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COVID-19 infections, hospital admissions and mortality outcomes: the associated risk factors among private medical insurance beneficiaries

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The highest-risk occupations for COVID-19 infection are in the fields of health, correctional services and police services.

COVID-19 has had a significant impact on morbidity and mortality in South Africa. This study aims to identify risk factors, including occupation, for SARS-CoV-2 infection, hospital admission, and mortality within the Government Employees Medical Scheme population across the three pandemic waves.

This is a retrospective cohort study. The study population consisted of 760 000 principal members of the scheme. Demographic data and claims information were used to identify age, income, province, occupation, and pre-existing chronic conditions.

The incidence and adjusted relative risk for infections were higher in people younger than the 40–49 age group; however, intensive care unit admissions and deaths increased with age; and a lower adjusted relative risk for infections and hospital admission. Males had a higher adjusted relative risk for intensive care admissions and mortality. The incidence and adjusted relative risk for infections and intensive care admissions increased with increasing income quintile; however, deaths were similar across all income quintiles.

This study confirms that older age, male gender, occupation and comorbidities are associated with COVID-19 infection, hospital admissions, intensive care admissions, and death. Females were more likely to be infected; however, males had a high risk for intensive care admission and death. The highest-risk occupations for COVID-19 infection are Health, Correctional Services and Police Services. The reduced relative risk in Wave 3 among healthcare workers was likely to have been attributable to their access to protective vaccination as well infection in previous waves.

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Introduction

The Government Employees Medical Scheme (GEMS) is registered in accordance with the Medical Schemes Act (131 of 1998).[1] The scheme reports to the Registrar of the Council for Medical Schemes and accepts liability related to its members' healthcare benefits in exchange for monthly premium contributions. We investigated the GEMS data which enabled us to investigate the South African COVID-19 pandemic, using variables not found in other South African data.

The scheme has more than 1.9 million beneficiaries and 760 000 principal members with an average age of 32.6 years and 48.9 years, respectively. The principal members consist of 15% pensioners, and the scheme has a chronic disease prevalence of 25%.

South Africa has experienced three waves of COVID-19. The World Health Organization (WHO)[2] has reported the emergence of variants of concern (VoC), Alpha (B.1.17), Beta (B.1.351), Gamma (P.1), and Delta (B.1.617.2). The Beta variant, first identified in South Africa, dominated Wave 2, peaking around January 2021. The Delta variant dominated Wave 3, which peaked in the inland provinces in July 2021. Studies have suggested that the Beta and Delta variants have been associated with higher transmission, hospitalisation and severity.[2–4]

Factors widely documented to be associated with severe COVID-19 or increased hospital mortality include older age, male sex, and comorbidities such as hypertension, diabetes, cardiovascular disease (CVD), chronic pulmonary disease and asthma, chronic renal disease, malignancy in the past five years, obesity, and past and current tuberculosis (TB) and HIV.[3–12]

International studies have identified high-risk occupations for SARS-COV-2 exposure, including healthcare workers, mortuary attendants, social care, transport, retail, education and abattoir workers, and police and firefighters.[13–21] Limited studies have been published in South Africa focusing on the risk exposure of different occupational groups.[8,22–24]

We aimed to identify independent risk factors for SARS-COV-2 infection, hospital admission, and mortality within the GEMS-insured population. The measures are compared across the three COVID-19 pandemic waves.

Our respective objectives were to identify the risk factors for SARS-COV-2 infection, COVID-19 hospital admission in general wards and intensive care units (ICU), and mortality across all three COVID-19 pandemic waves; and to describe these outcomes (infection, general admission, ICU admission and mortality) in different employment sectors during the three waves.

Methodology

The data used in the study were extracted from administrative claims, membership documentation and authorisations data. The study received ethics approval from Pharma-Ethics (Reference No: 210824214). In addition, the data were de-identified for analysis, and members signed a consent form allowing the research to be undertaken when joining the scheme.

The study included data for all GEMS active principal members older than 20 years. We extracted age, sex, provincial location, whether a member resides in one of the eight metropolitan municipalities, principal member's income, occupation, and pre-existing comorbidities. 'Metro' refers to the eight metropolitan areas, namely Johannesburg, Tshwane, Ekurhuleni, Nelson Mandela Bay, Buffalo City, eThekwini, Buffalo City and Cape Town.

Infections, general admissions, ICU admissions and deaths were measured using incidences. The incidence rates require the number of cases and the number of lives at risk over a period.

Infections were identified using International Classification of Disease version 10 (ICD-10)[25], with the code U07.1 denoting a positive COVID-19 diagnosis. SARS-CoV-2 cases were defined as members with a positive SARS-CoV-2 PCR test and claims recorded with the U07.1 code. Where members had multiple COVID-19 infections, all infections were included in the study. Hospital admissions were identified as hospital authorisations with the U07.1 code signifying the primary ICD-10 diagnosis for the admission. ICU admissions were defined as admissions with at least one day in a high care or ICU ward. Deaths were defined as deaths registered with the COVID-19 diagnosis code.

We defined wave periods by province using a threshold of 30 cases per 100 000 in each province, based on reported SARS-CoV-2 cases published by the National Institute for Communicable Diseases (NICD).[3] At the time of the analysis, Wave 3 had not yet ended. The number of individuals exposed to COVID-19 in each wave was taken to be all individuals in the population at the start of the waves. Infections were recorded in each wave, and admissions and deaths were recorded if the event occurred in the wave or in the time between the end of a wave and the start of the following wave, as admissions and deaths may lag infections and fall outside of the wave.

Results

Prior to the analysis, we compared the GEMS incidence to the national population to assess how representative GEMS is of the national population. The national population was based on a midpoint of Statistics South Africa (Stats SA) mid-year population estimates for 2020 and 2021. We also used Stats SA's 2020 General Household Survey (GHS) to compare the study population's age, sex, province and Metro distributions to national distributions. The number of cases in the national population was based on both reported COVID-19 cases and deaths published by the NICD and excess deaths reported by the SAMRC.

Figure 1 is a graphic representation of the GEMS population vs the distribution of the South African population. The population is generally older ($p<0.001$), is predominately female ($p<0.001$), and is over-represented in Gauteng, Western Cape and KwaZulu-Natal Provinces ($p<0.001$) and Metros ($p<0.001$), although the differences in provinces and Metros are minor in terms of their percentage distributions.

Figure 1: Infections and deaths of the study population vs national statistics, January 2021

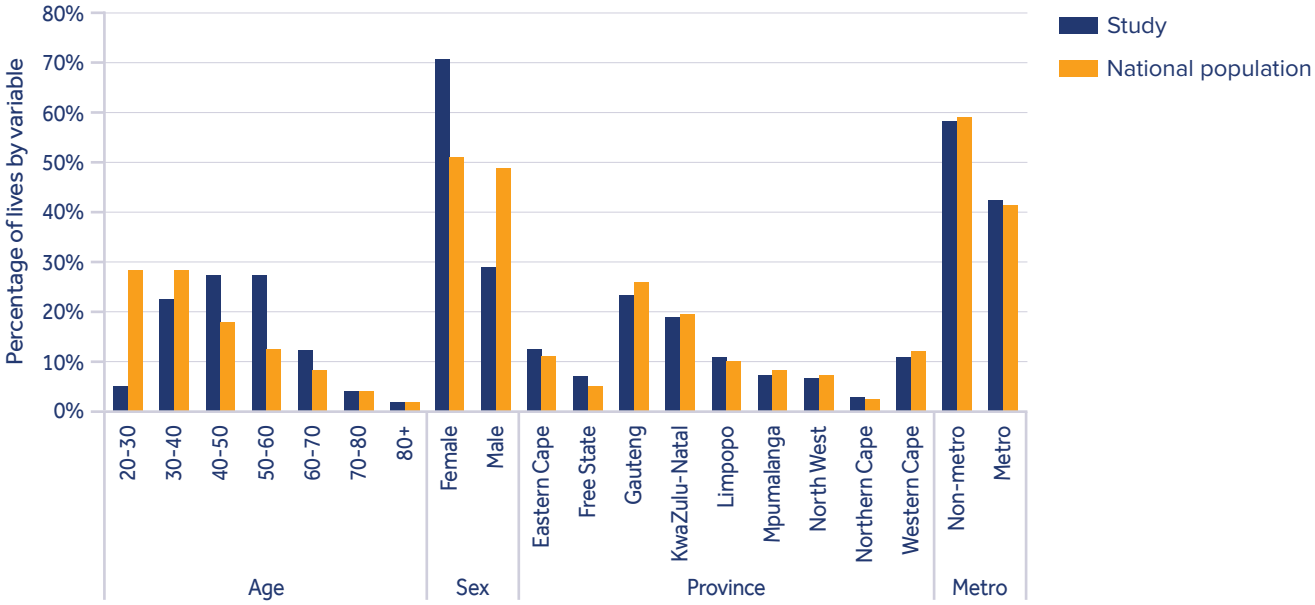
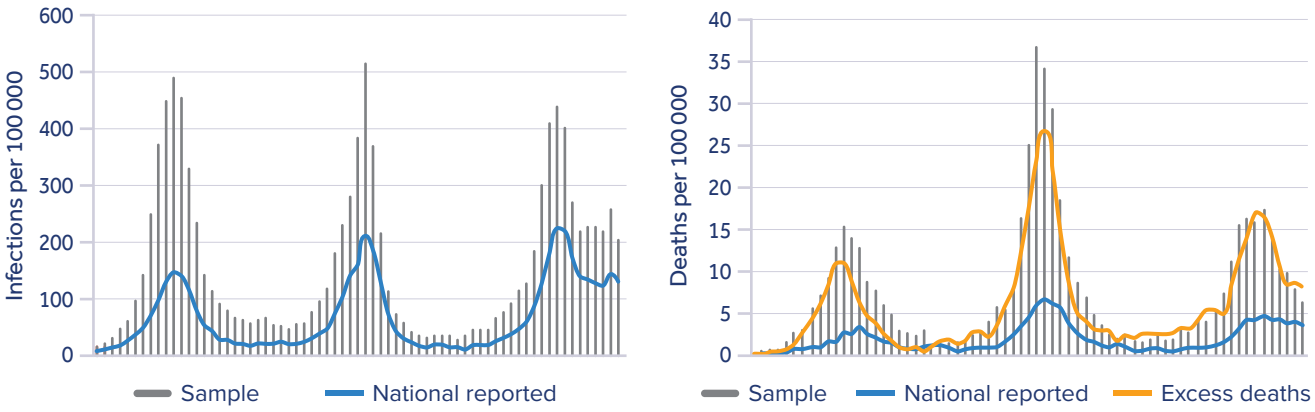


Figure 2 shows that rates of infections and deaths in the GEMS population during all the waves are higher than nationally reported infections and deaths, and closer to the rates of excess deaths reported by the South African Medical Research Council (SAMRC).[7]

Figure 2: Comparison infection and death rates to South African general population, 1 May 2020 to 31 August 2021



Incidence rates and relative risk

Overall incidence was compared between waves, with significance tested between Wave 1 and Waves 2 and 3. Wave 1 had the highest infection incidence. Wave 2 had a lower infection incidence rate compared to Wave 1, but higher admission and death incidences. Wave 3 had lower admission and ICU incidences than Wave 1, but not a lower death incidence (Table 2).

Table 1: Incidence by wave in the insured population

	Wave 1	Wave 2	Wave 3
Population at risk (number of members)	732 703	746 193	753 573
Infections per 1 000	56	43	53
Infections relative risk		0.77 p<0.001	0.95 p<0.001
General admission per 1 000	20	19	13
General admission relative risk		0.97 p>0.1	0.64 p<0.001
ICU admission per 100 000	467	530	258
ICU admission relative risk		1.14 p<0.001	0.55 p<0.001
Deaths per 100 000	226	406	248
Deaths relative risk		1.79 p<0.001	1.10 p>0.1

Table 2 shows that in all waves, the incidence of infection per 1 000 people was highest in the working-age groups (30–59), in females, and in members with chronic conditions. The incidences were lowest in income quintile 1. The incidence of infections differed by occupation throughout the waves. The highest incidences for infection were the highest in Correctional Services (90), Police Services (76), Education (63) and Health (61). Compared to Education, the other occupations had the highest ARR: Correctional Services (1.36), Police Services (1.27), and Health (1.07). Wave 2 maintained a similar pattern, except for those employed in the Department of Home Affairs which had increased infection incidence and ARR (1.68, p<0.001), and Health which had reduced incidence (38) and ARR (1.07; p<0.05). In Wave 3, Health's infection ARR was reduced by 49% (p<0.001). The provincial incidences differed by wave. In Wave 1, the infection incidences per 1 000 were highest in the Free State (96), Eastern Cape (69), KwaZulu-Natal (67), and Northern Cape (67), and the lowest in Limpopo (7). Wave 2 infection incidences were highest in the coastal provinces: Eastern Cape (62), KwaZulu-Natal (59), and Western Cape (56); Limpopo (51) was the only internal province that experienced a high infection incidence. Wave 3 occurred predominantly in Gauteng Province (75) and Northern Cape (77).

Tables 3 and 4 show general and ICU admission rates per 1 000 and 100 000 people respectively. The ARR for general admissions rose with increasing age and were the highest in Metro residents and those with chronic conditions. The ARR for admissions was not associated with the income quintile. The general admission ARR was lower for males in Wave 1 (ARR=0.98 p<0.001). However, the ARR for ICU admission was higher for males (1.15, p<0.001) and increased with income quintile. The ARRs for general and ICU admission were highest in Health (2.14 and 1.54, p<0.001). Compared to Gauteng, the ARRs for ICU admission were generally lower in all provinces except KwaZulu-Natal, which had 19% (p<0.005) more ICU admissions.

Table 5 shows incidences and ARR for deaths. The ARR for death increased with age in all waves, and were highest for males (1.36, p<0.001), those employed in Correctional Services (138, p<0.05) and Health (136, p<0.001); and those with chronic conditions, being particularly high in those with chronic renal disease (4.35, p<0.001) and diabetes (2.61, p<0.001). In Wave 3, the death ARR was reduced by 44% lower than in Wave 1 and lowest among all occupations. The rural provinces generally have a higher ARR for deaths. The ARRs were highest in Eastern Cape (1.51, p<0.001) and Free State (p<0.05).

Table 2: Incidence per 1 000 of infections, 95% confidence intervals in brackets, adjusted relative risk of infections

		Wave 1		Wave 2		Wave 3	
		Incidence	ARR	Incidence	ARR	Incidence	ARR
Age group	**20-29**	60 (57-62)	1.04	33 (31-35)	0.92**	61 (59-64)	1.13*
	30-39	60 (59-61)	1.04**	38 (37-39)	0.95***	52 (51-53)	1.04
	40-49 (reference)	62 (61-63)	1	43 (42-44)	1	52 (51-53)	1
	50-59	60 (59-61)	0.95***	49 (48-50)	1.02***	58 (57-59)	0.98
	60-69	37 (36-39)	0.76***	47 (46-48)	0.98***	44 (43-46)	0.76
	70-79	24 (22-26)	0.53***	38 (36-40)	0.79***	49 (47-52)	0.78***
	80+	32 (29-35)	0.7***	28 (25-31)	0.6*	54 (51-58)	0.81*
Gender	**Female (reference)**	58 (58-59)	1	43 (43-44)	1	54 (53-54)	1
	Male	50 (49-50)	0.86***	42 (41-42)	0.91***	52 (51-52)	0.9*
Province	**EC**	69 (67-70)	0.94	62 (60-63)	2.25***	22 (21-23)	0.27***
	FS	96 (94-99)	1.3***	16 (15-18)	0.61***	65 (63-67)	0.77***
	GP (reference)	60 (59-61)	1	27 (26-28)	1	75 (74-77)	1
	KZN	67 (65-68)	0.89***	59 (58-61)	2.18***	30 (29-31)	0.37***
	LP	7 (7-8)	0.1***	51 (50-53)	1.93***	52 (50-53)	0.64***
	MP	35 (33-37)	0.46***	36 (34-37)	1.35***	58 (56-60)	0.7**
	NW	49 (47-51)	0.73***	24 (22-25)	0.84**	63 (61-65)	0.79***
	NC	67 (64-71)	0.76***	20 (18-22)	0.61***	77 (73-81)	0.75***
	WC	53 (51-55)	0.8***	56 (55-58)	1.95***	62 (60-64)	0.76***
Metro	**Non-metro (reference)**	56 (55-57)	1	43 (43-44)	1	50 (49-50)	1
	Metro	56 (55-57)	0.84***	42 (42-43)	1.07***	60 (59-60)	0.97***
Income Quintile	**1 (reference)**	47 (46-49)	1	28 (27-29)	1	31 (30-32)	1
	2	64 (63-65)	1.27***	42 (41-44)	1.34	52 (51-53)	1.42***
	3	63 (62-65)	1.31***	40 (39-41)	1.34	58 (57-60)	1.58***
	4	64 (62-65)	1.35***	47 (46-49)	1.49**	63 (61-64)	1.63***
	5	63 (62-64)	1.35***	55 (54-57)	1.72***	66 (64-67)	1.79***
	Pensioner	32 (31-33)	0.76***	42 (41-43)	1.39***	48 (47-49)	1.19***
Occupation	**Correctional Services**	90 (86-93)	1.36***	53 (51-56)	1.32	66 (63-69)	1.02***
	Education (reference)	63 (62-64)	1	45 (44-46)	1	63 (62-64)	1
	Health	61 (60-62)	1.07***	38 (37-38)	1**	29 (29-30)	0.51***
	Home Affairs	50 (44-55)	0.84**	55 (49-61)	1.68***	71 (65-78)	1.02**
	Other	48 (47-49)	0.82***	43 (42-44)	1.23***	64 (63-66)	0.97***
	SA Police Service	76 (73-79)	1.27***	50 (47-52)	1.49***	69 (66-72)	1.16*
	Pensioner	32 (31-33)	1.05	42 (41-43)	1.07	48 (47-49)	1.28***
Cancer	**No (reference)**	49 (49-50)		47 (46-47)		69 (68-70)	
	Yes	56 (55-57)	1.05	43 (42-43)	1.07	53 (52-53)	1.28***
Cardiovascular Disease	**No (reference)**	57 (56-58)		51 (51-52)		65 (64-65)	
	Yes	56 (55-56)	1.09**	43 (42-43)	1.06	53 (52-53)	1.16
Chronic Renal Disease	**No (reference)**	112 (111-113)		97 (97-98)		103 (102-103)	
	Yes	56 (55-56)	1.9***	43 (42-43)	1.65	53 (53-54)	1.79
Chronic Respiratory Disease	**No (reference)**	64 (63-65)		56 (56-57)		72 (71-73)	
	Yes	56 (55-56)	1.14***	42 (42-43)	1.16	53 (52-53)	1.31***
Diabetes	**No (reference)**	71 (70-72)		68 (68-69)		63 (63-64)	
	Yes	54 (54-55)	1.39***	40 (40-40)	1.45	52 (52-53)	1.16***
HIV	**No (reference)**	66 (65-67)		44 (43-44)		40 (40-41)	
	Yes	54 (54-55)	1.09***	43 (42-43)	0.96***	55 (55-56)	0.84***
Hypertension	**No (reference)**	60 (59-60)		53 (52-53)		61 (61-62)	
	Yes	55 (54-55)	1.16***	40 (39-40)	1.17	51 (50-51)	1.14
Liver Disease	**No (reference)**	74 (73-75)		54 (54-55)		63 (62-64)	
	Yes	56 (55-56)	1.19	43 (42-43)	1.12	53 (53-54)	1.13

		Wave 1		Wave 2		Wave 3	
		Incidence	ARR	Incidence	ARR	Incidence	ARR
Neurological Disorder	No (reference)	57 (56-57)		47 (46-47)		65 (65-66)	
	Yes	56 (55-56)	1.02	43 (42-43)	1.04	53 (53-54)	1.12
Severe Mental Disorders	No (reference)	70 (69-71)		47 (47-48)		79 (79-80)	
	Yes	56 (55-56)	1.11*	43 (42-43)	0.99	53 (52-53)	1.27*
Transplants	No (reference)	91 (91-92)		68 (67-68)		102 (102-103)	
	Yes	56 (55-56)	1.13	43 (42-43)	1	53 (53-54)	1.16

Denotes p < 10%, * p < 0.05, ** p < 0.01, *** p < 0.001

Table 3: Incidence per 1 000 of general admissions, 95% confidence intervals in brackets, adjusted relative risk of general admissions

		Wave 1		Wave 2		Wave 3	
		Incidence	ARR	Incidence	ARR	Incidence	ARR
Age group	20-29	12 (11-14)	0.76***	8 (7-9)	0.57***	6 (5-7)	0.62*
	30-39	15 (14-15)	0.86***	10 (10-11)	0.64***	7 (6-7)	0.64***
	40-49 (reference)	19 (18-20)	1	16 (16-17)	1	10 (10-11)	1***
	50-59	24 (23-25)	1.17***	25 (24-25)	1.35***	16 (15-16)	1.31**
	60-69	22 (21-23)	1.15***	29 (28-30)	1.43***	17 (16-18)	1.25
	70-79	19 (17-20)	0.95	28 (26-30)	1.31***	25 (24-27)	1.58***
	80+	23 (20-25)	1.16*	25 (22-28)	1.25	37 (34-41)	2.32***
Gender	Female (reference)	20 (20-21)	1	19 (18-19)	1	12 (12-13)	1
	Male	18 (18-19)	0.92***	20 (19-20)	1.04***	13 (13-14)	0.98*
Province	EC	19 (18-20)	1.19***	22 (21-23)	1.54***	6 (6-7)	0.32***
	FS	23 (22-24)	1.46***	9 (8-9)	0.61***	17 (16-19)	0.84***
	GP (reference)	16 (15-16)	1	13 (13-14)	1	16 (16-17)	1
	KZN	23 (22-24)	1.38***	28 (27-29)	1.99***	9 (9-10)	0.52***
	LP	8 (8-9)	0.57***	17 (16-18)	1.23***	9 (8-10)	0.49***
	MP	13 (12-14)	0.87*	18 (17-20)	1.42***	12 (11-13)	0.66
	NW	18 (17-19)	1.19**	15 (14-16)	1.12	16 (15-17)	0.84***
	NC	18 (17-20)	1.21*	8 (7-10)	0.59***	21 (19-23)	1.03***
	WC	37 (36-38)	1.93***	26 (25-27)	1.57***	15 (14-16)	0.69**
Metro	Non-metro (reference)	18 (17-18)	1	18 (18-19)	1	12 (12-13)	1
	Metro	23 (23-24)	1.13***	20 (20-20)	1.02**	13 (13-14)	0.84***
Income Quintile	1 (reference)	22 (21-23)	1	14 (13-15)	1	8 (7-8)	1
	2	20 (19-21)	1.03	15 (15-16)	1.2***	10 (10-11)	1.34***
	3	17 (16-17)	1.04	15 (14-16)	1.31***	9 (9-10)	1.38***
	4	18 (17-19)	1.07*	19 (18-20)	1.36***	12 (11-13)	1.34***
	5	22 (21-23)	1.07*	23 (22-24)	1.43***	15 (14-15)	1.49***
	Pensioner	20 (19-21)	0.9*	27 (26-28)	1.4***	21 (20-22)	1.35***
Occupation	Correctional Services	21 (19-23)	1.3***	16 (15-18)	1.05**	13 (12-14)	1.12*
	Education (reference)	16 (15-16)	1	18 (17-18)	1	11 (11-12)	1
	Health	31 (30-32)	2.1***	21 (20-22)	1.52***	9 (8-9)	0.89***
	Home Affairs	12 (10-15)	0.94	16 (13-19)	1.36*	13 (10-16)	1.16
	Other	13 (12-13)	0.92**	14 (13-14)	1.04**	12 (12-13)	1.09***
	SA Police Service	18 (16-19)	1.22***	14 (12-15)	1.13	11 (10-12)	1.03*
	Pensioner	20 (19-21)	1.26***	27 (26-28)	1.22	21 (20-22)	1.4
Cancer	No (reference)	28 (28-28)		30 (30-31)		27 (27-28)	
	Yes	19 (19-20)	1.26***	19 (18-19)	1.22	12 (12-13)	1.4
Cardiovascular Disease	No (reference)	35 (35-35)		36 (36-37)		31 (31-32)	
	Yes	19 (19-19)	1.26***	18 (18-19)	1.21	12 (12-12)	1.4

		Wave 1		Wave 2		Wave 3	
		Incidence	ARR	Incidence	ARR	Incidence	ARR
Chronic Renal Disease	**No (reference)**	112 (111-113)		96 (96-97)		69 (68-70)	
	Yes	19 (19-20)	3.39***	19 (18-19)	2.46**	12 (12-13)	2.61*
Chronic Respiratory Disease	**No (reference)**	36 (35-36)		35 (35-36)		29 (29-30)	
	Yes	19 (19-19)	1.39***	18 (18-19)	1.36	12 (12-12)	1.6**
Diabetes	**No (reference)**	43 (43-44)		45 (44-45)		29 (29-30)	
	Yes	17 (16-17)	2.03***	16 (16-16)	1.86**	11 (11-11)	1.77***
HIV	**No (reference)**	23 (23-23)		21 (21-22)		11 (11-11)	
	Yes	19 (19-19)	1.27***	19 (18-19)	1.16**	13 (13-13)	1.06***
Hypertension	**No (reference)**	29 (29-30)		31 (31-32)		23 (22-23)	
	Yes	16 (16-17)	1.32***	15 (15-15)	1.31	9 (9-10)	1.34
Liver Disease	**No (reference)**	31 (30-31)		27 (27-27)		39 (39-40)	
	Yes	20 (19-20)	1.38	19 (19-19)	1.08	13 (12-13)	2.2
Neurological Disorder	**No (reference)**	33 (32-33)		34 (33-34)		27 (27-28)	
	Yes	19 (19-20)	1.32***	19 (18-19)	1.3	12 (12-13)	1.25
Severe Mental Disorders	**No (reference)**	34 (33-34)		31 (30-31)		27 (27-28)	
	Yes	19 (19-20)	1.4***	19 (18-19)	1.36	12 (12-13)	1.67
Transplants	**No (reference)**	76 (76-77)		64 (63-65)		62 (62-63)	
	Yes	20 (19-20)	1.14	19 (19-19)	1.2	13 (12-13)	1.46

Denotes p < 10%, * p < 0.05, ** p < 0.01, *** p < 0.001

Table 4: Incidence per 100 000 of ICU admissions, 95% confidence intervals in brackets, adjusted relative risk of ICU admissions

		Wave 1		Wave 2		Wave 3	
		Incidence	ARR	Incidence	ARR	Incidence	ARR
Age group	**20-29**	66 (40-92)	0.24***	65 (40-91)	0.23	24 (8-40)	0.16
	30-39	154 (135-173)	0.51***	146 (128-164)	0.91	54 (43-65)	0.71*
	40-49 (reference)	365 (339-391)	1	377 (350-403)	1	172 (154-190)	1*
	50-59	675 (640-711)	1.57***	774 (736-812)	1.68	362 (336-387)	1.68
	60-69	848 (787-909)	1.84***	1062 (995-1129)	1.92	482 (437-527)	1.72
	70-79	759 (656-862)	1.51***	978 (863-1093)	1.57	699 (603-795)	2.05
	80+	788 (635-941)	1.72***	754 (604-904)	1.31	718 (572-864)	2.1
Gender	**Female (reference)**	440 (422-458)	1	492 (473-511)	1	236 (223-249)	1
	Male	530 (510-549)	1.15***	620 (599-642)	1.21	310 (295-325)	1.14
Province	**EC**	411 (370-453)	0.83*	617 (566-668)	1.3***	104 (83-125)	0.23***
	FS	487 (427-547)	1	244 (202-287)	0.52***	368 (317-420)	0.76***
	GP (reference)	517 (482-552)	1	454 (421-486)	1	406 (375-436)	1
	KZN	627 (587-668)	1.19*	760 (716-805)	1.58***	159 (139-180)	0.37***
	LP	190 (161-220)	0.43***	355 (315-395)	0.78***	130 (106-154)	0.3***
	MP	322 (271-373)	0.75**	535 (470-600)	1.26***	209 (169-250)	0.51
	NW	410 (357-464)	0.87	464 (408-520)	0.99	353 (305-402)	0.77***
	NC	460 (365-555)	1.05	192 (131-253)	0.44***	579 (473-685)	1.26***
	WC	545 (494-596)	0.83**	664 (608-721)	1.14***	251 (217-285)	0.44*
Metro	**Non-metro (reference)**	400 (382-418)	1	495 (475-515)	1	230 (216-243)	1
	Metro	588 (566-610)	1.25***	593 (571-615)	1.08*	309 (293-324)	0.92***

		Wave 1		Wave 2		Wave 3	
		Incidence	ARR	Incidence	ARR	Incidence	ARR
Income Quintile	**1 (reference)**	338 (303-373)	1	284 (253-316)	1	115 (96-135)	1
	2	375 (338-412)	1.26***	343 (308-378)	1.32	171 (147-195)	1.51
	3	326 (292-361)	1.35***	321 (287-355)	1.46	147 (125-169)	1.65
	4	436 (397-476)	1.23**	552 (508-597)	1.6*	236 (208-264)	1.43
	5	555 (510-600)	1.25**	686 (637-735)	1.68**	321 (288-354)	1.68*
	Pensioner	767 (715-820)	1.11	970 (911-1029)	1.62**	546 (503-589)	1.49
Occupation	**Correctional Services**	535 (450-619)	1.32**	402 (329-474)	0.84***	252 (195-310)	1.04
	Education (reference)	415 (389-441)	1	517 (488-546)	1	228 (209-247)	1
	Health	504 (470-538)	1.54***	431 (400-462)	1.21***	119 (103-135)	0.68***
	Home Affairs	327 (184-470)	1	329 (185-473)	1	217 (99-334)	0.97
	Other	285 (257-312)	0.86*	370 (339-401)	1.01*	245 (220-270)	1.12**
	SA Police Service	321 (257-386)	1.04	309 (245-372)	1.03	157 (111-203)	0.82
	Pensioner	767 (718-817)	1.06	970 (915-1024)	1.04	546 (505-586)	1.01
Cancer	**No (reference)**	759 (739-779)		870 (848-891)		499 (483-516)	
	Yes	462 (446-478)	1.06	524 (508-541)	1.04	254 (243-266)	1.01
Cardiovascular Disease	**No (reference)**	1300 (1273-1326)		1324 (1298-1351)		884 (863-906)	
	Yes	440 (424-455)	1.38***	506 (489-522)	1.26	239 (228-251)	1.54
Chronic Renal Disease	**No (reference)**	4920 (4870-4972)		4509 (4462-4558)		2655 (2619-2693)	
	Yes	452 (437-468)	3.71***	519 (502-535)	3.03	252 (241-263)	3.42
Chronic Respiratory Disease	**No (reference)**	1097 (1073-1122)		1172 (1147-1197)		731 (712-751)	
	Yes	444 (428-459)	1.49***	507 (491-524)	1.43	242 (231-253)	1.68
Diabetes	**No (reference)**	1562 (1532-1592)		1681 (1650-1713)		839 (817-861)	
	Yes	334 (320-348)	2.66***	397 (382-412)	2.25**	195 (185-206)	2.1***
HIV	**No (reference)**	540 (521-558)		611 (592-631)		193 (183-204)	
	Yes	454 (437-470)	1.38***	516 (498-533)	1.34	269 (256-281)	0.99***
Hypertension	**No (reference)**	962 (936-988)		1087 (1060-1114)		610 (590-630)	
	Yes	295 (281-310)	1.55***	348 (332-363)	1.49	150 (140-160)	1.7
Liver Disease	**No (reference)**	617 (599-635)		901 (879-923)		2362 (2328-2397)	
	Yes	467 (451-482)	0.92	530 (513-547)	0	258 (246-269)	5.16
Neurological Disorder	**No (reference)**	983 (961-1006)		1129 (1104-1153)		644 (626-662)	
	Yes	460 (445-476)	1.23	523 (506-539)	1.31	254 (242-265)	1.16
Severe Mental Disorders	**No (reference)**	818 (798-839)		672 (653-691)		606 (588-624)	
	Yes	462 (447-478)	1.31*	528 (512-545)	0.97	254 (243-265)	1.6
Transplants	**No (reference)**	3538 (3496-3582)		2616 (2580-2653)		2456 (2422-2492)	
	Yes	462 (447-478)	1.51*	527 (511-544)	1.16	255 (244-267)	1.72

Denotes p < 10%, * p < 0.05, ** p < 0.01, *** p < 0.001

Table 5: Incidence per 100 000 deaths, 95% confidence intervals in brackets, and adjusted relative risk of deaths

		Wave 1		Wave 2		Wave 3	
		Incidence	ARR	Incidence	ARR	Incidence	ARR
Age group	**20-29**	11 (0-21)	0.12***	21 (6-35)	0.13	5 (0-13)	0.06
	30-39	36 (27-46)	0.35***	72 (59-85)	0.39	42 (33-52)	0.43
	40-49 (reference)	130 (115-146)	1	225 (205-246)	1	116 (102-131)	1
	50-59	310 (286-334)	2.01***	546 (514-578)	1.93	302 (279-326)	2.1
	60-69	466 (421-512)	2.64***	957 (893-1021)	2.75	467 (422-511)	2.32
	70-79	569 (479-658)	2.92***	1064 (944-1184)	2.83	864 (758-971)	3.6
	80+	1147 (963-1332)	6.55***	1241 (1049-1433)	3.82**	1959 (1719-2199)	8.41
Gender	**Female (reference)**	196 (184-209)	1	366 (350-382)	1	220 (207-232)	1
	Male	296 (281-311)	1.36***	499 (480-518)	1.26	318 (303-333)	1.22
Province	**EC**	350 (321-379)	1.51***	584 (548-621)	2.14**	126 (109-143)	0.31***
	FS	328 (300-356)	1.35*	172 (152-192)	0.63***	317 (290-344)	0.73***
	GP (reference)	208 (186-231)	1	248 (224-272)	1	370 (341-399)	1
	KZN	229 (205-254)	1	566 (527-604)	2.18***	130 (112-149)	0.35***
	LP	92 (71-112)	0.41***	491 (444-538)	1.84***	206 (175-236)	0.53***
	MP	156 (120-191)	0.76*	413 (356-470)	1.75***	254 (210-299)	0.73
	NW	243 (201-284)	1.11	285 (241-329)	1.07	290 (246-334)	0.73*
	NC	271 (198-344)	1.32	192 (131-253)	0.79*	508 (408-607)	1.32***
	WC	209 (178-241)	0.7***	426 (382-471)	1.26***	251 (217-285)	0.44
Metro	**Non-metro (reference)**	224 (210-237)	1	415 (397-433)	1	229 (215-242)	1
	Metro	231 (217-244)	0.95	388 (371-406)	1	283 (268-298)	0.91
Income Quintile	**1 (reference)**	146 (123-170)	1	188 (162-214)	1	109 (90-128)	1
	2	129 (108-151)	1.02	230 (201-259)	1.38*	131 (110-152)	1.25
	3	123 (102-144)	1.22	214 (187-242)	1.52	108 (89-127)	1.32
	4	190 (164-217)	1.13	383 (346-420)	1.55*	179 (154-203)	1.12
	5	237 (207-266)	1.11	449 (409-489)	1.51*	249 (220-278)	1.31
	Pensioner	539 (495-584)	1.12	951 (893-1009)	1.6*	701 (652-749)	1.39
Occupation	**Correctional Services**	234 (178-290)	1.38*	258 (199-316)	0.9*	208 (156-260)	1.19
	Education (reference)	176 (159-193)	1	358 (334-382)	1	180 (163-197)	1
	Health	175 (155-195)	1.36***	275 (250-299)	1.17	90 (76-104)	0.66***
	Home Affairs	115 (30-199)	0.96	247 (122-371)	1.2	183 (75-291)	1.12
	Other	128 (110-146)	0.9	242 (217-267)	1.03	187 (165-209)	1.12
	SA Police Service	149 (105-193)	1.31	227 (173-282)	1.21	143 (99-187)	0.99
	Pensioner	539 (498-581)	1.4**	951 (897-1004)	1.42	701 (655-746)	1.31
Cancer	**No (reference)**	644 (625-662)		1060 (1037-1084)		770 (751-790)	
	Yes	219 (208-230)	1.4**	395 (380-409)	1.42	240 (229-251)	1.31
Cardiovascular Disease	**No (reference)**	868 (846-890)		1122 (1097-1146)		1000 (977-1023)	
	Yes	205 (195-216)	1.49***	384 (369-398)	1.16*	226 (215-237)	1.39
Chronic Renal Disease	**No (reference)**	3154 (3114-3195)		4039 (3995-4086)		3558 (3516-3602)	
	Yes	217 (206-227)	4.35***	395 (381-409)	2.97*	240 (229-251)	4.71
Chronic Respiratory Disease	**No (reference)**	506 (489-523)		911 (889-933)		752 (732-772)	
	Yes	216 (205-227)	1.27**	388 (373-402)	1.34	232 (221-243)	1.58
Diabetes	**No (reference)**	833 (810-855)		1516 (1487-1546)		880 (858-902)	
	Yes	152 (143-162)	2.61***	278 (265-290)	2.56	180 (170-190)	2.23*

		Wave 1		Wave 2		Wave 3	
		Incidence	ARR	Incidence	ARR	Incidence	ARR
HIV	**No (reference)**	273 (260-286)		440 (423-456)		190 (180-201)	
	Yes	218 (206-229)	1.84***	400 (384-415)	1.4**	258 (246-270)	1.26***
Hypertension	**No (reference)**	532 (513-552)		931 (906-957)		637 (617-658)	
	Yes	120 (111-129)	1.6***	234 (221-246)	1.52	129 (120-138)	1.58
Liver Disease	**No (reference)**	309 (296-321)		901 (879-923)		1575 (1547-1603)	
	Yes	226 (215-237)	0	405 (391-420)	1.48	248 (237-259)	3.78
Neurological Disorder	**No (reference)**	693 (674-712)		956 (934-978)		763 (743-783)	
	Yes	220 (210-231)	1.4**	399 (385-413)	1.26	243 (231-254)	1.14
Severe Mental Disorders	**No (reference)**	284 (271-296)		370 (356-384)		501 (485-517)	
	Yes	225 (214-236)	0.96	406 (391-421)	0.73	246 (234-257)	1.49
Transplants	**No (reference)**	1490 (1462-1518)		2229 (2195-2263)		2252 (2218-2286)	
	Yes	224 (213-235)	1.12	403 (389-417)	1.32	246 (235-257)	1.36

Denotes p < 10%, * p < 0.05, ** p < 0.01, *** p < 0.001

Discussion

Our study, consisting of medical scheme principal members, shows that age, gender, occupation, and pre-existing chronic conditions are associated with risks of COVID-19 infection, general admission, ICU admission, and death. The findings can be generalised nationally among those employed.

Our study shows that infection risks are highest among those younger than 40–49 years. This may be because older people were more willing and/or able to isolate, and strict public health measures in Wave 1 probably assisted in keeping relative risk for infection in the older age groups significantly lower. However, this age group was susceptible to infection in Wave 3, when the Delta variant, which is far more transmissible, caused most infections.[3]

As found in other studies[22] the female gender was associated with more infections. This association can be due to the predominance of women in high risk occupations associated with high risk of COVID-19 exposure. However, men experienced more severe COVID-19 disease, as they had a higher ARR for ICU admission and death. The association with male gender can be due to negative health-seeking behaviour and undiagnosed and uncontrolled chronic conditions, which have been explained by the protective effects of oestrogen against cytokine storm.[18]

Higher-income earners' high level of infections and ICU utilisation could result from differential health-seeking behaviour, access to testing facilities, and private hospitals for low-income members. Studies have shown that high-income earners are more likely than low-income earners to seek health care early, particularly where there is no universal health care coverage.[27]

As found in other studies, infection risks are also associated with the occupation. In Wave 1, the risk of infection was significantly higher in the so-called first-line workers, including in Health, Education, Police Services and Correctional Services. During strict public health controls such as those regulated during Level 5 lockdown, only these departments were allowed to work.

Health-sector workers experienced reduced relative risk for infection and deaths in Wave 2 and Wave 3, although admission rates among health workers remained high in Wave 2. This could have been due to the Beta variant causing more severe illness. The Wave 2 reduction in infection may have resulted from natural immunity from high incidences of infection in Wave 1, or from improvements in usage of personal protective equipment. Wave 3 reductions in infection, general and ICU admissions, and death can be attributed to the immunisation programme implemented just before the onset of Wave 3. Healthcare workers were eligible for vaccination before the start of Wave 3, and would have had higher proportions vaccinated compared to workers in other occupations.

Correctional Services experienced high levels of infection and mortality throughout the all of the waves. Overcrowding in prisons has previously been associated with increased transmission of COVID-19 and other communicable diseases.[28]

Home Affairs employees had a relatively lower risk of infection in Wave 1 due to border closure and travel restrictions. Infections increased during Wave 2 and Wave 3, coinciding with the re-opening of offices and border posts. It is reported that many travellers forged negative COVID-19 test results, thus placing themselves, other travellers, and Home Affairs staff at risk.[26]

Wave 2 predominated in the Eastern coastal provinces and in Limpopo. The increased RR of infection in these provinces may be explained by factors such as people

migrating away from Gauteng to holiday destinations, and migrant workers returning home. The relative lack of natural immunity conferred by the prior prevalence of COVID-19 has been linked to the predominance of Wave 3 in Gauteng.[29] The difference in death incidences can also be attributable to bed availability. For example, in Wave 1, Western Cape did not have the highest incidences of infection, but did experience twice the ARR of admissions.

Conclusions

This study has shown that GEMS members in essential and public-facing occupations have been at risk of COVID-19 infection, especially those in congregate settings like schools or prisons; however, we are unable to identify or distinguish infections contracted in the workplace versus those acquired beyond the workplace.

In terms of the limitations of the study, Wave 3 was still in progress at the time of writing, so further case data may significantly change our results and conclusions. Some cases have incurred claims to GEMS, but have not been reported yet. Infections are highly under-reported overall, which would lead to underestimation of the burden of infection. In addition, because of variable access to testing, individuals with mild infection diagnosed with SARS-CoV-2 may not represent all mild or asymptomatic cases in the population.

Recommendations

To reduce the impact of a potential fourth SARS-CoV-2 wave, it is imperative to improve vaccination coverage, particularly of individuals at the highest risk of severe illness. It is also important to continue with public and workplace COVID-19 infection prevention measures such as physical distancing, hand hygiene, masking, good indoor ventilation, diagnostic testing, and isolation of staff members exposed to COVID-19.

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