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The intersection of age, sex, race and socio-economic status in COVID-19 hospital admissions and deaths in South Africa

Older age, male sex, and non-white race have been reported to be risk factors for COVID-19 mortality. Few studies have explored how these intersecting factors contribute to COVID-19 outcomes. This study aimed to compare demographic characteristics and trends in SARS-CoV-2 admissions and the health care they received. Hospital admission data were collected through DATCOV, an active national COVID-19 surveillance programme. Descriptive analysis was used to compare admissions and deaths by age, sex, race, and health sector as a proxy for socio-economic status. COVID-19 mortality and healthcare utilisation were compared by race using random effect multivariable logistic regression models. On multivariable analysis, black African patients (adjusted OR [aOR] 1.3, 95% confidence interval [CI] 1.2, 1.3), coloured patients (aOR 1.2, 95% CI 1.1, 1.3), and patients of Indian descent (aOR 1.2, 95% CI 1.2, 1.3) had increased risk of in-hospital COVID-19 mortality compared to white patients; and admission in the public health sector (aOR 1.5, 95% CI 1.5, 1.6) was associated with increased risk of mortality compared to those in the private sector. There were higher percentages of COVID-19 hospitalised individuals treated in ICU, ventilated, and treated with supplemental oxygen in the private compared to the public sector. There were increased odds of non-white patients being treated in ICU or ventilated in the private sector, but decreased odds of black African patients being treated in ICU (aOR 0.5; 95% CI 0.4, 0.5) or ventilated (aOR 0.5; 95% CI 0.4, 0.6) compared to white patients in the public sector. These findings demonstrate the importance of collecting and analysing data on race and socio-economic status to ensure that disease control measures address the most vulnerable populations affected by COVID-19.

Significance:

- These findings demonstrate the importance of collecting data on socio-economic status and race alongside age and sex, to identify the populations most vulnerable to COVID-19.
- This study allows a better understanding of the pre-existing inequalities that predispose some groups to poor disease outcomes and yet more limited access to health interventions.
- Interventions adapted for the most vulnerable populations are likely to be more effective.
- The national government must provide efficient and inclusive non-discriminatory health services, and urgently improve access to ICU, ventilation and oxygen in the public sector.
- Transformation of the healthcare system is long overdue, including narrowing the gap in resources between the private and public sectors.

Introduction

South Africa has experienced a high burden of COVID-19 and recorded over 3.6 million laboratory confirmed cases and 96 993 deaths as of 13 February 2022.[1] The official reported COVID-19 cases and deaths are an underestimate as indicated by sero-surveys and alternative methods for analysing COVID-19 attributable deaths. A population-based sero-survey undertaken in Gauteng prior to the onset of the fourth COVID-19 wave that was dominated by the Omicron variant, reported that 68% of people not vaccinated against COVID-19 were sero-positive[2], which implies that 10.5 million infections had taken place by then, compared with only 2.9 million cases being officially recorded as of 25 November 2021[3]. Furthermore, the South Africa Medical Research Council estimated 298 879 excess deaths between 3 May 2020 and 13 February 2022 attributable to COVID-19[4], which is three-fold higher than the 96 993 recorded deaths since the start of the pandemic through to 13 February 2022.

The risks for severe COVID-19 disease are disproportionately born among different communities. Older age, male sex, minority race groups, and lower socio-economic status (SES) have been shown to be associated with severe COVID-19 disease and death.[5-7] People from vulnerable racial and ethnic groups in many regions have been reported to be disproportionately affected by COVID-19, and have experienced increased risk of infection, hospitalisation and death.[8-10] This risk has also been reported in South Africa from a study of a large cohort of hospitalised patients, which demonstrated that non-white race was associated with increased risk of COVID-19 mortality.[11]

Race and SES are an important predictor of inequality in South Africa. South Africa is an upper-middle-income country with the distinction of having the highest level of income inequality in the world.[12] Black Africans, the unemployed, the less educated and female-headed households are most affected by poverty.[12,13] Racial classification was introduced by the apartheid regime and remains entrenched in South African society, with four defined race groups. In 2011, South Africans classified themselves in the census, resulting in 2020 mid-

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year population estimates of 80.8% being black African, 8.8% as coloured, 2.6% as Indian descent and 7.8% as white ancestry.[14]

Race and SES have an impact on health burden globally and in South Africa. Racial/ethnic and SES disparities in health have been linked to higher risk of infectious diseases and poorer disease outcomes[15], as well as reduced life expectancy and mortality[16]. South Africa has a significant burden of disease related to communicable and non-communicable disease, trauma, and injuries, with a disproportionate share borne by poor black Africans.[17]

An understanding of the relationship between race and other demographic characteristics with COVID-19 hospitalisation and mortality is important to effectively address the burden of disease among the most affected populations and to inform public health policy. In this study, we aimed to describe the trends and characteristics of SARS-CoV-2 admissions and the health care they received, and compare demographic characteristics of age, sex and race, as well as SES.

Methods

Study design, setting and data source

This study was a cross-sectional analysis using data collected from DATCOV, a national active surveillance system for COVID-19 hospital admissions in South Africa, between 5 March 2020 and 8 January 2022. DATCOV contains data on all individuals who had a positive real-time reverse transcription polymerase chain reaction (rRT-PCR) assay for SARS-CoV-2 or a positive SARS-CoV-2 antigen test, with a confirmed duration of stay in hospital of one full day or longer, regardless of reason for admission. The case reporting form, adapted from the World Health Organization's COVID-19 case reporting tool, contains basic demographic data (age, sex, and race which was self-defined by the patient as black African, white, coloured, Indian ancestry or other race group); exposures such as occupation; potential risk factors such as obesity, comorbid diseases and pregnancy status; treatment and outcomes. Race information was missing in 156 061/439 448 (35.5%) of patients. The Human Research Ethics Committee (Medical) at the University of the Witwatersrand (Johannesburg, South Africa) approved the project protocol as part of a national surveillance programme (M160667).

Data analysis

The wave periods were defined from the week South Africa crossed a weekly incidence risk of 30 cases per 100 000 persons at the start and end of the waves.[18]

- Pre-wave 1: week 10 (2020) – week 23 (2020) [5 March – 6 June 2020]
- Wave 1: week 24 (2020) – week 34 (2020) [7 June – 22 August 2020]
- Post-wave 1: week 35 (2020) – week 46 (2020) [23 August – 14 November 2020]
- Wave 2: week 47 (2020) – week 5 (2021) [15 November 2020 – 6 February 2021]
- Post-wave 2: week 6 (2021) – week 18 (2021) [7 February – 8 May 2021]
- Wave 3: week 19 (2021) – week 37 (2021) [9 May – 18 September 2021]
- Post-wave 3: week 38 (2021) – week 46 (2021) [19 September – 20 November 2021]
- Wave 4: week 47 (2021) – week 3 (2022) [21 November 2021 – 22 January 2022]

In addition, periods were combined to create four distinct wave periods that corresponded to the periods during which SARS-CoV-2 variants circulated: D614G in the first wave, Beta in the second wave, Delta in the third wave and Omicron in the fourth wave.

COVID-19 in-hospital mortality was defined as a death related to COVID-19 that occurred during the hospital stay and excluded deaths that occurred because of other causes or after discharge from hospital. Case-fatality risk was calculated among individuals with in-hospital outcome, i.e. COVID-19 deaths divided by COVID-19 deaths plus COVID-19 discharges, excluding individuals who were still admitted in hospital at the time of analysis. For the calculation of cumulative incidence, Stats SA mid-year population estimates for 2020 were utilised.[14]

Categorical variables were presented as frequencies and percentages, while continuous variables such as age were expressed as median and interquartile range (IQR). Chi-square and Kruskal–Wallis tests were used to compare proportions and median difference where appropriate.

Multivariable logistic regression analysis was performed to identify (1) the potential factors associated with COVID-19 in-hospital mortality and (2) the odds of being treated in ICU and ventilated, by race. Age, sex, race, presence of a comorbidity (hypertension, diabetes, chronic cardiac disease, chronic pulmonary disease and asthma, chronic renal disease, malignancy in the past 5 years, obesity, HIV, and past and current tuberculosis), health sector, province and wave period were considered as potential risk factors for COVID-19 in-hospital mortality. Socio-economic variables were not collected. Health sector of admission was used as a proxy for SES, with people admitted in public sector hospitals considered to be from lower SES and people admitted in private sector hospitals assumed to be from higher SES. There is strong alignment of individuals with higher SES being employed and able to afford medical insurance and seek private hospital care, while those of lower SES who are unable to afford private medical insurance are not able to access private hospital care. We assessed all variables that were significant with a *p*-value of less than 0.2 in the univariate analysis and excluded non-significant

factors ($p \geq 0.05$) with manual backward elimination. Statistical analyses were performed using STATA software version 16 (Stata Corp®, College Station, Texas, USA).

Results

Between 5 March 2020 and 8 January 2022, 386 171 admissions and 91 180 deaths were reported from 646 hospitals in South Africa.

Admission trends

The median age of hospitalised COVID-19 cases was 53 (38–65) years, which was similar among black African patients, coloured patients and patients of Indian descent, but higher among white patients (median age: 61 [IQR 50–73] years; $p < 0.001$) (Table 1). Most COVID-19 hospitalised patients were in the 40–59-year age group ($n = 160\ 172$, 36.5%), whilst only 5.9% ($n = 25\ 999$) were in the <20-year age group ($p < 0.001$). COVID-19 admissions were highest amongst the 40–59-year age group in patients of Indian descent (44.2%), coloured patients (39.6%), and black African patients (35.7%), while the highest percentage of admissions among white patients was in the 60–79-year (40.9%) age group. Overall, there were more admissions among female patients (55.4%) than male patients ($p < 0.001$); however, the trend was reversed with more admissions amongst male patients in those of Indian descent (55.4%) and white ancestry (54.2%). Among 282 496 patients with known race, the cumulative number of COVID-19 hospitalisations was 215 539 (76.3%) among black African patients, 32 672 (11.6%) in white patients, 19 784 (7.0%) among coloured patients and 14 501 (5.1%) in patients of Indian descent.

The number (and percentage) of admissions with no reported comorbidities was 6235 (43.0%) among those of Indian descent and 13 112 (40.1%) of white ancestry, compared with 4 663 (23.6%) among coloured and 60 317 (28.0%) among black African patients. Hypertension (115 032; 26.4%) and diabetes (74 544; 17.1%) were the most prevalent comorbidities amongst all race groups, but comorbidities with high prevalence in black patients were HIV (19 939; 9.3%) and current TB (1176; 1.1%); in white patients were malignancy (383; 1.2%) and obesity (2532; 8.1%); and in patients of Indian descent was chronic cardiac disease (676; 4.7%).

The highest number of COVID-19 hospitalisations was reported during the third wave dominated by the Delta variant (147 582), followed by the second wave which was dominated by the Beta variant (105 985), the first wave which was due to the wild-type virus (71 410) and, finally, the fourth wave (42 746) which was dominated by the Omicron variant.

The highest percentage of total admissions among black African patients was in the first (61 389/106 326; 57.7%) and fourth waves (22 904/42 746; 53.6%); among white patients in the third wave (17 509/157 205; 11.1%), among coloured patients in the third wave (7716/157 205; 4.9%) and among those of Indian descent in the second wave (5033/132 899; 3.8%). In the fourth wave, coloured patients, white patients and those of Indian descent accounted for a lower percentage of total admissions than for the prior three waves ($p < 0.001$), whereas black African patients accounted for a higher percentage of total admissions in the fourth wave compared to the second and third waves ($p < 0.001$).

The percentage of total admissions per wave decreased from the first to third wave among black African individuals and increased from the third to fourth wave (Figure 1). The percentage of total admissions per wave increased from the first to third wave among coloured people, people of Indian descent and white people, and then decreased from the third to fourth wave. The percentage of total admissions in which race was unknown increased with each wave.

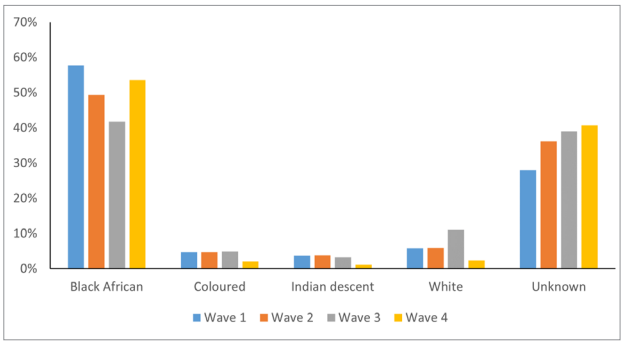

Figure 1: Percentage of COVID-19 admissions, by race group and wave period, in South Africa from 5 March 2020 to 8 January 2022.

Incidence of COVID-19 admissions and deaths

The incidence of COVID-19 admissions (per 100 000 persons) increased with age. While the overall incidence was higher in female (526.8) than male (417.0) individuals, it was higher in female individuals <60 years and in male individuals ≥60 years (Table 2). The incidence of admissions was highest among people of Indian descent (940.4) and was 446.9 in black African people, 376.5 in coloured people and 697.7 in white people. The incidence of admissions was higher in female than male individuals among black African and coloured people, and higher in male individuals among those of Indian descent and white ancestry.

The incidence risk of in-hospital COVID-19 deaths (per 100 000 persons) increased with age (Table 3). While overall incidence was higher in female (115.6) than male patients (104.3), it was higher in female patients <40 years and in male patients ≥40 years. Incidence of deaths was highest among patients of Indian descent (218.0), followed by white patients (157.2), black African patients (104.3), and coloured patients (89.0). Overall, in the 20–79-year age group, incidence of COVID-19 deaths was highest in those of Indian descent, whilst being highest among black African patients in the <20-year and ≥80-year age groups.

Factors associated with mortality

On multivariable analysis, black African (adjusted odds ratio [aOR] 1.3, 95% confidence interval [CI] 1.2, 1.3), coloured (aOR 1.2, 95% CI 1.1, 1.3), Indian descent (aOR 1.2, 95% CI 1.2, 1.3) and patients of other races (aOR 1.4, 95% CI 1.4, 1.5) had increased risk of in-hospital COVID-19 mortality compared to white patients. Furthermore, admission in the public health sector (aOR 1.5, 95% CI 1.5, 1.6) was associated with increased risk of mortality compared with admission to the private sector (Table 4). Other factors associated with in-hospital mortality were ages of 20–39 years (aOR 3.1, 95% CI 2.7, 3.6), 40–59 years aOR 8.6, 95% CI 7.4, 9.9), 60–79 years (aOR 19.4, 95% CI 16.8, 22.2) and ≥80 years (aOR 35.2, 95% CI 30.6, 40.6) compared to <20 years; male sex (aOR 1.3, 95% CI 1.3, 1.4); hypertension (aOR 1.1, 95% CI 1.0, 1.1), diabetes (aOR 1.4, 95% CI 1.3, 1.4), chronic cardiac disease (aOR 1.2, 95% CI 1.1, 1.3), chronic kidney disease (aOR 1.6, 95% CI 1.5, 1.7), malignancy (aOR 1.6, 95% CI 1.4, 1.9), HIV (aOR 1.3, 95% CI 1.2, 1.4), current TB (aOR 1.4, 95% CI 1.2, 1.6), and current and past TB (aOR 1.4, 95% CI 1.2, 1.6) compared to no history of or current TB. Also, being hospitalised in the Eastern Cape (aOR 1.9, 95% CI 1.8, 2.0), Free State (aOR 1.3, 95% CI 1.3, 1.4), Gauteng (aOR 1.4, 95%CI 1.4, 1.5), KwaZulu-Natal (aOR 1.5, 95% CI 1.4, 1.6), Limpopo (aOR 1.7, 95% CI 1.6, 1.9), Mpumalanga (aOR 1.4, 95% CI 1.3, 1.5), North West (aOR 1.2, 95% CI 1.0, 1.2) and Northern Cape (aOR 1.4, 95% CI 1.3, 1.6) was associated with higher in-hospital mortality compared with hospitalisation in the Western Cape. Individuals also had higher risk of mortality if admitted during the second wave (aOR 1.5, 95% CI 1.4, 1.5) or third wave (aOR 1.3, 95% CI 1.3, 1.4), but lower risk of mortality if admitted during the fourth wave (aOR 0.4, 95% CI 0.3, 0.4) compared with admission during the first wave. Factors associated with COVID-19 mortality amongst respective race groups are presented in Supplementary table 1.

Table 1: Characteristics of in-hospital COVID-19 patients by race group in South Africa, 5 March 2020 to 8 January 2021

Characteristics	Total *N*=439 448	Black African *n*=215 539 (49.1%)	Coloured *n*=19 784 (4.5%)	Indian descent *n*=14 501 (3.3%)	White *n*=32 672 (7.4%)	Other/unknown *n*=156 952 (35.7%)	*p*-value
Age (years), median [IQR]	53 [38–65]	50 [35–63]	53 [40–64]	54 [43–65]	61 [50–73]	54 [39–66]	<0.001
Age group							**<0.001**
<20 years	25 999 (5.9)	15 299 (7.1)	1198 (6.1)	317 (2.2)	681 (2.1)	8482 (5.4)	
20–39 years	94 425 (21.5)	54 668 (25.4)	3722(18.8)	2390 (16.5)	3175 (9.7)	30 470 (19.4)	
40–59 years	160 172 (36.5)	76 935 (35.7)	7850 (39.6)	6405 (44.2)	11 262 (34.5)	57 720 (36.8)	
60–79 years	129 006 (29.4)	57 821 (26.8)	6029 (30.5)	4685 (32.3)	13 370 (40.9)	47 101 (30.0)	
≥80 years	27 604 (6.3)	10 610 (4.9)	964 (4.9)	700 (4.8)	4173 (12.8)	11 157 (7.1)	
Unknown age	2264 (0.5)	206 (0.1)	21 (0.1)	4 (0.3)	11 (0)	2022 (1.3)	
Sex							**<0.001**
Female	243 648 (55.4)	128 761 (59.7)	10 552 (53.4)	6466 (44.6)	14 983 (45.8)	82 886 (52.8)	
Male	195 531 (44.5)	86 633 (40.2)	9226 (46.6)	8031 (55.4)	17 680 (54.2)	73 961 (47.1)	
Unknown	269 (0.1)	145 (0.1)	6 (0)	4 (0)	9 (0)	105 (0.1)	
Comorbid condition							**<0.001**
No	160 376 (36.5)	60 317 (28.0)	4663 (23.6)	6235 (43.0)	13 112 (40.1)	76 049 (48.5)	
Yes	172 707 (39.3)	87 084 (40.4)	7731 (39.1)	6117 (21.2)	14 904 (45.6)	56 871 (36.2)	
Unknown	106 365 (24.2)	68 138 (31.6)	7390 (37.4)	2149 (14.8)	4656 (14.3)	24 032 (15.3)	
Hypertension							**<0.001**
No	203 941 (46.8)	80 367 (37.4)	6532 (33.0)	7623 (52.7)	15 757 (48.2)	93 662 (60.9)	
Yes	115 032 (26.4)	56 738 (26.4)	5458 (27.6)	4332 (29.9)	11 820 (36.2)	36 684 (23.9)	
Unknown	116 702 (26.8)	77 876 (36.2)	7784 (39.4)	2519 (17.4)	5087 (15.6)	23 436 (15.2)	
Diabetes mellitus							**<0.001**
No	232 842 (53.4)	93 916 (43.7)	7970 (40.3)	8142 (56.2)	21 749 (66.6)	101 065 (65.7)	
Yes	74 544 (17.1)	35 899 (16.7)	3542 (17.9)	3669 (25.4)	4988 (15.3)	26 446 (17.2)	
Unknown	128 288 (29.5)	85 166 (39.6)	8262 (41.8)	2663 (18.4)	5926 (18.1)	26 271 (17.1)	
Chronic cardiac disease							**<0.001**
No	284 047 (64.6)	107 280 (49.8)	9946 (50.3)	10 509 (72.4)	24 439 (74.8)	131 873 (84.0)	
Yes	6977 (1.6)	3801 (1.8)	539 (2.7)	676 (4.7)	1390 (4.3)	571 (0.4)	
Unknown	148 424 (33.8)	104 458 (48.4)	9299 (7.0)	3316 (22.9)	6843 (20.9)	24 508 (15.6)	
Chronic pulmonary disease/asthma							**<0.001**
No	269 597 (63.1)	103 786 (50.0)	9527 (48.9)	10 336 (72.1)	23 851 (73.8)	122 097 (79.4)	
Yes	20 729 (4.8)	6848 (3.3)	980 (5.0)	710 (5.0)	1863 (5.8)	10 328 (6.7)	
Unknown	137 212 (32.1)	97 061 (46.7)	8989 (46.1)	3279 (22.9)	6598 (20.4)	21 285 (13.9)	
Chronic renal disease							**<0.001**
No	282 116 (64.8)	107 137 (49.8)	10 103 (51.1)	10 765 (74.3)	25 282 (77.4)	128 829 (83.8)	
Yes	7146 (1.6)	2701 (1.3)	300 (1.5)	221 (1.5)	335 (1.0)	3589 (2.3)	
Unknown	146 412 (33.6)	105 143 (48.9)	9371 (6.4)	3488 (24.1)	7046 (21.6)	21 364 (13.9)	

Table 1 continues...

...Table 1 continued

Characteristics	Total *N*=439 448	Black African *n*=215 539 (49.1%)	Coloured *n*=19 784 (4.5%)	Indian descent *n*=14 501 (3.3%)	White *n*=32 672 (7.4%)	Other/unknown *n*=156 952 (35.7%)	*p*-value
Malignancy							**<0.001**
No	286 804 (65.8)	108 315 (50.4)	10 239 (51.8)	10 926 (75.5)	25 168 (77.0)	132 156 (85.9)	
Yes	1821 (0.4)	1000 (0.5)	118 (0.6)	81 (0.6)	383 (1.2)	239 (0.2)	
Unknown	147 049 (33.8)	105 666 (49.2)	9417 (47.6)	3467 (23.9)	7112 (21.8)	21 387 (13.9)	
HIV							**<0.001**
No	269 640 (61.9)	96 747 (45.0)	9985 (50.5)	10 848 (74.9)	25 272 (77.4)	126 788 (82.4)	
Yes	26 273 (6.0)	19 939 (9.3)	485 (2.5)	68 (0.5)	103 (0.3)	5678 (3.7)	
Unknown	139 761 (32.1)	98 295 (45.7)	9304 (47.0)	3558 (24.6)	7288 (22.3)	21 316 (13.9)	
Tuberculosis							**<0.001**
No	270 557 (96.5)	99 373 (96.6)	9733 (97.2)	10 714 (99.6)	24 583 (99.7)	126 154 (95.5)	
Previous	5713 (2.0)	1546 (1.5)	118 (1.2)	24 (0.2)	29 (0.1)	3 996 (3.0)	
Current	1706 (0.6)	1176 (1.1)	92 (0.9)	13 (0.1)	36 (0.2)	389 (0.3)	
Current and past	2466 (0.9)	831 (0.8)	75 (0.8)	5 (0.1)	7 (0)	1548 (1.2)	
Obesity							**<0.001**
No	79 803 (18.8)	60 331 (28.3)	4455 (23.2)	3169 (22.7)	4515 (14.4)	7333 (5.0)	
Yes	15 589 (3.7)	11 061 (5.2)	1137 (5.9)	500 (3.6)	2532 (8.1)	359 (0.2)	
Unknown	328 711 (77.5)	141 544 (66.5)	13 595 (70.9)	10 286 (73.7)	24 417 (77.6)	138 869 (94.7)	
Wave period							**<0.001**
Pre-wave 1	9760 (2.2)	5631(2.6)	679 (3.4)	319 (2.2)	429 (1.3)	2702 (1.7)	
Wave 1	71 410 (19.3)	42 707 (19.8)	2686 (13.5)	3033 (20.9)	4234 (12.9)	18 750 (12.0)	
Post-wave 1	25 156 (5.7)	13 051 (6.1)	1596 (8.1)	612 (4.2)	1552 (4.7)	8345 (5.3)	
Wave 2	105 985 (24.1)	51 611 (23.9)	5056 (25.6)	4432 (30.6)	5806 (17.8)	39 080 (24.9)	
Post-wave 2	26 914 (6.1)	13 976 (6.5)	1136 (5.7)	601 (4.1)	2105 (6.4)	9096 (5.8)	
Wave 3	147 582 (33.6)	60 950 (28.3)	7139 (36.1)	4817 (33.2)	16 824 (51.5)	57 852 (36.9)	
Post-wave 3	9623 (2.2))	4688 (2.2)	577 (2.9)	216 (1.5)	685 (2.1)	3457 (2.2)	
Wave 4	42 746 (9.7)	22 904 (10.6)	913 (4.6)	466 (3.2)	1035 (3.2)	17 428 (11.1)	

Health services characteristics of cases of COVID-19 admissions

Overall, there were more admissions in the public sector (232 615; 52.9%) than in the private sector (206 833; 47.1%) (p<0.001; Table 5). Furthermore, people of Indian descent (10 880; 75.0%) ($p<0.001$) and white people (25 862; 79.2%) ($p<0.001$) were more likely to be hospitalised in the private sector than in the public sector. Compared to other race groups, a lower percentage of black African patients were treated in ICU (9.0%) ($p<0.001$), in high care (8.2%) ($p<0.001$) or were ventilated (5.1%) ($p<0.001$), whilst a higher percentage of white patients were treated with supplemental oxygen (61.6%) ($p<0.0001$).

Overall, there was a higher percentage of individuals treated in ICU in the private (45 792/206 833; 22.1%) compared to the public sector (12 550/232 615; 5.4%), across all age groups >20 years ($p<0.001$ for all); and across all race groups ($p<0.001$ for all) (Table 6). The percentage treated in ICU was highest among individuals aged 40–59 years in the public sector (4760; 6.4%) and among 60–79 years in the private sector (17 171; 29.3%). The lowest percentage of people treated in ICU were black African, in both the public (8435; 5.3%) and private sectors (10 982; 19.4%) ($p<0.001$ for both). The highest percentage treated in ICU in the public and private sectors were people of Indian descent (10.1% and 24.4%) and white people (8.8% and 23.3%).

There was a higher percentage of individuals ventilated in the private (19 800/206 833; 9.6%) compared to the public sector (7818/232 615; 3.4%) overall and across all age groups >20 years ($p<0.001$ for all). A higher percentage of individuals were ventilated in the private sector across all race groups ($p<0.001$ for all) except for those of Indian descent for whom a similar percentage were ventilated in public and private sectors (Table 6). In the public sector, the lowest percentage of patients ventilated were black African (6213; 3.9%) and the highest percentages were those of Indian descent (308; 8.5%) and white (477; 7.0%). In the private sector, the lowest percentage of patients ventilated were black African (4833; 8.5%) and those of Indian descent (924; 8.5%) and the highest percentage ventilated were coloured (956; 10.7%).

There was a higher percentage of individuals who received supplemental oxygen in the private (95 703/206 833; 46.3%) compared to the public sector (87 023/232 615; 37.4%), overall and across all age groups >20 years ($p<0.001$ for all) (Table 6). In the public sector, the lowest percentage of patients who received supplemental oxygen were black African (73 800; 46.4%) and the highest percentage who received supplemental oxygen were those of Indian descent (2096; 57.9%).

Table 2: Incidence risk of COVID-19 admissions (per 100 000 people) by age group, sex and race, South Africa, 5 March 2020 to 8 January 2022

Age category (years)	Male			Female			Total incidence risk
	Population mid-2020	Number of COVID-19 admissions	Incidence risk	Population mid-2020	Number of COVID-19 admissions	Incidence risk	
Black African							
<20	9 412 555	7029	74.7	9 224 565	8225	89.2	81.8
20–39	8 740 918	18 937	216.6	8 621 573	35 701	414.1	314.7
40–59	4 112 412	33 116	805.3	4 650 769	43 798	941.7	877.7
60–79	1 176 527	24 017	2041.3	1 937 390	33 763	1742.7	1855.5
≥80	77 062	3449	4475.6	199 956	7153	3577.3	3827.2
All ages	23 519 474	86 548	368.0	24 634 253	128 640	522.2	446.9
Coloured							
<20	921 642	594	64.5	897 967	604	67.3	65.8
20–39	837 744	1470	175.5	834 314	2250	269.7	222.5
40–59	570 179	3968	695.9	626 288	3880	619.5	655.9
60–79	212 647	2797	1315.3	299 946	3231	1077.2	1176.0
≥80	12 992	387	2978.8	34 021	576	1693.1	2048.4
All ages	2 555 204	9216	360.7	2 692 536	10 541	391.5	376.5
Indian descent							
<20	195 653	172	87.9	186 972	144	77.0	82.6
20–39	286 733	1209	421.6	235 644	1180	500.8	457.3
40–59	213 573	3754	1757.7	201 617	2650	1314.4	1542.4
60–79	85 051	2574	3026.4	112 737	2110	1871.6	2368.2
≥80	6652	319	4795.6	16 481	381	2311.8	3026.0
All ages	787 662	8 028	1019.2	753 451	6465	858.1	940.4
White							
<20	499 395	339	67.9	486 785	341	70.1	69.0
20–39	563 398	1404	249.2	563 840	1770	313.9	281.6
40–59	637 149	6521	1023.5	674 175	4737	702.6	858.5
60–79	477 067	7534	1579.2	547 852	5835	1065.1	1304.4
≥80	89 526	1876	2095.5	140 583	2296	1633.2	1813.1
All ages	2 266 535	17 674	779.8	2 413 235	14 979	620.7	697.7
All race groups							
<20	11 029 245	8134	73.7	10 796 289	9314	86.3	79.9
20–39	10 428 793	23 020	220.7	10 255 371	40 901	398.8	309.0
40–59	5 533 313	47 359	855.9	6 152 849	55 065	895.0	876.5
60–79	1 951 289	36 922	1892.2	2 897 925	44 939	1550.7	1688.1
≥80	186 232	6031	3238.4	391 041	10 406	2661.1	2847.4
All ages	29 128 872	121 466	417.0	30 493 475	160 625	526.8	473.1

Table 3: Incidence of COVID-19 deaths (per 100 000 people) by age group, sex and race, South Africa, 5 March 2020 to 8 January 2022

Age category (years)	Male			Female			Total incidence risk
	Population mid-2020	Number of COVID-19 deaths	Incidence risk	Population mid-2020	Number of COVID-19 deaths	Incidence risk	
Black African							
<20	9 412 555	287	3.0	9 224 565	306	3.3	3.2
20–39	8 740 918	1 910	21.9	8 621 573	2 520	29.2	25.5
40–59	4 112 412	7 372	179.3	4 650 769	9 024	194.0	187.1
60–79	1 176 527	10 251	871.3	1 937 390	13 305	686.7	756.5
≥80	77 062	1 788	2320.2	199 956	3 485	1742.9	1903.5
All ages	23 519 474	21 608	91.9	24 634 253	28 640	116.3	104.3
Coloured							
<20	921 642	12	1.3	897 967	8	0.9	1.1
20–39	837 744	142	17.0	834 314	165	19.8	18.4
40–59	570 179	861	151.0	626 288	717	114.5	131.9
60–79	212 647	1 090	512.6	299 946	1 173	391.1	441.5
≥80	12 992	199	1531.7	34 021	301	884.7	1063.5
All ages	2 555 204	2 304	90.2	2 692 536	2 364	87.8	89.0
Indian descent							
<20	195 653	3	1.5	186 972	4	2.1	1.8
20–39	286 733	123	42.9	235 644	95	40.3	41.7
40–59	213 573	747	349.8	201 617	452	224.2	288.8
60–79	85 051	965	1134.6	112 737	659	584.5	821.1
≥80	6 652	154	2315.1	16 481	158	958.7	1348.7
All ages	787 662	1 992	252.9	753 451	1 368	181.6	218.0
White							
<20	499 395	6	1.2	486 785	8	1.6	1.4
20–39	563 398	116	20.6	563 840	82	14.5	17.6
40–59	637 149	1 070	167.9	674 175	634	94.0	129.9
60–79	477 067	2 431	509.6	547 852	1 407	256.8	374.5
≥80	89 526	851	950.6	140 583	752	534.9	696.6
All ages	2 266 535	4 474	197.4	2 413 235	2 883	119.5	157.2
All race groups							
<20	11 029 245	308	2.8	10 796 289	326	3.0	2.9
20–39	10 428 793	2 291	22.0	10 255 371	2 862	27.9	24.9
40–59	5 533 313	10 050	181.6	6 152 849	10 827	176.0	178.6
60–79	1 951 289	14 737	755.2	2 897 925	16 544	570.9	645.1
≥80	186 232	2 992	1606.6	391 041	4 696	1200.9	1331.8
All ages	291 28 872	30 378	104.3	30 493 475	35 255	115.6	110.1

Table 4: Multivariable analysis of factors associated with in-hospital COVID-19 mortality, South Africa, 5 March 2020 to 8 January 2022 (N=423 385)

Characteristics	Case fatality risk *n/N* (%)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	*p*-value
Age group				
<20 years	759/24 553 (3.0)	Ref	Ref	
20–39 years	7054/90 387 (7.8)	2.7 (2.5, 2.9)	3.1 (2.7, 3.6)	**<0.001**
40–59 years	31 062/155 421 (20.0)	7.8 (7.3, 8.4)	8.6 (7.4, 9.9)	**<0.001**
60–79 years	46 480/124 392 (37.4)	18.7 (17.4, 20.1)	19.4 (16.8, 22.2)	**<0.001**
≥80 years	12 374/26 429 (46.8)	27.6 (25.6, 29.8)	35.2 (30.6, 40.6)	**<0.001**
Sex				
Female	50 416/234 947 (21.5)	Ref	Ref	
Male	47 459/188 204 (25.2)	1.2 (1.2, 1.3)	1.3 (1.3, 1.4)	**<0.001**
Race				
White	7358/31 892 (23.0)	Ref	Ref	
Black African	50 297/204 651 (24.6)	1.1 (1.0, 1.1)	1.3 (1.2, 1.3)	**<0.001**
Coloured	4671/19 059 (24.5)	1.0 (1.0, 1.1)	1.2 (1.1, 1.3)	**<0.001**
Indian descent	3360/14 132 (23.8)	1.0 (0.9, 1.1)	1.2 (1.2, 1.3)	**<0.001**
Other/unknown	32 225/153 651 (21.0)	0.8 (0.8, 0.9)	1.4 (1.4, 1.5)	**<0.001**
Hypertension				
No	36 722/199 049 (18.5)	Ref	Ref	
Yes	36 108/111 397 (32.6)	2.1 (2.1, 2.2)	1.1 (1.0, 1.1)	**<0.001**
Diabetes				
No	44 204/226 963 (19.5)	Ref	Ref	
Yes	24 832/72 624 (34.2)	2.1 (2.1, 2.2)	1.4 (1.3, 1.4)	**<0.001**
Chronic cardiac disease				
No	60 704/277 540 (21.9)	Ref	Ref	
Yes	2495/6663 (37.5)	2.1 (2.0, 2.2)	1.2 (1.1, 1.3)	**<0.001**
Chronic kidney disease				
No	59 580/275 564 (21.6)	Ref	Ref	
Yes	3145/6965 (45.2)	3.0 (2.8, 3.1)	1.6 (1.5, 1.7)	**<0.001**
Malignancy				
No	61 683/280 193 (22.0)	Ref	Ref	
Yes	656/1730 (37.9)	2.2 (2.0, 2.4)	1.6 (1.4, 1.9)	**<0.001**
Tuberculosis				
No	57 792/264 568 (21.8)	Ref	Ref	
Previous	1346/5521 (24.4)	1.2 (1.1, 1.2)	1.1 (0.9, 1.2)	0.089
Current	397/1596 (24.9)	1.2 (1.1, 1.3)	1.4 (1.2, 1.6)	**<0.001**
Current and previous	538/2372 (22.7)	1.0 (0.9, 1.2)	1.4 (1.2, 1.6)	**<0.001**
HIV				
No	57 621/263 688 (21.9)	Ref	Ref	
Yes	6052/24 799 (24.4)	1.2 (1.1, 1.2)	1.3 (1.2, 1.4)	**<0.001**
Sector				
Private	38 335/202 930 (18.9)	Ref	Ref	
Public	59 576/220 455 (27.0)	1.6 (1.5, 1.6)	1.5 (1.5, 1.6)	**<0.001**

Table 4 continues...

...Table 4 continued

Characteristics	Case fatality risk *n/N* (%)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	*p*-value
Province				
Western Cape	17 712/83 116 (21.3)	Ref	Ref	
Eastern Cape	12 653/41 176 (30.7)	1.6 (1.6, 1.7)	1.9 (1.8, 2.0)	**<0.001**
Free State	5810/25 621 (22.7)	1.1 (1.0, 1.1)	1.3 (1.3, 1.4)	**<0.001**
Gauteng	28 721/129 722 (22.1)	1.0 (1.0, 1.1)	1.4 (1.4, 1.5)	**<0.001**
KwaZulu-Natal	16 325/70 737 (23.1)	1.1 (1.0, 1.1)	1.5 (1.4, 1.6)	**<0.001**
Limpopo	5079/17 553 (28.9)	1.5 (1.4, 1.6)	1.7 (1.6, 1.9)	**<0.001**
Mpumalanga	4656/18 537 (25.1)	1.2 (1.2, 1.3)	1.4 (1.3, 1.5)	**<0.001**
North West	4614/27 254 (16.9)	0.7 (0.7, 0.8)	1.2 (1.0, 1.2)	**<0.001**
Northern Cape	2341/9669 (24.2)	1.2 (1.1, 1.2)	1.4 (1.3, 1.6)	**<0.001**
Wave period				
Wave 1	15 163/70 409 (21.5)	Ref	Ref	
Wave 2	11 593/41 039 (28.3)	1.4 (1.4-1.5)	1.5 (1.4-1.5)	**<0.001**
Wave 3	55 067/209 451 (26.3)	1.3 (1.2-1.3)	1.3 (1.3-1.4)	**<0.001**
Wave 4	3356/34 621 (9.7)	0.4 (0.3-0.4	0.4 (0.3-0.4)	**<0.001**

OR, odds ratio; 95% CI, 95% confidence interval

Table 5: Description of settings of care for in-hospital COVID-19 patients by race, South Africa, 5 March 2020 to 8 January 2022

Characteristic	Total *N*=439 448	Black African *n*=215 539 (49.1%)	Coloured *n*=19 784 (4.5%)	Indian descent *n*=14 501 (3.3%)	White *n*=32 672 (7.4%)	Others/unknown *n*=156 952 (35.7%)	*p*-value
Health sector							**<0.001**
Private sector	206 833 (47.1)	56 495 (26.2)	8972 (45.4)	10 880 (75.0)	25 862 (79.2)	104 624 (66.7)	
Public sector	232 615 (52.9)	159 044 (73.8)	10 812 (54.6)	3621 (25.0)	6810 (20.8)	52 328 (33.3)	
Treated in ICU							**<0.001**
No	381 106 (86.7)	196 122 (91.0)	16 952 (85.7)	11 482 (79.2)	26 033 (79.7)	130 517 (83.2)	
Yes	58 342 (13.3)	19 417 (9.0)	2832 (14.3)	3019 (20.8)	6639 (20.3)	26 435 (16.8)	
Treated in High Care							**<0.001**
No	402 267 (91.5)	197 849 (91.8)	17 152 (86.7)	12 133 (83.7)	28 601 (87.5)	146 532 (93.4)	
Yes	37 181 (8.5)	17 690 (8.2)	2632 (13.3)	2368 (16.3)	4071 (12.5)	10 420 (6.6)	
Received ventilation							**<0.001**
No	411 830 (93.7)	204 493 (94.9)	18 239 (92.2)	13 269 (91.5)	29 932 (91.6)	145 897 (93.0)	
Yes	27 618 (6.3)	11 046 (5.1)	1545 (7.8)	1232 (8.5)	2740 (8.4)	11 055 (7.0)	
Received oxygen							**<0.001**
No	256 722 (58.4)	117 081 (54.3)	9 807 (49.6)	6 872 (47.4)	12 531 (38.4)	110 431 (70.4)	
Yes	182 726 (41.6)	98 458 (45.7)	9 977 (50.4)	7 629 (52.6)	20 141 (61.6)	46 521 (29.6)	

In the private sector, the lowest percentage of patients who received supplemental oxygen were black African (24 658; 43.6%) and the highest percentage who received supplemental oxygen were white (16 374; 63.3%).

Of all the COVID-19 patients who died in hospital, 68 775/97 911 (70.2%) were not treated in ICU, which differed by sector: 39.9% in the private sector and 89.7% in the public sector were not treated in ICU (Table 7). There was also a difference by race group, with black African (3238; 38.0%) and white (2386; 44.8%) decedents having the highest percentage of non-ICU treatment in the private sector; and black African (37 530; 89.9%) highest in the public sector.

On multivariate analysis, adjusting for age, sex, individual comorbidities and province, in the private sector, there were increased odds of being treated in ICU for black African (aOR 1.1; 95% CI 1.0, 1.1) and coloured (aOR 1.3; 95% CI 1.2, 1.4) patients and patients of Indian descent (aOR 1.3; 95% CI 1.2, 1.4) compared to white patients. In contrast, in the public sector, there were decreased odds of being treated in ICU for black African patients (aOR 0.5; 95% CI 0.4, 0.5) compared to white patients (Table 8). Similar trends were observed for ventilation of patients (Table 9).

Table 6: Description of settings of care for in-hospital COVID-19 patients by health sector, age and race group, South Africa, 5 March 2020 to 8 January 2022 (*N*=439 448)

Characteristic	Total	Public	Private	*p*-value
Treated in ICU				
<20 years	1432/25 977 (5.5%)	834/15 637 (5.3%)	598/10 340 (5.8%)	0.120
20-39 years	6945/94 425 (7.4%)	2600/57 461 (4.5%)	4345/36 964 (11.7)	<0.001
40-59 years	25 345/160 172 (15.8%)	4760/74 004 (6.4%)	20 585/86 168 (23.9%)	<0.001
60-79 years	21 005/129 006 (16.3)	3834/70 364 (5.4%)	17 171/58 642 (29.3%)	<0.001
≥80 years	3356/27 604 (12.2%)	478/13 593 (3.5%)	2878/14 011 (20.5%)	<0.001
Unknown age	259/2264 (11.4%)	44/1 556 (2.8%)	215/708 (30.4%)	<0.001
Treated in ICU				
Black African	19 417/215 539 (9.0%)	8435/159 044 (5.3%)	10 982/56 495 (19.4%)	<0.001
Coloured	2832/19 784 (14.3%)	772/10 812 (7.1%)	2060/8972 (23.0%)	<0.001
Indian descent	3019/14 501 (20.8%)	367/3 621 (10.1%)	2652/10 880 (24.4%)	<0.001
White	6639/32 672 (20.3%)	600/6 810 (8.8%)	6039/25 862 (23.3%)	<0.001
Unknown	26 435/156 952 (16.8%)	2378/52 328 (4.5%)	24 059/104 624 (23.0%)	<0.001
Received ventilation				
<20 years	543/25 977 (2.1%)	387/15 637 (2.5%)	156/10 340 (1.5%)	<0.001
20–39 years	2966/94 425 (3.1%)	1392/57 461 (2.4%)	1574/36 964 (4.3%)	<0.001
40–59 years	12 275/160 172 (7.7%)	2931/74 004 (4.0%)	9344/86 168 (10.8%)	<0.001
60–79 years	10 564/129 006 (8.2%)	2745/70 364 (3.9%)	7819/58 642 (13.3%)	<0.001
≥80 years	1198/27 604 (4.3%)	358/13 593 (2.6%)	840/14 011 (6.0%)	<0.001
Unknown age	72/2 264 (3.2%)	5/1 556 (0.3%)	67/708 (9.5%)	<0.001
Received ventilation				
Black African	11 046/215 539 (5.1%)	6213/159 044 (3.9%)	4833/56 495 (8.5%)	<0.001
Coloured	1545/19 784 (7.8%)	589/10 812 (5.4%)	956/8972 (10.7%)	<0.001
Indian descent	1232/14 501 (8.5%)	308/ 621 (8.5%)	924/10 880 (8.5%)	<0.001
White	2740/32 672 (8.4%)	477/6810 (7.0%)	2263/25 862 (8.7%)	<0.001
Unknown	11 055/156 952 (7.0%)	231/52 328 (0.4%)	10 824/104 624 (10.3%)	<0.001
Received oxygen				
<20 years	4134/25 977 (15.9%)	2826/15 637 (18.1%)	1308/10 340 (12.6%)	<0.001
20–39 years	24 875/94 425 (26.3%)	14 060/57 461 (24.5%)	10 815/36 964 (29.3%)	<0.001
40–59 years	73 072/160 172 (45.6%)	29 859/74 004 (40.3%)	43 213/86 168 (50.1%)	<0.001
60–79 years	65 763/129 006 (51.0%)	33 379/70 364 (47.4%)	32 384/58 642 (55.2%)	<0.001
≥80 years	14 662/27 604 (53.1%)	6821/13 593 (50.2%)	7841/14 011 (56.0%)	<0.001
Unknown age	220/2264 (9.7%)	78/1556 (5.0%)	142/708 (20.1%)	<0.001
Received oxygen				
Black African	98 458/215 539 (45.7%)	73 800/159 044 (46.4%)	24 658/56 495 (43.6%)	<0.001
Coloured	9977/19 784 (50.4%)	5423/10 812 (50.2%)	4554/8972 (50.8%)	<0.001
Indian descent	7629/14 501 (52.6%)	2096/3621 (57.9%)	5533/10 880 (50.8%)	<0.001
White	20 141/32 672 (61.6%)	3767/6810 (55.3%)	16 374/25 862 (63.3%)	<0.001
Unknown	46 521/156 952 (29.6%)	1937/52 328 (3.7%)	44 584/104 624 (42.6%)	<0.001

Discussion

While the associations of age, sex and race with risk of COVID-19 mortality have been well established, our study reveals insights into the intersection of age, gender, race, and SES (using health sector of admission as a proxy) with COVID-19 mortality in South Africa. We propose that the COVID-19 mortality disparities revealed in this study were due to multiple intersecting risk factors affecting COVID-19 exposure, susceptibility to infection, and differences in access to care, as reported in other studies.[19,20] These risk factors have underlying structural and social determinants which the World Health Organization defines as 'the conditions in which people are born, grow, work, live, and age and people's access to power, money and resources'[21]. Attributing poor clinical outcomes in vulnerable race groups solely to genetics and biological differences has historically been responsible for marginalising their health needs.

Table 7: COVID-19 in-hospital deaths not treated in ICU by race group, South Africa, 5 March 2020 to 8 January 2022 (*N*=97 911)

Race	Private *n*/*N* (%)	Public *n*/*N* (%)	Total *n*/*N* (%)
Black African	3238/8532 (38.0%)	37 530/41 765 (89.9%)	40 768/50 297(81.1%)
Coloured	651/1748 (37.2%)	2576/2923 (88.1%)	3227/4671 (69.1%)
Indian descent	750/2202 (34.1%)	921/1158 (79.5%)	1671/3360 (49.7%)
White	2386/5323 (44.8%)	1731/2035 (85.1%)	4117/7358 (56.0%)
Other/unknown	8287/20 530 (40.4%)	10 705/11 695 (91.5%)	18 992/32 225 (59.0%)
Total	**15 312/38 335 (39.9%)**	**53 463/59 576 (89.7%)**	**68 775/97 911 (70.2%)**

Table 8: Factors associated with being treated in ICU, among (1) all patients, (2) private sector patients, and (3) public sector patients, South Africa, 5 March 2020 to 8 January 2022 (model adjusted for age, sex, individual comorbidities, and province)

Race	All patients		Private sector		Public sector	
	n (%) *N*=58 342	aOR (95% CI)	*n* (%) *N*=45 792	aOR (95% CI)	*n* (%) *N*=12 550	aOR (95% CI)
White	6639 (11.4%)	Ref	6039 (13.2%)	Ref	600 (4.8%)	Ref
Black African	19 417 (33.3%)	1.0 (1.0, 1.1)	10 982 (24.0%)	1.1 (1.0, 1.1)	8435 (67.2%)	0.5 (0.4, 0.5)
Coloured	2832 (4.8%)	1.4 (1.3, 1.6)	2060 (4.5%)	1.3 (1.2, 1.4)	772 (6.2%)	0.9 (0.7, 1.1)
Indian descent	3019 (5.2%)	1.3 (1.2, 1.4)	2657 (5.8%)	1.3 (1.2, 1.4)	367 (2.9%)	0.8 (0.6, 1.0)
Other/unknown	26 435 (45.3%)	1.3 (1.3, 1.4)	24 059 (52.5%)	1.4 (1.3, 1.4)	2376 (18.9%)	0.4 (0.3, 0.5)

aOR, adjusted odds ratio; 95% CI, 95% confidence interval

Table 9: Factors associated with receiving invasive mechanical ventilation, among (1) all patients, (2) private sector patients, and (3) public sector, South Africa, 5 March 2020 to 8 January 2022 (model adjusted for age, sex, individual comorbidities, and province)

Race	All patients		Private sector		Public sector	
	n (%) *N*=27 618	aOR (95%CI)	*n* (%) *N*=19 800	aOR (95%CI)	*n* (%) *N*=7818	aOR (95%CI)
White	2740 (10.0%)	Ref	2263 (11.4%)	Ref	477 (6.1%)	Ref
Black African	11 046 (40.0%)	1.4 (1.4, 1.5)	4833 (24.4%)	1.4 (1.3, 1.5)	6213 (79.5%)	0.5 (0.4, 0.6)
Coloured	1545 (5.6%)	2.1 (1.9, 2.3)	956 (4.8%)	1.6 (1.4, 1.8)	589 (7.5%)	1.1 (0.9, 1.4)
Indian descent	1232 (4.5%)	1.5 (1.3, 1.6)	924 (4.7%)	1.4 (1.2, 1.5)	308 (3.9%)	1.1 (0.8, 1.5)
Other/unknown	11 055 (40.0%)	1.8 (1.7, 1.9)	10 824 (54.7%)	1.9 (1.8, 2.0)	231 (3.0%)	0.7 (0.4, 1.0)

aOR, adjusted odds ratio; 95% CI, 95% confidence interval

Higher risk of mortality among non-white patients

The risk for in-hospital COVID-19 death was increased in individuals of non-white race. Systematic reviews have confirmed the higher risk of mortality among black, Asian and minority ethnicities (BAME) even after adjusting for confounders such as age, sex and comorbidities.[6,8,9] Even in low- and middle-income countries (LMIC), non-white people with COVID-19 who were admitted to hospital had significantly higher risk of mortality.[22] This disparity in COVID-19 deaths by race was present in our study among all age groups, and even among younger individuals who have low risk of COVID-19 mortality overall, non-white individuals exhibited higher mortality rates than white individuals, similar to another study[23].

There is currently little evidence that genetics, immunology or blood groups explain the racial and ethnic disparities in COVID-19 infection and severity.[23] Angiotensin-converting enzyme 2 (ACE2) appears elevated in African Americans[23] and Asians[24], which could place them at higher risk for COVID-19 severe disease.

Higher prevalence of comorbid disease may play a role in the increased severity of COVID-19 among non-white individuals.[25,26] BAME populations have a disproportionate burden of diabetes, cardiovascular disease, asthma, HIV, morbid obesity, liver disease, and kidney disease.[19,23,26-29] The risk of comorbidities results from generations of exposure to racial inequities, environmental hazards, and social factors such as food insecurity, which result in changes in the microbiome and localised inflammation, and contribute to the development of long-term stress, which results in compromised immunity, thus increasing the risk for comorbidities and perpetuating adverse health outcomes.[19,20,23,30]

We found a sex differential in mortality rates, with incidence of mortality higher in female individuals <40 years and in male individuals ≥40 years. Increased oestrogen in female individuals is associated with

improved immune function and reduced risk of viral infections compared to male individuals.[24] Severe COVID-19 disease in male individuals could be explained by androgen regulation of expression of both ACE2 and TMPRSS2, an endothelial cell surface protein that is involved in the viral entry and spread of SARS-CoV-2.[23,24]

In other studies, the overall male to female mortality sex ratio was not equal at all ages[31] and in one study was significantly higher among women, particularly in the 40–49-year age group[32]. The observed sex differences are complex, and intersectional analyses are required to understand risk factors that change with both sex and age, including differences in occupation, lifestyle (including smoking and alcohol use), comorbidities and health seeking behaviour, amongst others.[24,31,32] We need to consider the impact of gender and its social and cultural characteristics rather than only the biology of sex.

In our study, even within race groups, the risk for mortality differed by age and sex. Race-specific risk estimates are likely not fixed in men and women or by age group, requiring statistical analysis stratified by effect modifiers rather than adjusting for them in regression models.[33] The gendered disparities in COVID-19 is another important point of consideration given the multiple intersecting layers of oppression and marginalisation amongst women, especially black African women. During the pandemic, women in South Africa, especially women of colour, struggled to find shelter as they tackled poverty, unemployment, gender-based violence and food insecurity. In the USA, 'non-white' women have borne the greatest burden of COVID-19 disease and the socio-economic consequences of the pandemic.[30]

Higher mortality in young in LMIC

The risk of mortality increased with age, but there were proportionately more COVID-19 deaths reported among young people in South Africa compared to those in high income countries (HIC). Globally, deaths in individuals younger than 70 years accounted for 13% of all deaths in HIC and 63% in LMIC.[34] In our analysis, 67% of deaths were in people younger than 70 years. The COVID-19 mortality rate for those aged 70–79 is 12.6 times the rate for those aged 50–59 in HIC, 3.5 times in LMIC and 1.8 times in our study. This pattern holds overall as well as separately for male and female mortality rates.[34] The probability of a COVID-19 patient dying at age 40–49 years in a developing country is statistically similar to dying at age 60–69 in a rich country.[35] This difference is only partly related to differences in population age structure. Poorer outcomes in developing countries are driven by a higher prevalence of comorbid conditions, and by challenges in access to hospitals and critical care.[35]

Socio-economic status

Higher COVID-19 mortality in non-white groups may be attributable to increased risk of infection amongst these communities.[25,28] Our data revealed that most hospital admissions occurred amongst non-white people of working age – reflecting historical patterns of disadvantage that remain today. Admissions incidence was highest among working age individuals in non-white groups, and in older individuals among white people. Admissions were higher in female individuals in black and coloured groups, and higher in male individuals in Indian and white groups. A higher percentage of total admissions in the first wave were among black people, who may have been most severely hit in the early part of the pandemic due to employment in essential services, while other race groups were better able to shield and adopt measures for prevention and isolation, and access health services. In South African national blood service sero-surveys, sero-prevalence has been reported to be consistently higher among black African individuals.[36] Socio-economic factors among non-white groups – including poverty; unemployment; poor housing conditions; living in larger, multigenerational households; low level of education; as well as higher burden of underlying comorbidities; and poor access to health services – place them at increased risk for COVID-19 infection and death.[8,11,22,25,27,29,37] Frontline workers in South Africa are mostly women and mostly non-white and, as in other settings, have less opportunity to work from home, and have increased risk of exposure to SARS-CoV-2 through work and commuting using public transport.[25]

Healthcare access

Inequality in access to health care may also be driving increased COVID-19 infection and mortality rates.[9] Fewer black African people and more white people and those of Indian descent were admitted in the private sector, reflecting health insurance coverage by race group in South Africa, which was 10% in black, 17% in coloured, 52% in Indian and 73% in white groups.[38] In the USA, minorities are also less likely to have health insurance, resulting in reduced healthcare access.[28]

Almost half (47%) of all admissions were in the private sector, despite only 16% of the population having access to medical insurance and private health care. This might be due to lower thresholds for admission in the private sector and to limited bed availability in the public sector, but is unlikely to be due to patients in the public sector having lower risk of severe disease requiring hospitalisation.

A lower proportion of patients in the public sector were treated in ICU, ventilated or treated with supplemental oxygen, which reflects inequity of resources between the public and private sectors, including hospital beds, healthcare workers and equipment such as oxygen and ventilators. In South Africa, the average spend in the private sector was six times higher than that in the public sector.[39] Higher expenditure affords more healthcare specialists, hospitals, and expensive medicines and technology. A comparison of the quality of healthcare systems of 48 countries found that the South African private sector ranked sixth while the public sector ranked eighth from the bottom.[40]

There were also differences in treatment in ICU and ventilation by race and health sector. There was less inequality in treatment in the private sector where non-white groups with highest risk of mortality were most likely to be treated in ICU or ventilated. In the public sector, however, black African patients were less likely to have been treated in ICU and ventilated compared to white patients, despite having higher risk of mortality than white patients. The inequality could be due to black patients more likely accessing care in rural district hospitals that had no ICU or ventilators available. Of concern, this finding suggests possible rationing of care that unfairly disadvantaged black people in the public sector. In Brazil, ICU access was also considered to explain differences in mortality by ethnicity, with white patient more likely to be admitted to ICU than non-white patients.[22]

In South Africa, 47% of individuals in the 2018 general household survey reported facing constraints in access to health services, which showed bias towards the poor (63%) compared to the non-poor (36%).[41] Black South Africans, living in rural areas, with lower education levels, being unemployed and poor, were least likely to report access and experienced long distances to the nearest healthcare facilities.[41] The inequitable distribution of resources has an impact on 'the timeliness, range and quality of services provided to users' in public healthcare facilities.[41] Even in HICs like the USA, African Americans and Latin Americans had lower levels of access to a health provider[20], social and economic barriers to testing[42], varying medication prescriptions[28], and lower quality care for COVID-19[29].

Race and racism

Race and SES were important determinants of access to health care during apartheid when health systems were fragmented and discriminatory; but racial differences continue to impact access to health care today.[38] The consequences of structural inequality disproportionately affect vulnerable groups, who experience discrimination based on their race, gender, and SES. The pandemic has exposed pre-pandemic inequalities that illustrate multiple barriers to health care and historically disadvantaged groups remain most impacted by COVID-19.[30] In addition, the relationship between structural inequality and COVID-19 disease susceptibility and severity are bidirectional; the impact of the pandemic within these communities has worsened inequities in education, housing, employment, income, and access to quality health care.[43]

Some argue that 'racism, not race, drives inequity' in COVID-19 infection and outcomes.[43] The biomedical risk factors and social determinants that disproportionately influence COVID-19 morbidity and mortality

within BAME communities, are linked partly to structural racism.[29,37,44] 'These processes are complex and systemic, underpinned by unequal power relations and beliefs, and operating at individual, community, and organisational levels, resulting in stigmatisation, discrimination, and marginalisation of ethnic minorities'[6].

Limitations

This analysis had several limitations. Firstly, data quality in a surveillance system is dependent on the information submitted by healthcare facilities. Fields with the highest proportion of incomplete data included race (36%) and comorbidities (25–32%). The proportion with missing race information was similar to the 39% reported in a study in Brazil[22], and the 26% in a large UK data set[42]. Analysis was restricted to those with complete data. It is possible that there were differences amongst those who were excluded with unknown race. Secondly, DATCOV does not collect socio-economic data on income, education, occupation, household size, etc. and so we were limited to examining SES using health sector of admissions as a proxy. We were therefore unable to take a nuanced approach to inferring associations of COVID-19 mortality with inequality. It is also possible that some patients with medical aid were admitted in the public sector and some without medical aid were admitted in the private sector; however, these are likely to be small numbers and should not affect analysis. Therefore, sector of admission is likely to be a robust proxy for SES. In addition, race in this analysis may serve as a proxy for SES rather than as a risk factor in itself. Thirdly, the hospital surveillance system has incomplete data on reason for admission and includes patients with COVID-19 symptoms and those who tested positive for SARS-CoV-2 incidentally when admitted for other reasons. There could have been changes over time in the criteria and thresholds for hospitalisation which could have influenced the analysis of treatment in ICU or with ventilation, but it is likely that these changes over time were similar across race groups. Fourthly, our analysis did not include out-of-hospital mortality, which probably underestimates the true impact of COVID-19, as healthcare access would likely be more constrained among patients who are not hospitalised, as was demonstrated in Brazil.[22]

Conclusion

This study adds to the evidence of inequalities in South Africa, revealing how different intersecting systems (age, sex, race, SES) influence healthcare utilisation and health outcomes for people with COVID-19. These findings demonstrate the importance of collecting and analysing data on SES alongside race data.[45] This will ensure that disease control measures address the most marginalised groups affected by COVID-19.[32] Public health efforts should be targeted towards vulnerable populations, taking into consideration the pre-existing inequities that predispose them to have poor disease outcomes and yet have more limited access to health interventions.[44] The findings should also inform government efforts to provide inclusive non-discriminatory health services, and urgently improve access to ICU, ventilation and oxygen in the public sector.

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Competing interests

We have no competing interests to declare.

Authors' contributions

W.J. and S.M. contributed to the literature search. W.J., L.B., C.C., L.O. and C.M. contributed to study design and refining methods of analysis. L.O., W.J. and R.W. contributed to data analysis, and creation of tables and figures. W.J., L.O. and S.M. contributed to data interpretation and writing the initial draft. W.J. drafted the initial manuscript and all other co-authors contributed scientific inputs equally towards the interpretation of the findings and the final draft of the manuscript. W.J., L.O., R.W. and C.M. verified the underlying data.

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