

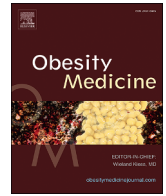


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Clinical profile of patients with type 2 diabetes after COVID-19 vaccination: A prospective study

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ABSTRACT

The purpose of this study was to characterize the clinical profile of patients with type 2 diabetes after COVID-19 vaccination. This prospective study has involved 100 adult diabetic patients followed in the primary health care. SARS-CoV-2 infection after COVID-19 vaccination was the outcome indicator.

According to the American Diabetes Association ([American Diabetes Association, 2021](#)) there is still no scientific evidence on the consequences of coronavirus acute respiratory syndrome 2 (SARS-CoV-2) on diabetes comorbidities, but it is known that diabetics are more likely to develop COVID-19 disease, particularly the elderly ([International Diabetes Federation. IDF, 2021](#)). Comorbidities such as obesity ([Drucker, 2021](#); [Giorgino et al., 2021](#); [Holly et al., 2020](#); [Zhou et al., 2021](#)), type 2 diabetes (T2D) ([Dennis et al., 2021](#); [Gregg et al., 2021](#); [Pugliese et al., 2020](#)), and hypercholesterolemia are those with the highest risk of disease severity ([Iqbal et al., 2020](#); [Mehrbood et al., 2021](#); [Pang et al., 2021](#)). Currently, 91.4% of the Portuguese population is fully vaccinated ([Serviço Nacional de Saúde, 2021](#)), while in the United States only 66.6% of the population ([Hannah et al., 2022](#)).

1. Objective

The aim of this study was to characterize the clinical profile of diabetic patients in primary health care after vaccination for COVID-19.

2. Material and methods

This is a prospective study starting in January 2022, in which 100 adult T2D patients over 65 years of age and being followed up in a diabetes consultation at a Primary Health Care Center in Portugal were recruited, as shown in [Fig. 1](#). The main outcome to be assessed longitudinally is the sequelae of SARS-CoV-2 infection in T2D comorbidities. In this phase of the study the following variables were collected: socio-demographic data (age; gender – male/female; body mass index ([World Health Organization, 2022](#)); family income level – under/above 400€); duration of diabetes; comorbidities (arterial hypertension; stroke; hypercholesterolemia; other cardiovascular diseases – acute myocardial infarction, heart failure, arrhythmias; respiratory diseases – chronic obstructive pulmonary disease and asthma); type of medication (oral and injectable insulin; oral insulin; injectable insulin); and vaccination. The sample was

Abbreviations: BMI, body mass index; T2D, type 2 diabetes; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

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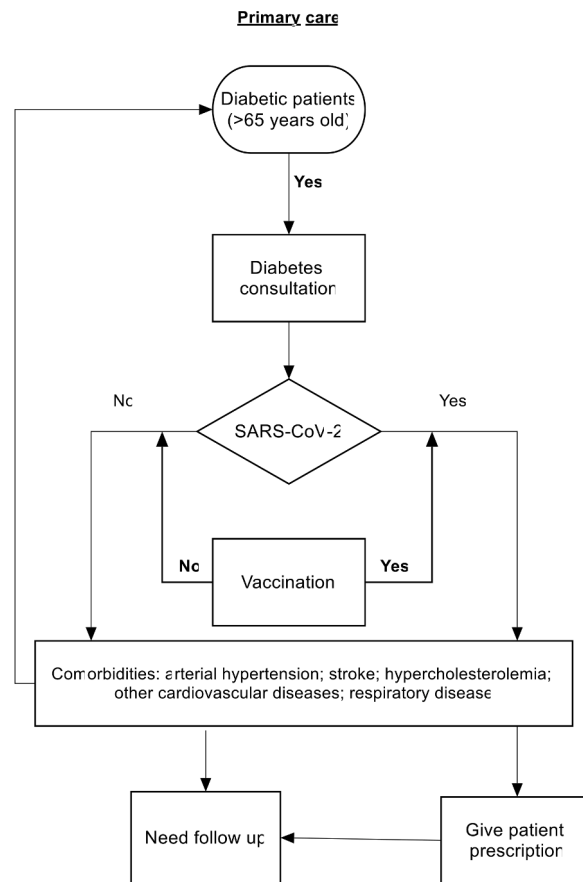


Fig. 1. Study design.

stratified into 2 groups: 1) non-infected/infected with SARS-CoV-2 and 2) unvaccinated/vaccinated. The chi-square test (χ^2) was used to determine the statistical differences between the subgroups for categorical variables and for nominal variables the t -test was used with the use of Levene's test for equality of variances. Multivariable logistic regression was used to determine the factors associated with COVID-19 infection with SARS-CoV-2 (non-infected/infected) as the dependent variable and the remaining variables as independent variables. The group with the lowest incidence was used as the reference value. Odds ratio values with 95% confidence interval (CI) will be presented.

The software IBM SPSS statistics for Windows, version 24, were used to perform statistical analyses.

3. Results

In a total of 100 patients with T2D followed in the diabetes consultation in a primary health care center with ages over 65 years; 45% are men and 55% women with a mean age of 76.5 ± 8.5 , normal weight (44%) and overweight (41%). Their main comorbidities are hypertension with 51% of the cases and hypercholesterolemia with 57%, and 94% of the diabetics are on oral insulin medication. Patients have an average duration of diabetes of 11.7 ± 6.3 years. The mean follow-up process was 4 ± 1.0 months, and the maximum 6 ± 1.5 months. The vaccination rate was 84%.

Of the 100 patients, SARS-CoV-2 was more frequent in women (61.8%), only one is class II obese and two are class III obese. When we compared the subgroups (non-infected/infected) we found a statistically significant relationship for the comorbidity hypercholesterolemia ($p = 0.039$), and the same behavior occurs for the subgroup (unvaccinated/vaccinated), hypercholesterolemia shows a statistically significant correlation ($p = 0.005$).

Patient characteristics are shown in Table 1.

The results of logistic regression analysis show that female gender (OR = 0.048; 95% CI = 0.01–0.222) is the only factor associated with SARS-CoV-2 infection. Table 2 shows the result of the multivariate regression considering SARS-CoV-2 as the dependent variable.

Table 1
Characteristics of diabetic patients followed in the primary care.

Characteristics	All subjects N = 100	SARS CoV-2		P value	Vaccination		P value
		Non-infected N = 42	Infected N = 58		Unvaccinated N = 16	Vaccinated N = 84	
Age, n (%)							
Mean ± SD	76.5 ± 8.5	78.1 ± 8.6	75.4 ± 8.3	0.127 ^a	77.3 ± 8.6	76.4 ± 8.5	0.720 ^a
Gender, n (%)							
Male	45 (45)	21 (46.7)	24 (53.3)	0.392	7 (15.6)	38 (84.4)	0.913
Female	55 (55)	21 (38.2)	34 (61.8)		9 (16.4)	46 (83.6)	
BMI (kg/m²), n (%)							
Mean ± SD	25.6 ± 5.0	25.5 ± 5.1	25.8 ± 5.0	0.848 ^a	24.3 ± 2.7	25.4 ± 3.4	0.171 ^a
Underweight (<18.5)	4 (4)	2 (50.0)	2 (50.0)	0.736	1 (25.0)	3 (75.0)	0.716
Normal weight (18.5 ≤ BMI <25)	44 (44)	18 (40.9)	26 (59.1)		8 (18.2)	36 (81.8)	
Over weight (25 ≤ BMI <30)	41 (41)	18 (43.9)	23 (56.1)		6 (14.7)	35 (85.3)	
Obese class I (30 ≤ BMI <35)	7 (7)	3 (42.9)	4 (57.1)		1 (14.3)	6 (85.7)	
Obese class II (35 ≤ BMI <40)	1 (1)	0	1 (100.0)		0	1 (100.0)	
Obese class III (≥40)	3 (3)	1 (33.3)	2 (66.7)		0	3 (100.0)	
Family income level (euros)							
Under 400	34 (34)	18 (52.9)	16 (47.1)	0.112	3 (8.6)	31 (91.2)	0.160
Above 400	66 (66)	24 (36.4)	42 (63.6)		13 (19.7)	53 (80.3)	
Physical activity							
Yes	88 (88)	38 (43.2)	50 (56.8)	0.517	13 (14.8)	75 (85.2)	0.365
No	12 (12)	4 (33.3)	8 (66.7)		3 (25.0)	9 (75.0)	
Comorbidity, n (%)							
Arterial hypertension							
Yes	51 (51)	23 (45.1)	28 (54.9)	0.522	9 (17.6)	42 (82.4)	0.647
No	49 (49)	19 (38.8)	30 (61.2)		7 (14.3)	42 (85.7)	
Stroke							
Yes	23 (23)	8 (34.8)	15 (65.2)	0.424	3 (13.0)	20 (87.0)	0.659
No	77 (77)	34 (44.2)	43 (55.8)		13 (16.9)	64 (83.1)	
Hypercholesterolemia							
Yes	57 (57)	29 (50.9)	28 (49.1)	0.039	4 (7.0)	53 (93.0)	0.005
No	43 (43)	13 (30.2)	30 (69.8)		12 (27.9)	31 (72.1)	
Other cardiovascular diseases (AMI, heart failure, arrhythmias)							
Yes	23 (23)	10 (43.5)	13 (56.5)	0.870	4 (17.4)	19 (82.6)	0.836
No	77 (77)	32 (41.6)	45 (58.4)		12 (15.6)	65 (84.4)	
Respiratory diseases (COPD, asthma)							
Yes	25 (25)	14 (56.0)	11 (44.0)	0.101	4 (16.0)	21 (84.0)	0.910
No	75 (75)	28 (37.3)	47 (62.7)		12 (16.0)	63 (84.0)	
Medication, n (%)							
Oral and injectable insulin							
Yes	3 (3)	2 (66.7)	1 (33.3)	0.379	0	3 (100.0)	0.443
No	97 (97)	40 (41.2)	57 (58.8)		16 (16.5)	81 (83.5)	
Oral insulin							
Yes	94 (94)	38 (40.4)	56 (59.6)	0.207	16 (17.0)	78 (83.0)	0.270
No	6 (6)	4 (66.7)	2 (33.3)		0	6 (100.0)	
Injectable insulin							
Yes	4 (4)	3 (75.0)	1 (25.0)	0.172	0	4 (100.0)	0.373
No	96 (96)	39 (40.6)	57 (59.4)		16 (16.7)	80 (83.3)	

Abbreviations: SARS CoV-2, Severe Acute Respiratory Syndrome Coronavirus 2; BMI, Body Mass Index; AMI, Acute Myocardial Infarction; COPD, Chronic Obstructive Pulmonary Disease.

^a T-test.

4. Discussion

This study showed the importance of the profile of comorbidities underlying T2D in SARS-CoV-2 infection after COVID-19 vaccination. T2D appears to be correlated with SARS-CoV-2 infection, particularly those with hypercholesterolemia. Our study also shows that although most diabetics are vaccinated (84.0%), this does not mean that they cannot be infected or reinfected with SARS-CoV-2. It is well known that the vaccines available in our market cannot guarantee 100% efficacy for the new SARS-CoV-2 variants.

Our study indicated that SARS-CoV-2 was more frequent in women with obesity (BMI > 35kg/m²) although this correlation is not statistically significant. There are still no studies to support our results after vaccination, however it is known that diabetic patients with obesity are more likely to get COVID-19 and develop more severe disease (Govender et al., 2021; Al-Sabah et al., 2020). On the other hand, we speculate that our results may be associated with physical inactivity and excess calorie intake.

Table 2
Risk factors of SARS-CoV-2 infection from multivariable logistic regression.

Independent variables	OR	95% C.I.
Gender		
Male (Ref.)	1	
Female	0.048	0.01–0.222
Constant	171,668,697	

Variables used in the adjustment model: age, gender, body mass index, family income level, duration of diabetes, arterial hypertension, stroke, hypercholesterolemia, other cardiovascular diseases, respiratory diseases, type of medication (oral and injectable insulin; oral insulin; injectable insulin).

Abbreviations: SARS CoV-2, Severe Acute Respiratory Syndrome Coronavirus 2; OR, odds ratio; C.I., confidence interval; Ref., reference group.

Another result of our study concerns the significant association of hypercholesterolemia with SARS-CoV-2 infection as well as vaccination. These results are partially in line with other studies (Greenhalgh et al., 2020; Radenkovic et al., 2020). Some authors (Greenhalgh et al., 2020) indicate that the use of medications for hypercholesterolemia may increase the incidence and severity of COVID-19 by lowering blood cholesterol levels. Contrarily, Radenkovic et al. (2020) indicate that statins, used to treat hypercholesterolemia, have antithrombotic, anti-inflammatory, and immunomodulatory effects, and act on the main protease of Coronavirus, inhibiting its replication. We speculate that our results may be associated with i) the use of statins and ii) vaccination against COVID.

Our study has limitations. First, the small sample size did not allow us to draw more concise data. Second, we did not obtain information about the type of vaccine given to our patients and their immunity. The strength of the study is the fact that it is being conducted on a very specific population.

5. Conclusion

It was concluded that diabetic women over 65 years of age are a risk factor for SARS-CoV-2. It also appears that there is an association of hypercholesterolemia with SARS-CoV-2 infection and with vaccination in this population.

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CRedit authorship contribution statement

Maria Cristina Carrondo: Conceptualization, Methodology, Software, Data curation, Writing – original draft, Visualization, Investigation, Validation, Writing – review & editing. **Joaquim Jorge Moita:** Conceptualization, Validation, Writing – review & editing.

Declaration of competing interest

None of the authors has any declarations of interest.

References

- Al-Sabah, S., Al-Haddad, M., Al-Youha, S., et al., 2020. COVID-19: impact of obesity and diabetes on disease severity. *Clin Obes* 10 (6), e12414. <https://doi.org/10.1111/cob.12414>.
- American Diabetes Association. Diabetes and coronavirus (COVID-19), what you need to know. Getting a COVID-19 Vaccine, Cited at: April 24, 2021; Available from: <https://www.diabetes.org/coronavirus-covid-19/vaccination-guide>.
- Dennis, J.M., Mateen, B.A., Sonabend, R., et al., 2021. Type 2 diabetes and COVID-19-related mortality in the critical care setting: a national cohort study in England, march-july 2020. *Diabetes Care* 44 (1), 50–57. <https://doi.org/10.2337/dc20-1444>.
- Drucker, D.J., 2021. Diabetes, obesity, metabolism, and SARS-CoV-2 infection: the end of the beginning. *Cell Metabol.* 33 (3), 479–498. <https://doi.org/10.1016/j.cmet.2021.01.016>.
- Giorgino, F., Bhana, S., Czupryniak, L., et al., 2021. Management of patients with diabetes and obesity in the COVID-19 era: experiences and learnings from south and east Europe, the Middle East, and Africa. *Diabetes Res. Clin. Pract.* 172, 108617. <https://doi.org/10.1016/j.diabres.2020.108617>.
- Govender, N., Khaliq, O.P., Moodley, J., et al., 2021. Insulin resistance in COVID-19 and diabetes. *Prim Care Diabetes* 15 (4), 629–634. <https://doi.org/10.1016/j.pcd.2021.04.004>.
- Greenhalgh, T., Koh, G.C.H., Car, J., 2020. Covid-19: a remote assessment in primary care. *BMJ* 368, m1182. <https://doi.org/10.1136/bmj.m1182>.
- Gregg, E.W., Sophiea, M.K., Weldegiorgis, M., 2021. Diabetes and COVID-19: population impact 18 Months into the pandemic. *Diabetes Care* 44 (9), 1916–1923. <https://doi.org/10.2337/dc21-0001>.
- Hannah, R., Edouard, M., Lucas, R.G. Coronavirus pandemic (COVID-19). *Published online at OurWorldInData.org*. Cited at: April 27, 2022. Available from: <https://ourworldindata.org/coronavirus>.
- Holly, J.M.P., Biernacka, K., Maskell, N., et al., 2020. Obesity, diabetes and COVID-19: an infectious disease spreading from the east collides with the consequences of an unhealthy western lifestyle. *Front. Endocrinol.* 11, 582870. <https://doi.org/10.3389/fendo.2020.582870>.
- International Diabetes Federation. IDF. Diabetes atlas 2021 –. Available from: https://diabetesatlas.org/idfawp/resource-files/2021/07/IDF_Atlas_10th_Edition_2021.pdf. tenth ed.
- Iqbal, Z., Ho, J.H., Adam, S., et al., 2020. Heart UK's Medical Scientific and Research Committee. Managing hyperlipidaemia in patients with COVID-19 and during its pandemic: an expert panel position statement from HEART UK. *Atherosclerosis* 313, 126–136. <https://doi.org/10.1016/j.atherosclerosis.2020.09.008>.
- Mehrbod, P., Eybpoosh, S., Farahmand, B., et al., 2021. Association of the host genetic factors, hypercholesterolemia and diabetes with mild influenza in an Iranian population. *Virology* 18 (1), 64. <https://doi.org/10.1186/s12985-021-01486-3>.
- Pang, J., Liu, M., Ling, W., et al., 2021. Friend or foe? ACE2 inhibitors and GLP-1R agonists in COVID-19 treatment. *Obes Med* 22, 100312. <https://doi.org/10.1016/j.obmed.2020.100312>.
- Pugliese, G., Vitale, M., Resi, V., et al., 2020. Is diabetes mellitus a risk factor for COroNAvirus Disease 19 (COVID-19)? *Acta Diabetol.* 57 (11), 1275–1285. <https://doi.org/10.1007/s00125-020-05000-0>.

doi.org/10.1007/s00592-020-01586-6.

Radenkovic, D., Chawla, S., Pirro, M., et al., 2020. Cholesterol in relation to COVID-19: should we care about it? *J. Clin. Med.* 9 (6), 1909. <https://doi.org/10.3390/jcm906>.

Serviço Nacional de Saúde. Plano de vacinação COVID-19, Cited at: april 24, 2021. Available from: <https://covid19estamoson.gov.pt/plano-vacinacao-covid-19/>.

World Health Organization. Regional office for Europe. Body mass index – BMI. Cited at: April 27, 2022. Available from: <https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi>.

Zhou, Y., Chi, J., Lv, W., et al., 2021. Obesity and diabetes as high-risk factors for severe coronavirus disease 2019 (Covid-19). *Diabetes Metab Res Rev* 37 (2), e3377. <https://doi.org/10.1002/dmrr.3377>.