

Obesity and COVID-19 in adult patients with diabetes

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Online-only Supplemental Material

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Supplementary Table 1. Comparison of COVID-19 patients with and without BMI data.

Characteristics	With BMI data (n=1637)	Without BMI data (n=1340)	P
Age, years, median [IQR]	60·00 [50·00, 68·00]	61·00 [49·00, 69·00]	0·335
Gender, male, n, %	814 (49·7)	703 (52·5)	0·147
Smoking status, n, %			0·181
Never/unknown	1214 (92·6)	972 (91·0)	
Former/current	97 (7·4)	96 (9·0)	
Comorbidities n, %			
Any	642 (39·2)	558 (41·6)	0·192
None	995 (60·8)	782 (58·4)	0·320
1	415 (25·4)	350 (26·1)	
> 1	227 (13·9)	208 (15·5)	
Malignancy	29 (1·8)	25 (1·9)	0·181
Hypertension	473 (28·9)	405 (30·2)	0·453
Coronary artery disease	90 (5·5)	92 (6·9)	0·141
Congestive heart failure	16 (1·0)	26 (1·9)	0·039
COPD	46 (2·8)	53 (4·0)	0·103
Chronic kidney disease	6 (0·4)	10 (0·7)	0·247
Chronic liver disease	32 (2·0)	41 (3·1)	0·069
Diabetes mellitus	231 (14·1)	185 (13·8)	0·853
Symptoms on admission, n, %			
Fever	854 (52·2)	739 (55·1)	0·113
Chills	69 (4·2)	63 (4·7)	0·581
Dry cough	760 (46·4)	678 (50·6)	0·026
Sore throat	69 (4·2)	48 (3·6)	0·430
Myalgia	462 (28·2)	433 (32·3)	0·017
Fatigue	471 (28·8)	449 (33·5)	0·006
Headache	54 (3·3)	43 (3·2)	0·973
Diarrhoea	127 (7·8)	98 (7·3)	0·699
Dyspnoea	355 (21·7)	366 (27·3)	<0·001
RR, median [IQR]	20·00 [19·00, 22·00]	20·00 [19·00, 21·00]	0·001
SBP, mm Hg, median [IQR]	130·00 [120·00, 140·00]	129·00 [120·00, 140·00]	0·718

DBP, mm Hg, median [IQR]	80·00 [74·00, 89·00]	80·00 [74·00, 88·00]	0·362
FPG, mmol, median [IQR]	4·96 [4·55, 5·80]	5·11 [4·62, 6·42]	< 0·001
CT image, n, %			
Ground-glass opacity	459 (28·0)	604 (45·1)	< 0·001
Bilateral pulmonary infiltration	25 (1·5)	51 (3·8)	< 0·001
Consolidation			0·001
Left lung	46 (2·8)	24 (1·8)	
Right lung	64 (3·9)	47 (3·5)	
Both lungs	686 (41·9)	485 (36·2)	

Abbreviations: IQR, interquartile range; COPD, Chronic obstructive pulmonary disease; RR, respiratory rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; FPG, Fasting plasma glucose level

^BMI categories: underweight, BMI <18·5 kg/m², normal weight, 18·5–23·9 kg/m², overweight, 24·0–27·9 kg/m², and obesity, ≥28 kg/m²

P-value was calculated from Kruskal-Wallis test for non-normally distributed continuous variables, from Chi-square test or Fisher exact test for categorical variables.

Supplementary Table 2. Likelihood ratio tests between interaction models and multivariable models.

	Severe pneumonia			Oxygen therapy		
	Log-likelihood	Degree of Freedom	<i>P</i> *	Log-likelihood	Degree of Freedom	<i>P</i> *
Model 1	-2181.4	8	-	-2060.5	8	-
Model 2	-2172.2	11	< 0.001	-2058.1	11	0.195
Model 3	-2176.8	11	< 0.001	-2058.5	11	< 0.001
Model 4	-2177.8	12	0.143	-2056.5	12	0.049
Model 5	-2175.9	12	0.027	-2056.6	12	0.096
Model 6	-2155.3	12	< 0.001	-2049.6	12	< 0.001

Model 1 (as reference) includes covariates of BMI, age, sex, and comorbidities score;

Model 2 adds an interaction term of BMI*age to model 1;

Model 3 adds an interaction term of BMI*sex to model 1;

Model 4 adds a covariate of diabetes and an interaction term of BMI*diabetes to model 1;

Model 5 adds a covariate of ARB prescription and an interaction term of BMI* ARB prescription to model 1;

Model 6 adds a covariate of IL-6 inhibitor prescription and an interaction term of BMI* IL-6 inhibitor prescription to model 1.

Supplementary Table 3. Crude and adjusted odds ratio (OR) of severe outcomes of COVID-19 of underweight, overweight and obese patients, with reference to normal weight patients. The subgroups are hypertensive patients with and without ARB prescription, and the patients with and without IL-6 inhibitor prescription in hospital.

	Severe Pneumonia				Oxygen therapy			
	Crude OR	P	Adjusted OR*	P	Crude OR	P	Adjusted OR*	P
ARB prescription								
Underweight	1.63 (0.34, 7.79)	0.541	2.03 (0.39, 10.61)	0.404	1.06 (0.22, 5.14)	0.942	1.17 (0.23, 5.98)	0.851
Overweight	1.54 (0.78, 3.23)	0.205	2.08 (0.94, 4.59)	0.070	2.21 (1.08, 4.54)	0.030	2.35 (1.08, 5.13)	0.031
Obesity	1.20 (0.45, 3.17)	0.716	1.34 (0.48, 3.76)	0.577	1.15 (0.41, 3.21)	0.797	1.17 (0.41, 3.36)	0.771
No ARB								
Underweight	0.37 (0.15, 0.891)	0.027	0.42 (0.17, 1.06)	0.066	0.96 (0.436, 2.13)	0.925	1.15 (0.51, 2.62)	0.734
Overweight	0.82 (0.606, 1.107)	0.194	0.86 (0.63, 1.18)	0.354	0.75 (0.558, 1.02)	0.067	0.80 (0.59, 1.09)	0.15
Obesity	0.77 (0.493, 1.211)	0.260	0.80 (0.50, 1.27)	0.339	1.10 (0.701, 1.72)	0.686	1.12 (0.71, 1.76)	0.629
Tocilizumab prescription								
Underweight	1.37*10 ⁷ (0,Inf)	0.989	2.92*10 ⁶ (0, Inf)	0.990	2.05 (0.27, 15.57)	0.488	4.47 (0.33, 60.99)	0.261
Overweight	1.44 (0.47,4.4)	0.521	1.34 (0.40,4.46)	0.636	0.86 (0.32, 2.28)	0.754	0.85 (0.31, 2.34)	0.755
Obesity	0.98 (0.14, 6.85)	0.982	1.58 (0.19, 13.18)	0.673	0.41 (0.08, 2.16)	0.293	0.46 (0.08, 2.78)	0.395
No tocilizumab								
Underweight	0.84 (0.56, 1.19)	0.321	0.83 (0.58, 1.19)	0.303	0.82 (0.54, 1.24)	0.350	0.75 (0.49, 1.14)	0.177
Overweight	1.15 (0.98, 1.34)	0.080	1.17 (1.00, 1.37)	0.049	0.95 (0.80, 1.13)	0.543	0.99 (0.83, 1.18)	0.868
Obesity	1.50 (1.18, 1.92)	0.001	1.54 (1.20, 1.98)	0.001	1.56 (1.21, 2.02)	0.001	1.67 (1.28, 2.16)	<0.001

*Multivariable models include BMI, age, sex, and comorbidity scores.

Supplementary Table 4. Adjusted odds ratio (OR) estimated from sensitivity analyses: 1) by using raw data, and 2) adding smoking status as covariate.

	Severe Pneumonia				Oxygen therapy			
	Sensitivity 1^	P	Sensitivity 2#	P	Sensitivity 1^	P	Sensitivity 2#	P
All patients								
Underweight	0.97 (0.57, 1.63)	0.896	0.81 (0.55, 1.20)	0.292	0.79 (0.44, 1.39)	0.410	0.71 (0.48, 1.05)	0.085
Overweight	1.08 (0.85, 1.37)	0.551	1.10 (0.93, 1.31)	0.270	0.94 (0.73, 1.22)	0.657	0.96 (0.81, 1.14)	0.647
Obesity	1.34 (0.92, 1.97)	0.132	1.41 (1.07, 1.86)	0.015	1.37 (0.92, 2.03)	0.122	1.36 (1.04, 1.79)	0.025
Age < 65								
Underweight	0.50 (0.17, 1.48)	0.211	0.32 (0.14, 0.70)	0.005	0.57 (0.20, 1.67)	0.308	0.91 (0.52, 1.62)	0.756
Overweight	1.20 (0.89, 1.64)	0.233	1.34 (1.08, 1.66)	0.007	0.95 (0.69, 1.33)	0.776	0.97 (0.79, 1.20)	0.799
Obesity	1.08 (0.66, 1.76)	0.764	1.31 (0.95, 1.81)	0.098	1.17 (0.71, 1.93)	0.536	1.47 (1.07, 2.03)	0.017
Age ≥ 65								
Underweight	1.28 (0.67, 2.45)	0.461	1.17 (0.71, 1.92)	0.543	0.92 (0.46, 1.87)	0.825	0.55 (0.32, 0.95)	0.033
Overweight	0.90 (0.62, 1.32)	0.601	0.72 (0.53, 0.98)	0.034	0.95 (0.63, 1.43)	0.812	0.94 (0.70, 1.27)	0.681

Obesity	2.23 (1.12, 4.43)	0.022	1.97 (1.12, 3.46)	0.019	1.87 (0.96, 3.65)	0.067	1.16 (0.68, 1.98)	0.591
Men								
Underweight	1.30 (0.62, 2.70)	0.488	0.97 (0.55, 1.69)	0.907	0.94 (0.43, 2.06)	0.879	0.88 (0.51, 1.53)	0.659
Overweight	1.17 (0.84, 1.62)	0.356	1.23 (0.97, 1.55)	0.094	0.85 (0.60, 1.20)	0.354	0.90 (0.71, 1.14)	0.365
Obesity	1.54 (0.90, 2.65)	0.116	1.79 (1.23, 2.62)	0.003	1.21 (0.69, 2.14)	0.502	1.30 (0.89, 1.90)	0.170
Women								
Underweight	0.74 (0.34, 1.58)	0.432	0.70 (0.40, 1.22)	0.209	0.66 (0.28, 1.55)	0.338	0.58 (0.34, 1.01)	0.054
Overweight	1.00 (0.70, 1.41)	0.979	1.00 (0.78, 1.28)	0.985	1.07 (0.74, 1.54)	0.740	1.00 (0.77, 1.28)	0.980
Obesity	1.18 (0.68, 2.03)	0.563	1.03 (0.68, 1.57)	0.881	1.49 (0.86, 2.60)	0.159	1.34 (0.90, 2.00)	0.151
Diabetes								
Underweight	1.45 (0.39, 5.48)	0.580	1.39 (0.56, 3.44)	0.482	1.19 (0.28, 5.05)	0.816	1.06 (0.42, 2.68)	0.906
Overweight	0.91 (0.49, 1.66)	0.748	0.81 (0.51, 1.29)	0.370	1.66 (0.86, 3.19)	0.132	1.57 (0.99, 2.48)	0.057
Obesity	1.02 (0.40, 2.56)	0.975	1.53 (0.72, 3.25)	0.270	2.34 (0.89, 6.16)	0.085	1.54 (0.73, 3.28)	0.261

^: Adjusted for age, sex, and comorbidity score; #: Adjusted for age, sex, comorbidity score and smoking status.

Supplementary Table 5. Sensitivity analysis for crude and adjusted odds ratio (OR) of severe outcomes of COVID-19 of underweight, overweight and obese patients, with reference to normal weight patients, from multiple imputed data.

	Severe Pneumonia				Oxygen therapy			
	Crude OR		Adjusted OR		Crude OR		Adjusted OR	
	Before MI	After MI						
All patients								
Underweight	0.95 (0.68, 1.33)	0.84 (0.60, 1.18)	0.95 (0.67, 1.33)	0.84 (0.60, 1.18)	0.84 (0.60, 1.18)	1.18 (0.87, 1.61)	0.84 (0.60, 1.18)	1.19 (0.87, 1.61)
Overweight	1.13 (0.97, 1.32)	1.09 (0.91, 1.30)	1.14 (0.98, 1.32)	1.10 (0.91, 1.31)	0.95 (0.82, 1.10)	0.84 (0.71, 1.01)	0.95 (0.81, 1.10)	0.84 (0.70, 1.00)

Obesity	1.46 (1.14, 1.86) [#]	1.28 (1.01, 1.62) [#]	1.47 (1.15, 1.88) [#]	1.29 (1.02, 1.65) [#]	1.40 (1.10, 1.79) [#]	1.21 (0.96, 1.53)	1.40 (1.10, 1.79) [#]	1.20 (0.94, 1.52)
Age < 65								
Underweight	0.54 (0.30, 0.97) [#]	0.63 (0.37, 1.06)	0.54 (0.30, 0.97) [#]	0.61 (0.36, 1.03)	0.73 (0.43, 1.23)	1.19 (0.77, 1.85)	0.71 (0.42, 1.21)	1.20 (0.77, 1.86)
Overweight	1.26 (1.05, 1.52) [#]	1.19 (0.95, 1.48)	1.28 (1.06, 1.55) [#]	1.21 (0.97, 1.52)	0.96 (0.80, 1.15)	0.91 (0.73, 1.14)	0.97 (0.80, 1.17)	0.91 (0.72, 1.14)
Obesity	1.26 (0.95, 1.69)	1.16 (0.87, 1.54)	1.28 (0.95, 1.71)	1.19 (0.88, 1.60)	1.23 (0.92, 1.64)	1.24 (0.94, 1.65)	1.25 (0.93, 1.67)	1.23 (0.92, 1.64)
Age ≥ 65								
Underweight	1.23 (0.79, 1.92)	1.05 (0.67, 1.65)	1.28 (0.82, 2.00)	1.04 (0.66, 1.64)	0.93 (0.59, 1.46)	1.15 (0.74, 1.77)	0.94 (0.59, 1.48)	1.14 (0.73, 1.76)
Overweight	0.92 (0.71, 1.19)	0.92 (0.68, 1.25)	0.90 (0.69, 1.17)	0.92 (0.67, 1.25)	0.93 (0.72, 1.21)	0.73 (0.54, 0.99) [#]	0.93 (0.71, 1.21)	0.73 (0.54, 0.99) [#]
Obesity	2.28 (1.41, 3.67) [#]	1.65 (1.09, 2.49) [#]	2.21 (1.37, 3.57) [#]	1.64 (1.07, 2.49) [#]	1.93 (1.22, 3.04) [#]	1.16 (0.76, 1.78)	1.88 (1.19, 2.97) [#]	1.15 (0.75, 1.78)
Men								
Underweight	1.40 (0.88, 2.24)	1.23 (0.72, 2.10)	1.43 (0.89, 2.29)	1.25 (0.73, 2.14)	0.99 (0.62, 1.60)	0.87 (0.50, 1.51)	1.03 (0.64, 1.68)	0.87 (0.50, 1.52)
Overweight	1.22 (0.98, 1.50)	1.11 (0.86, 1.43)	1.23 (0.99, 1.52)	1.12 (0.86, 1.44)	0.84 (0.68, 1.04)	0.82 (0.64, 1.04)	0.85 (0.68, 1.05)	0.81 (0.63, 1.04)
Obesity	1.84 (1.31, 2.58)	1.26 (0.94, 1.71)	1.85 (1.31, 2.61) [#]	1.26 (0.93, 1.72)	1.36 (0.97, 1.90)	1.26 (0.93, 1.70)	1.33 (0.94, 1.87)	1.24 (0.91, 1.68)
Women								
Underweight	0.62 (0.37, 1.03)	0.67 (0.43, 1.04)	0.62 (0.37, 1.03)	0.67 (0.43, 1.04)	0.69 (0.42, 1.12)	1.37 (0.94, 1.99)	0.69 (0.42, 1.13)	1.36 (0.94, 1.98)
Overweight	1.08 (0.87, 1.34)	1.09 (0.84, 1.41)	1.08 (0.86, 1.34)	1.08 (0.83, 1.41)	1.08 (0.87, 1.35)	0.86 (0.66, 1.13)	1.07 (0.86, 1.33)	0.86 (0.66, 1.12)
Obesity	1.14 (0.80, 1.63)	1.42 (0.94, 2.14)	1.14 (0.80, 1.64)	1.42 (0.94, 2.15)	1.43 (1.01, 2.02) [#]	1.07 (0.72, 1.59)	1.40 (0.98, 1.99)	1.06 (0.71, 1.58)
Diabetes								
Underweight	1.46 (0.60, 3.55)	1.65 (0.71, 3.85)	1.50 (0.61, 3.65)	1.67 (0.71, 3.93)	1.20 (0.48, 2.96)	1.62 (0.73, 3.60)	1.22 (0.49, 3.05)	1.57 (0.70, 3.50)
Overweight	0.90 (0.60, 1.35)	0.91 (0.56, 1.49)	0.88 (0.58, 1.34)	0.90 (0.55, 1.49)	1.64 (1.10, 2.44) [#]	0.88 (0.55, 1.41)	1.68 (1.11, 2.54) [#]	0.91 (0.56, 1.47)
Obesity	1.03 (0.56, 1.89)	1.11 (0.60, 2.04)	1.01 (0.54, 1.89)	1.10 (0.59, 2.05)	1.95 (1.04, 3.64) [#]	1.36 (0.72, 2.57)	2.06 (1.08, 3.92) [#]	1.43 (0.74, 2.75)

Abbreviations: MI, multiple imputation; Multivariable models include BMI, age, sex, and comorbidity scores. #: P < 0.05.

