a risk of end-organ harm, COVID-19 may cause an inflammatory "cytokine storm".[4] While fresh cardiovascular disorders (CVD) and fresh cases of DM have been linked to initial COVID-19 contamination, longer-term consequences after the contamination have not been extensively described.[5]

Cardiac arrest, cardiac damage with raised troponin levels, and increased morbidity and mortality probability among COVID-19-positive individuals who get hospitalised are some of cardiac symptoms of COVID-19.[6,7] In first 4 weeks, COVID-19 can be additionally linked to sudden myocardial infarction and ischemic stroke.[8-1] Patients with COVID-19 have witnessed new-onset hyperglycemia, frequently referred to as "stress hyperglycemia," which has been linked with poorer outcome.[5,11] Both existent and newly developed DM might have sequelae, such as hyperosmolarity condition and diabetic ketoacidosis condition.[12-14] Elevated concentrations of cytokine interleukin-6 (IL-6) and cytokine tumour necrosis factor alpha (TNF) are indicative of direct pancreatic injury by SARS-CoV-2 and/or accompanying systemic inflammatory condition with chronic COVID-19, which results in decreased pancreatic insulin production and insulin resistance.[15,16]

Long-term effects of COVID are currently getting more attention. Majority of individuals with COVID-19 report having symptoms for longer than 4 weeks following their initial appearance.[17-19] After COVID-19 infection, there is worry that cardiovascular conditions and metabolic conditions may be harmed. Severity of sickness and COVID-19 vulnerability, meanwhile, are known to be linked to cardiometabolic risk.

Additionally, during the peak of the disease outbreak, patient safety prohibitions such as "lockdowns" or "work from home" instructions were linked to significant changes in eating patterns, exercise routines, and other health associated behaviours that may have had an effect on CVD as well as diabetes in the general populace even in the nonappearance of COVID-19 infection. Hence, after accounting for premorbid variations between individuals with and without symptoms as well as variations in time in matched controls, controlled trials are required to assess the overall effects of COVID-19 contamination on cardiovascular health outcomes and diabetic outcomes. In patients hospitalized from COVID-19, there is worries regarding the possible consequence of "long COVID-19" syndromes; nevertheless, few research have documented on prolonged follow-up for substantial population-based study samples.

By applying data mining technique to digital medical data, Al-Aly et al.[5] discovered an increase in burden of several health issues around 30 days and 6 months after COVID-19. According to Knight et al arterial problems and venous problems persisted at an increased level for 49 weeks following COVID-19.[20] Recovery period following COVID-19 is still poorly understood, though. With longitudinal data from digital medical records, it is possible to analyse COVID-19 results over longer period of time. In order to compare group of patients with COVID-19 exposure to matched cohort of patients without COVID-19 diagnosis, conducted study. Sought to determine overall impact of COVID contamination on cardiovascular consequences and metabolic consequences over intervals of 4 weeks, 3 months, and 12 months in order to identify areas for future research that may be most important and to guide clinical care and public health initiatives.

METHODS

This study was carried out at Jawaharlal Nehru medical college and hospital, Bhagalpur, Bihar during September 2020 to April 2021. This is prospective study.

Inclusion criteria included patient who are RTPCR Positive (COVID-19) and age ≥13 to <80 years. Exclusion criteria excluded patient who are severely ill, on ventilatory support and age < 13 and >80.

Ethical approval from Ethical committee of Jawaharlal Nehru medical college and hospital, Bhagalpur, Bihar, had been taken prior.

Data source and participant selection

Information for all individuals diagnosed as suffering of COVID-19 were taken at the beginning of the investigation from the health department's release of electronic medical records in February 2021. The index deadline for COVID-19 contamination was the day of the first coding. We considered individuals with medical assessment of "confirmed" or "suspected" COVID-19 since conclusive testing was not generally accessible during the early stages of the epidemic. However, we performed a risk assessment using just patients who had a polymerase chain reaction (PCR) test validated COVID-19 medical coding documented. A subset of normal control patients without COVID-19 designation up until case reference date was contrasted to COVID-19 group.

Control participants were randomly selected from the March 2021 version registered populace, which at the moment of sampling offered the most recent data available in the database. Controls were to begin keeping records no later than eighteen months after the commencement of the recording for their associated case, and they had to be compared for age, gender, and family practice. Patients who had widespread CVD/DM reported more than a year or within a year of the commencement of their record were not eligible to serve as controls.

Outcome measures

The main outcomes analysed were first ever documented CVD as well as DM diagnoses. Stroke, venous thrombosis, pulmonary embolism, cardiomyopathy and myocarditis, heart failure, myocardial infarction and ischemic heart disease, supraventricular tachycardia, atrial arrhythmias, and atrial fibrillation were the subcategories into which CVD diagnoses were divided. Type 1 diabetes and type 2 DM diagnoses were made, and oral hypoglycemic medications and insulin were started. A subsequent record of HbA1c ≥ 48

mmol/mol was deemed definitive of diabetes after reviewing the HbA1c records. When administered insulin during three months of diagnosis and had a diagnostic age of 35 years or below, participants were identified as having a type 1 DM profile.[22] The date of death served as the measurement of mortality.

Covariates

Data collected during the research period prior to the index date was used to define variables. body mass index (BMI), status of smoking were covariates chosen because of documented correlations with CVD and DM.

The data were then combined for the time periods following the index date (long COVID-19), for five to twelve weeks following the index date (post-acute COVID19), for four weeks after the date of indexing (acute COVID-19), prior to the index date (Pre-index). For COVID-19 patients as well as control subjects, incidence rates with precise poisson confidence intervals (CIs) were computed.

We were aware that the prevalence of CVD and diabetes may shift between 13 and 52 weeks after the confirmation of COVID-19. In order to compare each 4-week period after a COVID-19 detection with baseline, we calculated adjusted rate ratios and associated 95% confidence intervals (CIs) in secondary analyses. The loess method was used to fit a smoothed curve to the estimates before they were plotted. We limited our sensitivity analysis to the COVID-19 subjects who have tested positive for the SARS-CoV-19 infection via PCR.

To assess variables connected to PCR confirmation, logistic regression framework developed. SPSS programme, ver 2021, used to implement all computations. After process of peer review, added risk assessment to see if accounting for number of consultations could help to explain correlation between COVID-19 and diabetes incidence.

RESULTS

It was observed that CVD events was 3,092 in COVID-19 study group while it was 1,761 in control study group at phase before the index date. CVD events was 1,362 in COVID -19 study group while it was 131 in control study group at phase corresponding to four weeks after the indexed date. CVD events was 781 in COVID -19 study group while it was 298 in control study group at phase corresponding to five to twelve weeks since the date of indexing. CVD events was 781 in COVID-19 study group while it was 298 in control study group at phase corresponding to five to twelve weeks since the date of indexing. CVD events was 2,134 in COVID -19 study group while it was 298 in control study group at phase corresponding to 13 to 52 weeks since date of indexing.

It was found that CVD events was greater in CIVID -19 group as compared to control group at all the phases of observations. It was further observed that cases of CVD decreased at four weeks after date of indexing. It further decreased after five weeks to twelve weeks after date of indexing. However, it increased after 13 to 52 weeks from date of indexing. The findings were significant statistically. (p≤0.001) (Table 1 and 2).

It was observed that DM events was 3,474 in COVID -19 study group while it was 2,547 in control study group at phase before the index date. DM events was 424 in COVID-19 study group while it was 168 in control study group at phase corresponding to four weeks after the indexed date. DM events was 690 in COVID-19 study group while it was 386 in control study group at phase corresponding to five to twelve weeks since the date of indexing. CVD events was 690 in COVID-19 study group while it was 386 in control study group at phase corresponding to five to twelve weeks since the date of indexing. DM events was 3,263 in COVID-19 study group while it was 2,164 in control study group at phase corresponding to 13-52 weeks since the date of the indexing.

It was found that DM events was greater in COVID-19 group as compared to control group at all the phases of observations. It was further observed that cases of DM decreased at four weeks after date of indexing. It increased after five weeks to twelve weeks after date of indexing. Again it increased after 13 to 52 weeks from date of indexing. The findings were significant statistically. (p≤0.01) (Table 1 and 2).

**Table 1: Prevalence of CVDs and DM at different periods of time of follow up of COVID-19.**

| Phase	Before index date		Acute: up to 4 weeks from index		Post-acute: 5 to 12 weeks from index		Long: 13 to 52 weeks from index	
	COVID-19	**Control**	**COVID-19**	**Control**	**COVID-19**	**Control**	**COVID-19**	**Control**
Patient weeks	21,894,812	22,462,512	1,765,413	1,750,536	3,485,891	3,461,146	16,635,311	16,351,221
CVD events	3,092	1,761	1,362	131	781	298	2,134	1,567
CVD incidence per 100,000 patient weeks (95% CI)	14.21 (13.59 to 14.67)	7.59 (7.31 to 8.01)	77.06 (73.86 to 84.12)	7.42 (6.21 to 8.73)	23.14 (20.64 to 24.79)	8.52 (7.58 to 9.57)	12.76 (12.24 to 13.19)	9.11 (8.78 to 9.69)

Continued.

Phase	Before index date		Acute: up to 4 weeks from index		Post-acute: 5 to 12 weeks from index		Long: 13 to 52 weeks from index	
	COVID-19	Control	COVID-19	Control	COVID-19	Control	COVID-19	Control
Diabetes diagnoses	3,474	2,547	424	168	690	386	3,263	2,164
DM incidence per 100,000 patient weeks (95% CI)	15.93 (15.31 to 16.51)	11.45 (10.91 to 11.81)	23.84 (21.61 to 26.21)	9.57 (8.21 to 11.52)	19.61 (19.21 to 22.07)	11.21 (10.13 to 12.42)	19.57 (18.13 to 20.37)	13.18 (12.73 to 13.85)

**Table 2: Results of analysis in difference in incidences of DM and CVD at different periods of observations.**

| Variables	DM		All CVD outcomes	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Acute COVID-19 up to 4 weeks RR (95% CI)	1.82 (1.56 to 2.29)	1.83 (1.56 to 2.23)	5.71 (4.81 to 6.91)	5.72 (4.84 to 7.21)
P value	<0.001	<0.001	<0.001	<0.001
Post-acute COVID-19 5 to 12 weeks RR (95% CI)	1.29 (1.13 to 1.51)	1.31 (1.32 to 1.51)	1.46 (1.33 to 1.76)	1.51 (1.32 to 1.82)
P value	<0.001	<0.001	<0.001	<0.001
Long COVID-19 13 to 52 weeks RR (95% CI)	1.08 (0.99 to 1.16)	1.08 (0.99 to 1.17)	0.79 (0.71 to 0.87)	0.91 (0.76 to 0.91)
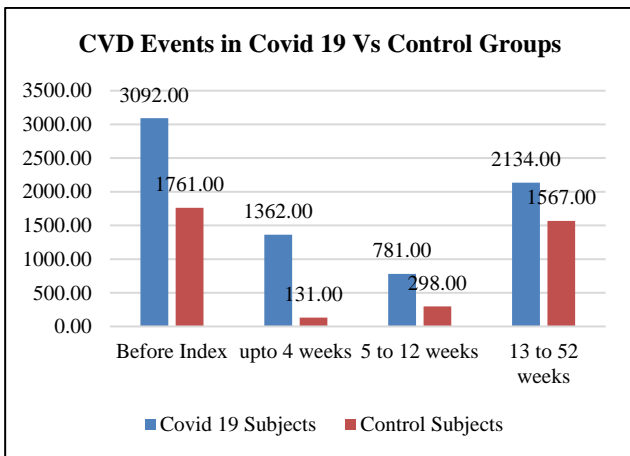
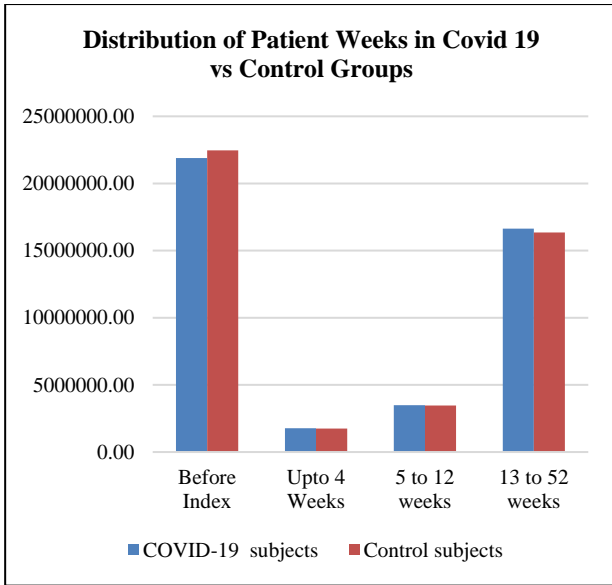**Figure 1: CVD events in COVID-19 vs control groups.**
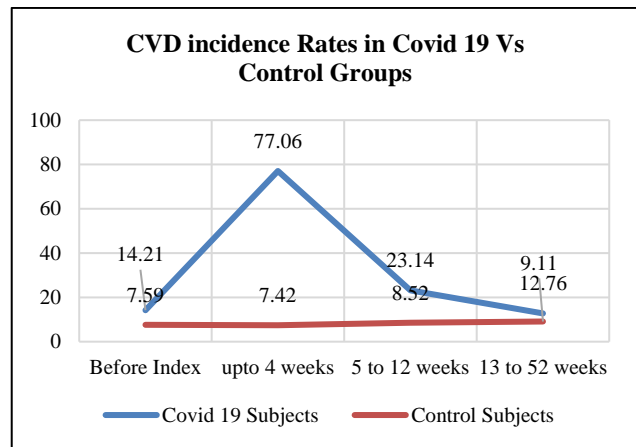
Figure 3: CVD incidence rates in COVID-19 vs control groups.
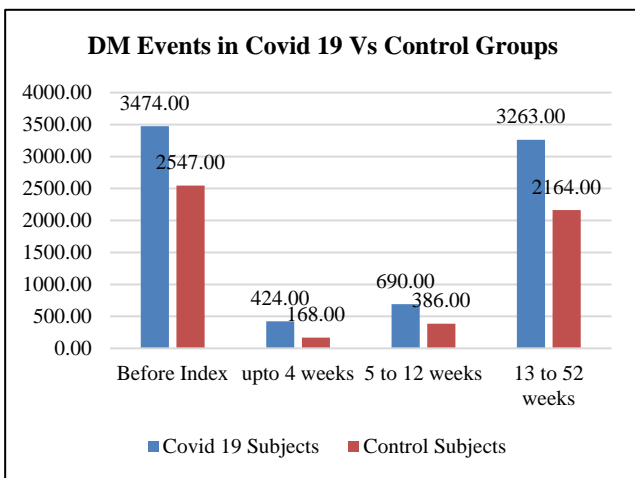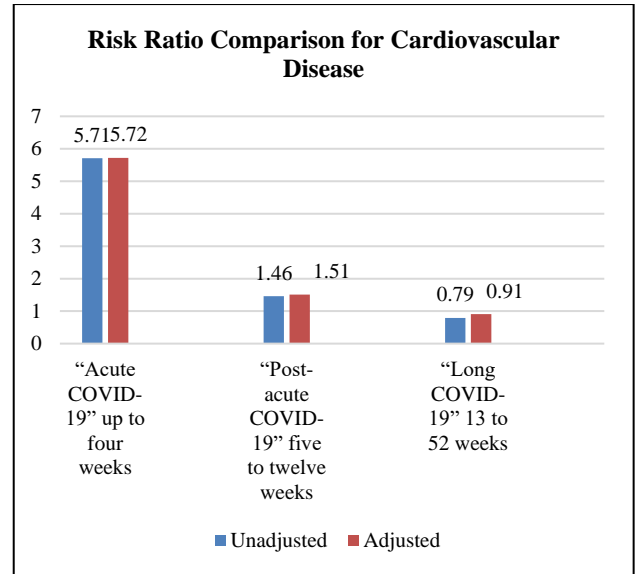

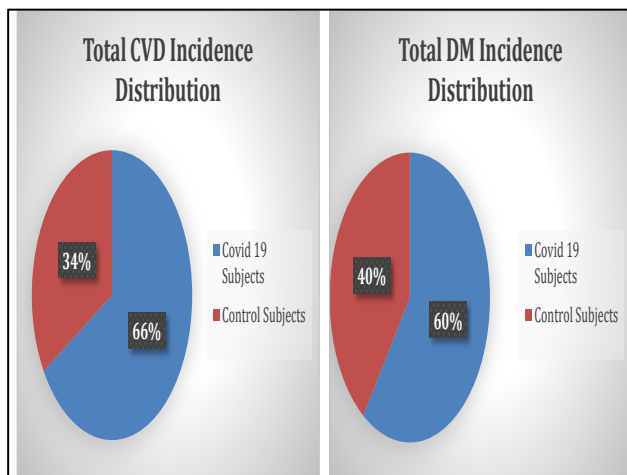**Figure 2: DM events in COVID-19 vs control groups.**
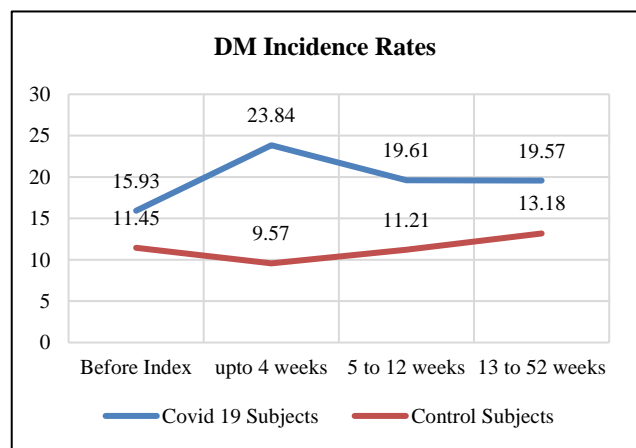
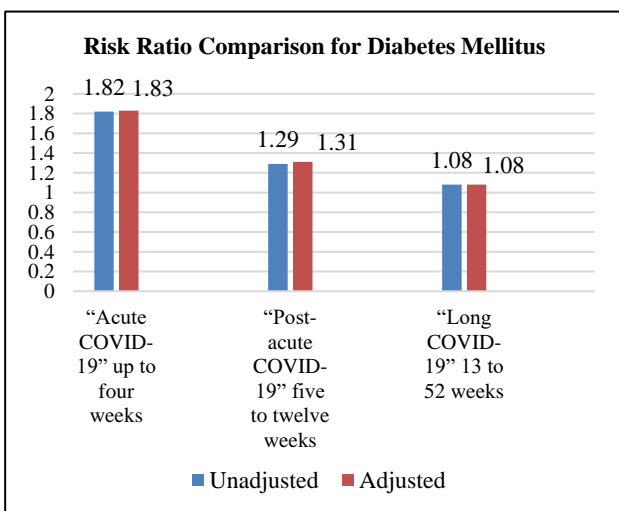**Figure 4: DM incidence rates in COVID-19 vs control groups.**

Figure 5: Distribution of patient weeks in COVID-19 vs control groups.

Figure 6: Total CVD and DM incidence distribution.

Figure 7: Risk ratio comparison for DM.

Figure 8: Risk ratio comparison for cardiovascular disease.

DISCUSSION

There is currently increasing focus on COVID-19's long-term consequences. The majority of COVID-19 patients claim that their symptoms persisted for more than 4 weeks after they first manifested. There is concern that metabolic and cardiovascular problems may be damaged by COVID-19 infection. Conversely, it is known that the severity of the illness and COVID-19 vulnerability are related to cardiometabolic risk.[20,21]

Furthermore, during the height of the disease outbreak, restrictions on patients were associated with substantial alterations in eating habits, exercise routines, and other health-related behaviours that may have had an impact on CVD and diabetes in the general population even in the absence of COVID-19 infection. Hence, controlled trials are necessary to determine the overall impact of COVID-19 contamination on cardiovascular health outcomes and diabetic outcomes after adjusting for premorbid changes between people with and without symptoms as well as variations in time in matched controls.[22,23] Concerns about the potential consequences of "long COVID-19" syndromes are present in COVID-19 patients who are hospitalised, but there are few studies that have established prolonged follow-up for sizable population-based study populations.

It was observed that CVD events was 3,092 in COVID-19 study group while it was 1,761 in control study group at phase before the index date. CVD events was 1,362 in COVID-19 study group while it was 131 in control study group at phase corresponding to four weeks after the indexed date. CVD events was 781 in COVID-19 study group while it was 298 in control study group at phase corresponding to five to twelve weeks since the date of indexing. CVD events was 781 in COVID-19 study

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The 2019 Coronavirus disease (COVID-19) is a multi-organ system ailment that is becoming well recognized. By activating inflammatory mediators, the SARS-CoV-2 virus attacks the respiratory system and triggers host immunological reactions that may have systemic effects.[24,25] COVID-19 may result in an inflammatory "cytokine storm" due to the immune system's downregulation, abnormal platelet aggregation, coagulopathy, endothelial cell dysfunction, and thrombosis that may injure end organs. Although the initial COVID-19 contamination has been connected to recent cardiovascular diseases (CVD) and cases of diabetic mellitus (DM), longer-term effects following the contamination have not been thoroughly discussed.[26,27]

Some of the cardiac symptoms of COVID-19 include cardiac arrest, heart damage with elevated troponin levels, and a higher likelihood of morbidity and mortality among COVID-19-positive patients who are admitted to the hospital. Also connected to abrupt myocardial infarction and ischemic stroke in the first four weeks is COVID-19. Individuals with COVID-19 have had "stress hyperglycemia," or new-onset hyperglycemia, which has been associated with a worse prognosis.[28-30] Existing DM and newly formed DM may both have complications, such as hyperosmolarity and diabetic ketoacidosis. Lowered pancreatic insulin production and insulin resistance are caused by direct pancreatic injury caused by SARS-CoV-2 and/or the accompanying systemic inflammatory condition with chronic COVID-19, which is indicated by elevated levels of cytokines interleukin-6 (IL-6) as well as the tumour necrosis factor alpha (TNF).[15,16]

In this study, information was obtained via the health department's release of electronic medical data in February 2021 for all persons who had been diagnosed with COVID-19 at the outset of the investigation. The first day of coding was the COVID-19 contamination index deadline. Although conclusive testing wasn't always available in the early stages of the epidemic, we took into account people having medical assessments of "confirmed" or "suspected" COVID-19.

However, we restricted our risk analysis to patients whose COVID-19 medical coding had been validated by a polymerase chain reaction (PCR) test. The COVID-19 group was compared to a subset of normal control patients who had not yet received a COVID-19 classification as of the case reference date.

Control subjects were chosen at random from the registered population of the March 2021 version, which at the time of sampling provided the most recent data accessible in the database. The controls were to be compared for age, gender, and family practice, and they had to start keeping records no later than eighteen months following the start of the recording for their related case. Patients who reported widespread CVD or DM within a year of the start of their record or more than a year prior were not eligible to act as controls.

The primary outcomes were the first-ever documented diagnosis of DM and CVD. The subcategories into which CVD diagnoses were separated included stroke, venous thrombosis, pulmonary embolism, cardiomyopathy and myocarditis, heart failure, myocardial infarction and ischemic heart disease, supraventricular tachycardia, atrial arrhythmias, and atrial fibrillation. Diagnoses for type 1 and type 2 DM were made, and insulin and oral hypoglycemic drugs were started. Reviewing the HbA1c records, a subsequent record of HbA1c 48 mmol/mol was declared to constitute proof of diabetes. Participants were classified as having a type 1 DM profile when given insulin within three months of diagnosis and had a diagnostic age of 35 years or less.[22] The mortality rate was calculated based on the date of death.

It was observed that DM events was 3,474 in COVID-19 study group while it was 2,547 in control study group at phase before the index date. DM events was 424 in COVID-19 study group while it was 168 in control study group at phase corresponding to four weeks after the indexed date. DM events was 690 in COVID-19 study group while it was 386 in control study group at phase corresponding to five to twelve weeks since the date of indexing. CVD events was 690 in COVID-19 study group while it was 386 in control study group at phase corresponding to five to twelve weeks since the date of indexing. DM events was 3,263 in COVID-19 study group while it was 2,164 in control study group at phase corresponding to 13 to 52 weeks since date of indexing.

It was found that DM events was greater in COVID-19 group as compared to control group at all the phases of observations. It was further observed that cases of DM decreased at four weeks after date of indexing. It increased after five weeks to twelve weeks after date of indexing. Again, it increased after 13 to 52 weeks from date of indexing. The findings were significant statistically (p≤0.01).

In early COVID-19 infection, it is well known that antecedent hypertension and ischemic heart disease are

linked to more severe illness and higher mortality.[21] Variety of CV problems, including as palpitations, heart problems, and thrombotic abnormalities, can occur in hospitalised patients.[21] yet there aren't many studies that have followed these patients over the long term in absence of preexisting CVD. Knight and colleagues described the cardiovascular results of a sizable population in England in preprint. According to their findings, CVD outcomes may continue to be worse for up to 49 weeks after COVID-19 infection.[20]

More severe COVID-19 sickness is also linked to preexisting DM, however other research point to a possible link between COVID-19 and newly developed diabetes, 14.4% of individuals who were hospitalised during the early COVID-19 epidemic, according to a systematic assessment of 8 cases, went on to acquire new-onset diabetes.[22,23] The observation that the virus penetrates beta cells of pancreas, lowers insulin production, and accelerates beta-cell death.[24,25] points to a potential impact of SARS-CoV-2 disease on pancreatic function. Reduced exercise and deconditioning brought on by COVID-19 may potentially increase insulin resistance [26] Increased chances of discovering diabetes that had not yet been diagnosed may also result from interactions with medical professionals. In earlier studies, hospital-based populations with lower sample size or lower follow-up times were frequently reported. This extensive population-based investigation demonstrates that people with COVID-19 had a somewhat increased baseline risk of developing diabetes.

Al-Aly and colleagues identified an increase in the burden of numerous health concerns 30 days and six months following COVID-19 by using a data mining technique on digital medical data.[5] According to Knight and colleagues, venous and arterial issues remained for 49 weeks after COVID-19 at a higher degree.[20] Nonetheless, there is currently lack of knowledge regarding the recovery phase following COVID-19. A longer length of time can be used to analyze COVID-19 results when using longitudinal data from digital medical records. We conducted a study to contrast a cohort of individuals exposed to COVID-19 to a matched cohort of people undiagnosed with COVID-19. In order to pinpoint the areas for potential future research that may be most crucial and to direct clinical care and public health initiatives, we sought to ascertain the overall impact of COVID-19 contamination on cardiovascular consequences and metabolic consequences over intervals of 4 weeks, 3 months, and 12 months.

Major limitation of study is the poor information from patient, poor compliance with treatment protocol, and delay in report.

CONCLUSION

Early on after COVID-19 infection, the risk of CVD is elevated, and this risk is elevated for up to three months.

However, there does not appear to be a long-term rise in the prevalence of CVD or DM in COVID-19 patients who do not already have these illnesses. This study shows that after COVID-19 infection, the incidence of DM is high for at minimum 12 weeks before it starts to decline. Given the elevated baseline risk, COVID-19 patients should be advised to take steps to lower their risk of developing diabetes, including changes to their diet, approach to weight management, and level of physical activity.

REFERENCES

1. Crook H, Raza S, Nowell J, Young M, Edison P. Long COVID-mechanisms, risk factors, and management. BMJ. 2021;374:n1648.
2. Pranata R, Huang I, Lim MA, Wahjoepramono EJ, July J. Impact of cerebrovascular and cardiovascular diseases on mortality and severity of COVID-19-systematic review, meta-analysis, and meta-regression. J Stroke Cerebrovasc Dis. 2020;29:104949.
3. Williamson EJ, Walker AJ, Bhaskaran K, Bacon S, Bates C, Morton CE et al. Factors associated with COVID-19-related death using Open Safely. Nature. 2020;584:430-36.
4. Magadum A, Kishore R. Cardiovascular manifestations of COVID-19 infection. Cells. 2020;9:2508.
5. Al-Aly Z, Xie Y, Bowe B. High-dimensional characterization of post-acute sequelae of COVID-19. Nature. 2021;594(7862):259-64.
6. Hendren NS, Drazner MH, Bozkurt B, Cooper LT. Description and Proposed Management of the Acute COVID-19 Cardiovascular Syndrome. Circulation. 2020;141:1903-14.
7. Rey JR, Caro-Codón J, Rosillo SO, Iniesta AM, Castrejón-Castrejón S, Marco-Clement I. Heart failure in COVID-19 patients: prevalence, incidence and prognostic implications. Eur J Heart Fail. 2020;22:2205-215.
8. Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet. 2020;395:1054-62.
9. Shi S, Qin M, Shen B, Cai Y, Liu T, Yang F et al. Association of Cardiac Injury with Mortality in Hospitalized Patients With COVID-19 in Wuhan, China. JAMA Cardiol. 2020;5:802-10.
10. Katsoularis I, Fonseca-Rodríguez O, Farrington P, Fors Connolly AM. Risk of acute myocardial infarction and ischaemic stroke following COVID-19 in Sweden: a self-controlled case series and matched cohort study. Lancet. 2021;398:599-607.

11. Singh AK, Singh R. Hyperglycemia without diabetes and new-onset diabetes are both associated with poorer outcomes in COVID-19. Diabetes Res Clin Pract. 2020;167:108382.

12. Li J, Wang X, Chen J, Zuo X, Zhang H, Deng A. COVID-19 infection may cause ketosis and ketoacidosis. Diabetes Obes Metab. 2020;22:1935-41.

13. Reddy PK, Kuchay MS, Mehta Y, Mishra SK. Diabetic ketoacidosis precipitated by COVID-19: A report of two cases and review of literature. Diabetes Metab Syndr. 2020;14:1459-62.

14. Papachristou S, Stamatiou I, Stoian AP, Papanas N. New-Onset Diabetes in COVID-19: Time to Frame Its Fearful Symmetry. Diabetes Ther. 2021;12:461-4.

15. Maddaloni E, Buzzetti R. COVID-19 and diabetes mellitus: unveiling the interaction of two pandemics. Diabetes Metab Res Rev. 2020:e33213321.

16. Prete M, Favoino E, Catacchio G, Racanelli V, Perosa F. SARS-CoV-2 Inflammatory Syndrome. Clinical Features and Rationale for Immunological Treatment. Int J Mol Sci. 2020;21:3377.

17. Public Health England. Coronavirus (COVID-19) in the UK. UK summary. London: Public Health England, 2021. Available at: https://coronavirus. data.gov.uk/. Accessed on 27 July, 2023.

18. Office for National Statistics. Prevalence of ongoing symptoms following coronavirus (COVID-19) infection in the UK: 2 September 2021. London: Office for National Statistics, 2021. Available at: https://www.ons.gov.uk/peoplepopulationandcom munity/healthandsocialcare/conditionsanddiseases/bu lletins/prevalenceofongoingsymptomsfollowingcoro naviruscovid19infectionintheuk/2september2021.Ac cessed. Accessed on 23 September, 2023

19. Shah W, Hillman T, Playford ED, Hishmeh L. Managing the long-term effects of covid-19: summary of NICE, SIGN, and RCGP rapid guideline. BMJ. 2021;372:n136.

20. Knight R, Walker V, Ip S, Cooper JA, Bolton T, Keene S et al. Association of COVID-19 with arterial and venous vascular diseases: a population-wide cohort study of 48 million adults in England and Wales. MedRxiv. 2021:2021.11.22.21266512.

21. Wolf A, Dedman D, Campbell J, Booth H, Lunn D, Chapman J et al. Data resource profile: Clinical Practice Research Datalink (CPRD) Aurum. Int J Epidemiol. 2019;48:1740-40.

22. Imkampe AK, Gulliford MC. Trends in Type 1 diabetes incidence in the UK in 0- to 14-year-olds and in 15- to 34-year-olds, 1991-2008. Diabet Med. 2011;28:811-4.

23. Zakeri R, Bendayan R, Ashworth M, Bean DM, Dodhia H, Durbaba S et al. A case-control and cohort study to determine the relationship between ethnic background and severe COVID-19. E Clin Med. 2020;28.

24. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: Development and validation. J Chronic Dis. 1987;40:373-83.

25. Khan NF, Perera R, Harper S, Rose PW. Adaptation and validation of the Charlson Index for Read/OXMIS coded databases. BMC Fam. Pract. 2010;11:1.

26. Gulliford MC, Charlton J, Latinovic R. Risk of diabetes associated with prescribed glucocorticoids in a large population. Diabetes Care. 2006;29:2728-9.

27. Holford TR. The Analysis of Rates and of Survivorship Using Log-Linear Models. Biometrics. 1980;36:299-305.

28. Williams R, Jenkins DA, Ashcroft DM, Brown B, Campbell S, Carr MJ et al. Diagnosis of physical and mental health conditions in primary care during the COVID-19 pandemic: a retrospective cohort study. Lancet Public Health. 2020;5:e543-50.

29. Sudre CH, Murray B, Varsavsky T, Graham MS, Penfold RS, Bowyer RC et al. Attributes and predictors of long COVID. Nat Med. 2021;27:626-31.

30. Taquet M, Dercon Q, Luciano S, Geddes JR, Husain M, Harrison PJ. Incidence, co-occurrence, and evolution of long-COVID features: A 6-month retrospective cohort study of 273,618 survivors of COVID-19. PLoS Med. 2021;18(9):e1003773.