A point-prevalence study of body mass indices in HIV-positive and HIV-negative patients admitted to hospital with COVID-19 in South Africa

A Parker,[1,2] MB ChB, FCP (SA), MMed (Int), Cert ID (SA); **A G B Broadhurst,**[1] MB ChB; **M S Moolla,**[1,3] MB ChB, FCP (SA), MMed (Int); **L Amien,**[1] MB ChB; **R Ahmed,**[1] MB ChB; **J J Taljaard,**[2] MB ChB, DTM&H, MMed (Int); **G Meintjes,**[4,5] MB ChB, FCP (SA), FRCP, MPH, PhD; **P Nyasulu,**[3] PhD; **C F N Koegelenberg,**[6] MB ChB, MMed (Int), FCP (SA), FRCP, Cert Pulmonology (SA), PhD

[1] *Division of General Medicine, Department of Medicine, Faculty of Medicine and Health Sciences, Stellenbosch University and Tygerberg Hospital, Cape Town, South Africa*
[2] *Division of Infectious Diseases, Department of Medicine, Faculty of Medicine and Health Sciences, Stellenbosch University and Tygerberg Hospital, Cape Town, South Africa*
[3] *Division of Epidemiology and Biostatistics, Department of Global Health, Faculty of Medicine and Health Sciences, Stellenbosch University, Cape Town, South Africa*
[4] *Department of Medicine, Faculty of Health Sciences, University of Cape Town and Groote Schuur Hospital, Cape Town, South Africa*
[5] *Wellcome Centre for Infectious Disease Research in Africa, Institute of Infectious Disease and Molecular Medicine, University of Cape Town, South Africa*
[6] *Division of Pulmonology, Department of Medicine, Faculty of Medicine and Health Sciences, Stellenbosch University and Tygerberg Hospital, Cape Town, South Africa*

Corresponding author: *A Parker (aparker@sun.ac.za)*

Background. Obesity is now well recognised as a risk factor for severe COVID-19, but the true prevalence of obesity in hospitalised adults with COVID-19 remains unclear because formal body mass indices (BMIs) are not routinely measured on admission.
Objectives. To describe the true prevalence of obesity measured by the BMI, and associated comorbidities, in patients hospitalised with severe COVID-19, including people with HIV (PWH).
Methods. We conducted a point-prevalence study of measured BMI in consecutive patients with severe COVID-19 admitted to the medical COVID-19 wards in a tertiary academic hospital in Cape Town, South Africa (SA). Patients were enrolled over a 2-week period during the peak of the first COVID-19 wave in SA.
Results. We were able to measure the BMI in 122 of the 146 patients admitted during the study period. The prevalence of HIV was 20% (*n*=24/122). Most of the participants were overweight or obese (*n*=104; 85%), and 84 (68.9%) met criteria for obesity. The mean (standard deviation) BMI was 33 (7.5), and 34.5 (9.1) in PWH. Of PWH, 83% (*n*=20/24) were overweight or obese and 75% (*n*=18) met criteria for obesity. Multimorbidity was present in 22 (92%) of PWH.
Conclusion. We found that most patients, including PWH, met criteria for being overweight or obese. The high prevalence of obesity in PWH and severe COVID-19 reinforces the need for targeted management of non-communicable diseases, including obesity, in PWH.
Keywords. HIV, obesity, body mass index, COVID-19, multimorbidity.

Afr J Thoracic Crit Care Med 2023;29(3):e660. https://doi.org/10.7196/AJTCCM.2023.v29i3.660

Study synopsis

What the study adds

- We found that the true prevalence of obesity, including in people with HIV (PWH), measured with the formal body mass index in hospitalised patients with severe COVID-19 was much higher than reported previously.
- Multimorbidity was present in over half of all patients, and in 92% of PWH.

Implications of the findings

- Urgent public health measures are required to tackle the rise in obesity, including in low- and middle-income countries.
- HIV care must integrate management of non-communicable diseases, including obesity.
- The pathogenic mechanism of the link between obesity and severe COVID-19 needs further research.

Obesity has emerged as a significant risk factor for COVID-19 severity and mortality.[1,2] Models have estimated that 30.2% of adult COVID-19 hospitalisations are attributable to obesity.[3] A limitation to many studies is that anthropometric measurements such as the body mass index (BMI) are not routinely performed during hospital admission, which may have resulted in over- or underestimation of the true prevalence of obesity.[4] Reasons for not routinely recording anthropometric measurements are multifactorial.[2,5] The patient may

have been too ill to stand for weight measurement, or staff may have wanted to limit non-essential interactions with patients owing to the infectious nature of SARS-CoV-2.

Southern Africa is the region with the largest HIV-infected population globally.[6] An estimated 68% of females and 31% of males are reported to be either overweight or obese in South Africa (SA), with the highest rates in Western Cape Province (73% of females and 44% of males).[7] While large epidemiological studies have reported HIV as an independent risk factor for adverse COVID-19 outcomes, data on obesity and concurrent opportunistic infections were lacking, which may have influenced these findings.[8,9] Other studies have shown that HIV was not associated with increased COVID-19 mortality when comorbidities such as obesity were accounted for.[2,10]

With the introduction of effective antiretroviral therapy (ART), mortality among people with HIV (PWH) has declined over the past 15 years,[6] and the life expectancy of PWH is now nearing that of the general population.[11] Non-communicable diseases such as obesity are now a major threat in people ageing with HIV.[12]

It remains unclear whether HIV infection itself, or comorbidities in PWH, have been the major driver of COVID-19 mortality in this patient population. Data on measured BMIs in PWH admitted to hospital with severe COVID-19 are lacking. We therefore aimed to describe the true prevalence of obesity in a population of HIV-positive and HIV-negative patients with severe COVID-19 who were admitted to medical wards during the first COVID-19 wave in SA.

Methods

Study design, population and setting

This was a cross-sectional study to measure the BMIs of patients with severe COVID-19 admitted to the medical wards of Tygerberg Hospital, Cape Town, over a 2-week period from 15 to 29 May 2020, during the first COVID-19 wave in SA. Tygerberg Hospital is a tertiary hospital with 1 384 active beds, making it the largest hospital in the Western Cape and the second-largest hospital in SA. During the first COVID-19 wave, the hospital was a designated COVID-19 hospital for the province.

Inclusion and exclusion criteria

All adults with a positive SARS-CoV-2 polymerase chain reaction test requiring admission to the COVID wards with severe COVID-19 (as defined by chest radiograph infiltrates and the need for supplemental oxygen) were included. Patients admitted to the intensive care unit (ICU) and those who were unable to stand for height and weight measurement were excluded.

Data collection

We captured data on age, sex, and the presence of four comorbidities: hypertension, diabetes mellitus, HIV and obesity. Multimorbidity was defined as the presence of two or more of these chronic conditions. Obesity was assessed by formally measuring the BMI. All patients had weight and height measurements performed. The BMI was calculated by dividing the weight in kilograms by the height in metres squared. Weights and heights were measured by the same three members of the study team, using the same protocol. A single measurement was done in a standing position and within 24 hours of admission. The same medical-grade column scale (Charder Electronic Co. Ltd, Taiwan), which is calibrated annually, was used for both height and weight measurement. The scale was disinfected between patients. The BMI was categorised into underweight (<18.5), normal weight (18.5 - 24.9), overweight (25 - 29.9) and obesity (>30). Obesity was subclassified into class I obesity (30 - 34.9), class II obesity (35 - 39.9) and class III (formerly morbid) obesity, which was defined as a BMI ≥40. As per routine practice at our hospital, all patients received an HIV test (HIV chemiluminescence assay) where HIV status was not known. We also captured data on outcome, which was defined as the need for ICU admission or death.

Ethical considerations

Ethics approval with a waiver of informed consent for this study was obtained from the Health Research Ethics Committee of Stellenbosch University (ref. no. N20/04/002_COVID-19)

Statistical analysis

Data were analysed using Stata software, version 16.1 (StataCorp, USA). For data that were normally distributed we used means and standard deviations (SDs) to describe the variables. For non-normal data we used medians and interquartile ranges (IQRs). Chi-square and Fisher's exact tests where appropriate were used to describe significant differences between categorical factors. We used Student's *t*-test to compare means of continuous variables for data that were normally distributed, and the Mann-Whitney *U*-test for non-normally distributed continuous variables. Statistical significance was set at $p<0.05$ with corresponding 95% confidence intervals.

Results

BMI measurements were done in 122 of 146 patients admitted during the 14-day study period. We excluded 24 patients because they did not meet the study eligibility criteria or were unable to provide informed consent for BMI testing. The mean (SD) age of the patients was 49.4 (11.2) years, and most were female (n=71; 58%). The mean (SD) height was 1.66 (0.08) m and the mean (SD) weight 90.9 (22.7) kg (Table 1).

The prevalences of HIV, hypertension and diabetes mellitus were 20% (n=24), 44% (n=54) and 38% (n=46), respectively. The median (IQR) CD4 cell count in PWH was 321 (160 - 579) cells/μL. HIV viral load (VL) was only available for 13/24 PWH, of whom 12 had a suppressed VL (<1 000 copies/mL). Eighty-five percent (n=104) of the patients were overweight or obese. In this group, 84 (69% of the total) were obese, of whom 17 (14% of the total) met the criteria for class III obesity (Table 1).

In PWH, 20/24 (83%) were overweight or obese; 18 (75%) met the criteria for obesity and 5 (21%) had class III obesity. PWH had higher mean (SD) BMIs than HIV-negative patients, but this was not statistically significant (34.5 (9.1) v. 32.6 (7.0), respectively; p=0.355) (Table 2). There was no difference in BMI between patients with and without hypertension or in patients with and without diabetes mellitus (Table 2).

Multimorbidity was present in 59% (n=72) of the sample population, of whom 39 (32% of the total) had two comorbidities, 30 (25%) had three comorbidities, and 3 (2.5%) had all four comorbidities. Only 2 patients had none of the four comorbidities. Of PWH, 22 (92%) had

Table 1. Baseline demographic features and comorbidities (*N*=122 patients)

	n (%)*
Age (years), mean (SD)	49.4 (11.2)
Female	71 (58)
Weight (kg), mean (SD)	90.9 (22.7)
Height (m), mean (SD)	1.66 (0.08)
BMI (measured), mean (SD)	33.0 (7.5)
BMI distribution	
Underweight (<18.5)	3 (3)
Normal weight (18.5 - 24.9)	15 (12)
Overweight (25 - 29.9)	20 (16)
All obese >30	84 (69)
Class I	44 (36)
Class II	23 (19)
Class III	17 (14)
Hypertension	54 (44)
Diabetes	46 (38)
HIV	24 (20)

SD = standard deviation; BMI = body mass index.
*Except where otherwise indicated.

Table 2. BMI stratified by HIV status, hypertension and diabetes mellitus

	n	BMI, mean (SD)	*p*-value
HIV status			0.36
Positive	24	34.5 (9.1)	
Negative	98	32.6 (7.0)	
Hypertension			0.23
Yes	54	32.0 (7.4)	
No	68	33.7 (7.4)	
Diabetes			0.54
Yes	46	32.4 (8.0)	
No	76	33.3 (7.1)	

BMI = body mass index; SD = standard deviation.

multimorbidity, with 11 (46%) having one additional comorbidity, 8 (33%) two additional comorbidities, and 3 (13%) all four comorbidities. Only 2 PWH did not have an additional comorbidity.

Seven percent (*n*=9) of the study sample required ICU admission, and 4 patients (3%) died. There was a trend towards higher BMIs in the ICU/death group, but this was not statistically significant.

Discussion

In this point-prevalence study of non-immune COVID-19 patients who were admitted to hospital during the first COVID-19 wave in SA, we found that the proportion of patients who met criteria for being overweight or obese on measured BMI (85%) was far higher than previously reported in similar settings.[2,4,8,13] The prevalence of overweight/obesity in previous studies ranged from 19% to 39%, with one study not reporting obesity data.[8] These studies are likely to have underestimated the true prevalence of obesity, since data were reliant on medical records which may have been incomplete, BMI was not formally measured,[4,13] or data were dependent on the clinician's 'impression of obesity', which may have been inaccurate.[2] There was also a very high prevalence of obesity in PWH hospitalised with severe COVID-19, with a non-significant trend towards a higher mean BMI in this population compared with HIV-negative patients.

Obesity as a risk factor for severe infections of pandemic potential is not unique to SARS-CoV-2. Obesity was a significant risk factor for mortality during the 2009 H1N1 (swine flu) pandemic.[14] Obesity is also reported as a risk factor for severity in Middle East respiratory syndrome coronavirus (MERS-CoV)[15] and dengue virus infections.[16,17]

Adipocytes are known to become infected by SARS-CoV-2,[18] with SARS-CoV-2 demonstrated in visceral adipocytes in postmortem samples. There is an abundance of angiotensin-converting enzyme 2 receptors on visceral adipocytes.[18] This direct infection of the adipocyte is likely to promote the pro-inflammatory reaction seen in patients with severe COVID-19.[19] Further studies are required to investigate whether PWH have a higher SARS-CoV-2 adipocyte viral load or disproportionate cytokine response driven by adipocytes compared with HIV-negative patients with moderate to severe COVID-19. Understanding the pathogenic link between obesity and COVID-19 may provide important insights into the link between obesity and other severe infections such as influenza, and may help to mitigate against future viruses of pandemic potential.

The present study also demonstrated a large burden of multimorbidity, including in PWH. Multimorbidity is associated with a decline in functional status and quality of life, and increased mortality.[20,21] The increase in multimorbidity, and specifically obesity, in PWH is recognised as concerning.[22] Uncontrolled HIV infection is associated with weight loss that is reversed by ART.[23] With the availability of ART, PWH are now living longer and are reaching the age groups where metabolic comorbidities are more likely.[21]

Our findings suggest that the prevalence of obesity was probably grossly underestimated in studies from our region where formal BMI measurements were not performed. The prevalence of obesity in the present study was also much higher than reported in a hospitalised cohort of patients prior to the COVID pandemic,[24] as well as higher than the background prevalence of obesity in the study setting.[7] The results of this study further strengthen the link between obesity and COVID-19 severity and suggest that obesity also played a significant role in COVID-19 hospital admissions in PWH.

The strengths of our study are that weights and heights were measured, providing an accurate estimate of the BMI, and that the study population included a high proportion of PWH. A limitation to the study is the small sample size, which was limited by the technical difficulty of measuring the BMI in ill patients. A control group of patients without COVID-19 may have strengthened the study and would have allowed for deeper inferential statistics. As this was a single-centre study, the findings may not be generalisable to other settings.

Conclusion

We found that most patients, including PWH, who were admitted with severe COVID-19 in the first wave in SA over a 14-day period met criteria for being overweight or obese when the BMI was formally measured. The high prevalence of obesity and multimorbidity in PWH hospitalised with severe COVID-19 reinforces the need for targeted

management of non-communicable diseases, including obesity, in PWH. The relationship between obesity, HIV and COVID-19 needs further investigation.

Declaration. CFNK is a member of the editorial board.

Acknowledgements. None.

Author contributions. AP and AGBB designed the study and AP wrote the manuscript. AGBB, MSM, LA and RA collected the data, which were analysed by PN. The study was supervised by JJT, GM and CFNK. All co-authors reviewed and approved the manuscript.

Funding. No study-specific funding. GM was supported by the Wellcome Trust (214321/Z/18/Z and 203135/Z/16/Z) and the South African Research Chairs Initiative of the Department of Science and Technology and the National Research Foundation of South Africa (grant no. 64787). The funders had no role in the study design, data collection, data analysis, data interpretation, or the writing of this report. The opinions, findings and conclusions expressed in this manuscript reflect those of the authors alone. Given that this research was funded, in part, by the Wellcome Trust for the purposes of open access, GM has applied a CC BY public copyright licence to any Author Accepted Manuscript version arising from this submission.

Conflicts of interest. None.

1. Huang Y, Lu Y, Huang YM, et al. Obesity in patients with COVID-19: A systematic review and meta-analysis. Metabolism 2020;113:154378. https://doi.org/10.1016/j.metabol.2020.154378
2. Parker A, Boloko L, Moolla MS, et al. Clinical features and outcomes of COVID-19 admissions in a population with a high prevalence of HIV and tuberculosis: A multicentre cohort study. BMC Infect Dis 2022;22(1):559. https://doi.org/10.1186/s12879-022-07519-8
3. Centers for Disease Control and Prevention. Obesity, race/ethnicity, and COVID-19. https://www.cdc.gov/obesity/data/obesity-and-covid-19.html (accessed 14 December 2022).
4. Parker A, Koegelenberg CFN, Moolla MS, et al. High HIV prevalence in an early cohort of hospital admissions with COVID-19 in Cape Town, South Africa. S Afr Med J 2020;110(10):982-987. https://doi.org/10.7196/SAMJ.2020.v110i10.15067
5. Gao M, Piernas C, Astbury NM, et al. Associations between body-mass index and COVID-19 severity in 6.9 million people in England: A prospective, community-based, cohort study. Lancet Diabetes Endocrinol 2021;9(6):350-359. https://doi.org/10.1016/S2213-8587(21)00089-9
6. Joint United Nations Programme on HIV/AIDS (UNAIDS). Fact sheet 2023. Latest global and regional statistics on the status of the AIDS epidemic. https://www.unaids.org/sites/default/files/media_asset/UNAIDS_FactSheet_en.pdf (accessed 14 December 2022).
7. National Department of Health, South Africa, Statistics South Africa, South African Medical Research Council, ICF. South Africa Demographic and Health Survey 2016: Key indicators report. Pretoria: Stats SA, 2017. https://www.statssa.gov.za/publications/Report%2003-00-09/Report%2003-00-092016.pdf (accessed 20 July 2020).
8. Western Cape Department of Health in collaboration with the National Institute for Communicable Diseases, South Africa. Risk factors for COVID-19 death in a population cohort study from the Western Cape Province, South Africa. Clin Infect Dis 2021;73(7):e2002-e2015. https://doi.org/10.1093/cid/ciaa1198
9. Bertagnolio S, Thwin SS, Silva R, et al. Clinical features of, and risk factors for, severe or fatal COVID-19 among people living with HIV admitted to hospital: Analysis of data from the WHO Global Clinical Platform of COVID-19. Lancet HIV 2022;9(7):e486-e495. https://doi.org/10.1016/S2352-3018(22)00097-2
10. Hadi YB, Naqvi SFZ, Kupec JT, Sarwari AR. Characteristics and outcomes of COVID-19 in patients with HIV: A multicentre research network study. AIDS 2020;34(13):F3-F8. https://doi.org/10.1097/QAD.0000000000002666
11. Trickey A, Zhang L, Sabin CA, Sterne JAC. Life expectancy of people with HIV on long-term antiretroviral therapy in Europe and North America: A cohort study. Lancet Healthy Longev 2022;3:S2. https://doi.org/10.1016/s2666-7568(22)00063-0
12. Roomaney RA, van Wyk B, Pillay-van Wyk V. Aging with HIV: Increased risk of HIV comorbidities in older adults. Int J Environ Res Public Health 2022;19(4):2359. https://doi.org/10.3390/ijerph19042359
13. Mash RJ, Presence-Vollenhoven M, Adeniji A, et al. Evaluation of patient characteristics, management and outcomes for COVID-19 at district hospitals in the Western Cape, South Africa: Descriptive observational study. BMJ Open 2021;11(1):e047016. https://doi.org/10.1136/bmjopen-2020-047016
14. Morgan OW, Bramley A, Fowlkes A, et al. Morbid obesity as a risk factor for hospitalisation and death due to 2009 pandemic influenza A(H1N1) disease. PLoS ONE 2010;5(3):e9694. https://doi.org/10.1371/journal.pone.0009694
15. Badawi A, Ryoo SG. Prevalence of comorbidities in the Middle East respiratory syndrome coronavirus (MERS-CoV): A systematic review and meta-analysis. Int J Infect Dis 2016;49:129-133. https://doi.org/10.1016/j.ijid.2016.06.015
16. Zulkipli MS, Dahlui M, Jamil N, et al. The association between obesity and dengue severity among pediatric patients: A systematic review and meta-analysis. PLoS Negl Trop Dis 2018;12(2):e0006263. https://doi.org/10.1371/journal.pntd.0006263
17. Tan VPK, Ngim CF, Lee EZ, et al. The association between obesity and dengue virus (DENV) infection in hospitalised patients. PLoS ONE 2018;13(7):e0200698. https://doi.org/10.1371/journal.pone.0200698
18. Saccon TD, Mousovich-Neto F, Ludwig RG, et al. SARS-CoV-2 infects adipose tissue in a fat depot- and viral lineage-dependent manner. Nat Commun 2022;13(1):5722. https://doi.org/10.1038/s41467-022-33218-8
19. Martínez-Colón GJ, Ratnasiri K, Chen H, et al. SARS-CoV-2 infection drives an inflammatory response in human adipose tissue through infection of adipocytes and macrophages. Sci Transl Med 2022;14(674):eabm9151. https://doi.org/10.1126/scitranslmed.abm9151
20. Wolff JL, Starfield B, Anderson G. Prevalence, expenditures, and complications of multiple chronic conditions in the elderly. Arch Intern Med 2002;162(20):2269-2276. https://doi.org/10.1001/archinte.162.20.2269
21. De Francesco D, Sabin CA, Reiss P. Multimorbidity patterns in people with HIV. Curr Opin HIV AIDS 2020;15(2):110-117. https://doi.org/10.1097/COH.0000000000000595
22. Kim DJ, Westfall AO, Chamot E, et al. Multimorbidity patterns in HIV-infected patients: The role of obesity in chronic disease clustering. J Acquir Immune Defic Syndr 2012;61(5):600-605. https://doi.org/10.1097/QAI.0b013e31827303d5
23. Kumar S, Samaras K. The impact of weight gain during HIV treatment on risk of pre-diabetes, diabetes mellitus, cardiovascular disease, and mortality. Front Endocrinol (Lausanne) 2018;9:705. https://doi.org/10.3389/fendo.2018.00705
24. Alexopoulos A-S, Fayfman M, Zhao L, et al. Impact of obesity on hospital complications and mortality in hospitalized patients with hyperglycemia and diabetes. BMJ Open Diab Res Care 2016;4)1):e000200. https://doi.org/10.1136/bmjdrc-2016-000200

Submitted 6 January 2023. Accepted 11 July 2023. Published 22 August 2023.