388

The Open Public Health Journal

Content list available at: https://openpublichealthjournal.com

RESEARCH ARTICLE

Spatial Analysis of Perceived Health System Capability and Actual Health System Capacity for COVID-19 in South Africa

Tholang Mokhele[1,*], Ronel Sewpaul[2], Sibusiso Sifunda[3], Gina Weir-Smith[1,4], Simangele Dlamini[1], Thabang Manyaapelo[3,5], Inbarani Naidoo[6], Whadi-Ah Parker[7], Natisha Dukhi[4], Sean Jooste[2], Saahier Parker[2], Khangelani Zuma[3,7], Mosa Moshabela[8], Musawenkosi Mabaso[6] and Sasiragha P. Reddy[2]

[1]*Geospatial Analytics, eResearch Knowledge Centre, Human Sciences Research Council, Pretoria, South Africa*

[2]*Human and Social Capabilities, Human Sciences Research Council, Cape Town, South Africa*

[3]*Human and Social Capabilities, Human Sciences Research Council, Pretoria, South Africa*

[4]*School of Geography, Archaeology and Environmental Studies, University of Witwatersrand, Johannesburg, South Africa*

[5]*Social Science and Research Ethics Department, Africa Health Research Institute, Mtubatuba, South Africa*

[6]*Human and Social Capabilities, Human Sciences Research Council, Durban, South Africa*

[7]*School of Public Health, University of Witwatersrand, Johannesburg, South Africa*

[8]*School of Nursing and Public Health Medicine, University of KwaZulu-Natal, Durban, South Africa*

Abstract:

Introduction:

People's confidence in the health system's capability in managing the COVID-19 pandemic can determine public support, risk perceptions, and compliance to the required behaviors during the pandemic. Therefore, this paper investigated people's perception of health system capability to manage the COVID-19 pandemic in different spatial areas across the country using data from an online survey.

Methods:

Multivariate logistic regression models were used to examine factors associated with people's perception of the health system capability to manage the COVID-19 pandemic at the national and provincial levels. Spatial comparative analysis was conducted to contrast spatial density indicators of the number of hospitals, hospital beds, and ICU beds per given population across various provinces.

Results:

Findings showed that South Africans had low confidence in the health system capability, with only two in five (40.7%) reporting that they thought that the country's health system was able to manage the COVID-19 pandemic. Sex and knowledge on COVID-19 were significantly associated with the people's perception of the health system capability to manage the pandemic at the national level and in four of the nine provinces.

Conclusion:

Overall, the findings of this study clearly highlight challenges facing the country's health system, both perceived or real, that needed to be addressed as part of the preparation for the COVID-19 pandemic. Timeous implementation of a countrywide National Health Insurance (NHI) system is now more critical than ever in improving healthcare outcomes of the South African population beyond the existence of the COVID-19 epidemic.

Keywords: COVID-19, Spatial analysis, Health system, Capability, Capacity, South Africa.

1. INTRODUCTION

Coronavirus Disease 2019 (COVID-19) is a novel coronavirus caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV2). This novel coronavirus first emerged as a causative agent that led to a respiratory disease outbreak in December 2019 in Wuhan, China [1]. South Africa recorded its first confirmed case of COVID-19 on the 5th March 2020. Since then the number of confirmed cases has grown exponentially, and as of the 7th of July 2021 South Africa has

---

[*] Address correspondence to this author at Geospatial Analytics, eResearch Knowledge Centre, Human Sciences Research Council, Pretoria, South Africa; E-mail: TAMokhele@hsrc.ac.za

recorded 2.09 million cases. Globally, health systems have been scrutinized for their capability to manage the COVID-19 pandemic. Clinically, the COVID-19 disease is characterised by a dry cough, fever, fatigue and shortness of breath. In severe cases, patients present with severe respiratory illness such as pneumonia or acute respiratory distress syndrome (ARDS), both of which could be fatal and requires hospitalization [2]. According to a presentation made to Members of the South African Parliament by the Director-General of the National Department of Health at the early days of the pandemic, there were a total of 119 416 hospital beds available from both private and public hospitals across South Africa [3, 4]. There were also 3 318 Intensive Care Unit (ICU) beds available. However, it was projected that ICU beds could exceed 14 700 at the highest peak of the COVID-19 pandemic.

In South Africa, inequalities exist in access to health services between the public and private sectors, as well as within the public sector itself, especially between urban and rural areas [5 - 11]. The public health system supports around 84% of the population (those who are uninsured), while the private sector only services 16% of the population (those with medical insurance). However, the annual per capita healthcare expenditure of the private sector is almost 10 times more than that of the public sector [6]. Those who can afford medical insurance are predominantly from the White population group and those who cannot afford it are mainly Black Africans. The inequalities in access to healthcare in South Africa are inherited from the racial segregation policies of the apartheid government [12]. The COVID-19 outbreak has dramatically highlighted the necessity for a more integrated healthcare system [13]. The COVID-19 pandemic presents a significant opportunity for the National Health Insurance (NHI) to be piloted in real-time. In March 2020, the Competition Commission had published a COVID-19 block exemption for the health sector for promoting better coordination, sharing of information and standardisation of practice across the entire healthcare sector, as well as promoting agreements between the National Department of Health and the private healthcare sector [14]. Spatial accessibility of healthcare facilities is also an important factor in the fight against the COVID-19 outbreak. Spatial accessibility is often concerned with the complex relationship between the spatial separation of the population and the supply of healthcare facilities and thus has a strong underlying geographic component [15 - 18]. Spatial accessibility is regarded as a primary deciding factor of access to healthcare and healthcare utilization [19, 20].

In addition, people's confidence in the capability of the health system to manage the COVID-19 pandemic is also crucial. For instance, in India, it was reported that some people escaped from hospitals or quarantine mainly due to the confidence deficit in the public health system in many parts of the country [21]. Therefore, this paper explores South Africans' perceptions of the country's health system capability to manage the COVID-19 pandemic. It further assesses the country's health system capacity in various geographic areas and draws comparisons with perceptions of the health system capability to manage the COVID-19 pandemic.

2. MATERIALS AND METHODS

2.1. Data

This paper utilised data from the Human Sciences Research Council's (HSRC) COVID-19 online survey conducted in South Africa from 27 March 2020 to 2 April 2020. The survey was open to all adults (18 years and older) residing in South Africa, regardless of race, sex or nationality. Targeted minimum sample size was not pre-determined for this online survey. The questionnaire development was done through a consultative process with socio-behavioral scientists, public health scientists and epidemiologists both locally and internationally [22, 23]. The questionnaire development was further informed by work on public opinions and reactions to the coronavirus emergency prior to the survey as COVID-19 was an emerging pandemic at that time [24, 25]. The self-administered structured questionnaire (48 items) included socio-demographic, knowledge and infection control measures regarding COVID-19, risk of contracting COVID-19, perception of health system capability, hygiene practices, preparedness for self-isolation/quarantine, preparedness for lockdown and the use of social media in accessing the information on COVID-19. Cronbach's alpha analysis was undertaken for the six items used to create the knowledge score. Cronbach's alpha was 0.628. An alpha between 0.6-0.7 indicates an acceptable level of reliability. The survey alerts were distributed and broadcasted *via* various platforms, and these included a data-free messaging platform, various social media platforms, the HSRC organisational website, as well as local and national radio and television stations.

2.2. Measures

Socio-demographic variables used included sex, age, race, employment, knowledge score (continuous variable), risk perception and self-isolation or quarantine possibility. These variables were categorized as follows; age groups in years (18-29, 30-39, 40-49, 50-59, 60+), sex (male or female), race groups (Black African, Coloured, White, Indian/Asian), employment status (employed full-time, employed informal/part-time, student, unemployed, self-employed), and dwelling type (formal dwelling or informal dwelling). A knowledge score was developed from six knowledge variables about COVID-19, four of which were variables related to knowledge about the transmission (COVID-19 is spread by direct contact with the virus from (Select all that apply)) with options being (infected people coughing/sneezing, pets, touching face after being in contact with an infected person, contact in a public gathering with an infected person, contaminated surfaces and I don't know); one variable related to knowledge about incubation (After how long will an infected person show signs of being sick?) with options being (immediately, after 1-2 days, after 2-14 days, after 15-20 days, and I don't know); and one variable related to knowledge about symptoms (Which of the following best describes the symptoms of COVID-19: (Select all that apply)) with options being (shortness of breath, body pain, sweating, headaches, coughs, sneezing, red-itchy eyes, runny nose, fever, and I don't know). Respondents were assigned a value of 1 for each of the four transmission modes identified, for correct identification of

the incubation period of 2-14 days and for correct identification of fever, cough and shortness of breath as the main symptoms. The final knowledge sum score ranged from 0 to 6. For risk perception, self-perceived risk of contracting coronavirus was assessed using the question "How do you rate your personal risk of contracting COVID-19?" with response options being 1=very high risk, 2=high risk, 3=moderate risk, 4=low risk and 5= very low risk. These responses were recoded into 1=low risk (very low risk, and low risk), 2=moderate risk and 3=high risk (very high risk and high risk). For the perception of self-isolation or quarantine possibility, this was assessed using the question "Do you think you may end up in a situation of self-isolation or quarantine?" with response options being 1=yes, 2=no and 3=don't know. These responses were recoded into 0=no (no and don't know) and 1=yes (yes). The primary outcome variable, people's perception of health system capability in dealing with the COVID-19 pandemic, was assessed using the following question "Do you feel each of the following are able to manage the South African COVID-19 outbreak? SA health system" with options being 1=yes, 2=no and 3=don't know. These were dichotomised into 0=no (no and don't know) and 1=yes (yes) for logistic regression models.

2.3. Statistical Analysis

Data were analysed using Stata version 15.0 [26]. The data were benchmarked using Statistics South Africa 2019's mid-year adult population estimates for the generalisability of the findings [27]. Differences in estimates between the socio-demographic variables were compared using Chi-squared tests with a statistical significance level of $p \leq 0.05$. Multivariate logistic regression was performed to determine factors associated with the perception that the country's health system was capable of managing the COVID-19 pandemic. Odds ratio (OR) with 95% CIs and $p \leq 0.05$ were reported for the level of statistical significance. This was done at both national and provincial levels to determine differences across provinces. Race group and dwelling type were excluded from the logistic regression analyses due to low response rates from Indian/Asian and Coloured groups in three provinces, namely Northern Cape, Limpopo and Mpumalanga.

2.4. Spatial Analysis

Spatial density indicators were developed using secondary data for the numbers of hospitals, hospital beds and ICU beds gathered from several sources [4, 28, 29]. The 2019 population estimates from Statistics South Africa (Stats SA) were used to calculate spatial density indicators of the number of hospitals, hospital beds and ICU beds per given population. Spatial comparative analysis was employed to generate maps showing the perception of health system capability and density indicators of the health system across various provinces using ArcGIS 10. The health facilities earmarked by the national

government to focus on COVID-19 were also geocoded and mapped for spatial analysis of their distribution and geographic accessibility.

3. RESULTS
3.1. Demographics of Respondents

The study sample comprised 53 488 respondents. After benchmarking against population demographics, females constituted 53.9% and Black Africans accounted for 76.4% followed by Whites at 10.8%. In terms of age composition, 29.9% were 18-29 years old followed by those aged between 30 and 39 years old (25.7%).

3.2. Perception of Health System Capability in Managing COVID-19

Table **1** highlights people's perceptions towards health system capability to manage the COVID-19 pandemic across different socio-demographic variables and provinces. Overall, two in five South Africans (40.7%) reported that they thought that the country's health system was able to manage the COVID-19 outbreak. The people's perception of the health system capability to manage COVID-19 varied significantly across all socio-demographic variables ($p < 0.01$ for age and $p < 0.001$ for all other variables). Males had a significantly higher prevalence of perceiving the health system as capable than females. The older persons (70 years and older) had the lowest confidence in the health system capability (29.0%) compared to other age groups. Black Africans had the highest confidence in the health system capability (46.9%), while participants from the White population group had the lowest (13.4%).

Those employed part-time or informally had the highest confidence (44.8%) in the health system capability and self-employed adults had the lowest (34.4%). The confidence in the health system capability was less prevalent among those who thought they were at moderate and high risk of contracting COVID-19 (around 38% each) and among those who thought they might end up in self-isolation or quarantine (34.1%). People residing in informal dwellings had a higher confidence in the health system capability (55.7%) than those who lived in formal dwellings (40.0%).

Fig. (**1**) highlights that the Western Cape had the lowest percentage (30.8%) of people who felt that the national health system was capable of dealing with the COVID-19 pandemic. Gauteng and Eastern Cape were under the second-lowest category of 35.2% to 39.4%. North West and Free State had the highest percentages of people (more than half each) who had confidence in the health system's capability in managing the COVID-19 pandemic. These were followed by Limpopo, with 48.8% of people having confidence in the country's health system to deal with the COVID-19 pandemic.

Table 1. People's confidence in the health system capability in managing the COVID-19 pandemic

Socio-Demographics	Total	%	95% CI	P-Value
Sex	-	-	-	-
Male	15 476	44.4	[42.3-46.5]	<0.001
Female	33 721	37.6	[36.0-39.1]	-

(Table 1) contd.....

Socio-Demographics	Total	%	95% CI	P-Value
Age Group	-	-	-	-
18-29	8 794	43.0	[40.8-45.2]	<0.01
30-39	13 074	39.6	[37.5-41.7]	-
40-49	13 089	40.7	[38.3-43.2]	-
50-59	10 683	43.0	[39.8-46.3]	-
60-69	5 887	40.7	[35.8-45.9]	-
70+	1 864	29.0	[19.0-41.5]	-
Race Group	-	-	-	-
Black African	7 883	46.9	[45.2-48.5]	<0.001
Coloured	4 376	30.1	[28.3-31.9]	-
White	36 322	13.4	[12.8-14.1]	-
Indian/Asian	3 878	17.8	[16.1-19.6]	-
Employment Status	-	-	-	-
Employed full-time	28 204	40.0	[38.4-41.6]	<0.001
Employed informal/part-time	3 774	44.8	[40.3-49.3]	-
Student	2 932	43.3	[39.6-47.0]	-
Unemployed	8 131	43.4	[39.7-47.2]	-
Self-employed	10 339	34.4	[30.1-39.0]	-
Risk Perception	-	-	-	-
Low	22 917	44.7	[42.9-46.6]	<0.001
Moderate	21 110	38.1	[35.8-40.4]	-
High	9 458	38.3	[35.6-41.0]	-
Self-Isolation/Quarantine Possibility	-	-	-	-
Yes	24 546	34.1	[32.3-36.0]	<0.001
No	11 593	50.9	[48.3-53.4]	-
I don't know	17 264	40.2	[37.9-42.6]	-
Dwelling Type	-	-	-	-
Formal dwelling	52 878	40.0	[38.7-41.3]	<0.001
Informal dwelling	599	55.7	[49.6-61.6]	-
Province	-	-	-	-
Eastern Cape	2 462	39.0	[34.7-43.6]	<0.001
Free State	1 254	52.1	[46.2-58.0]	-
Gauteng	24 543	39.2	[37.7-40.7]	-
KwaZulu-Natal	6 399	39.8	[36.9-42.7]	-
Limpopo	1 020	48.8	[42.1-55.6]	-
Mpumalanga	957	40.0	[33.9-46.4]	-
North West	971	52.4	[44.9-59.8]	-
Northern Cape	478	47.2	[39.0-55.6]	-
Western Cape	15 404	30.8	[29.1-32.5]	-
Total	53 488	40.7	[39.4-42.0]	-

Table 2. Multivariate logistic regression models showing factors associated with people's perception of health system capability in managing the COVID-19 pandemic at the national and provincial levels

-	National	EC	FS	GP	KZN	LP	MP	NW	NC	WC
Socio-Demographics	OR	OR	OR	OR	OR	OR	OR	OR	OR	OR
Sex	-	-	-	-	-	-	-	-	-	-
Male	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Female	0.75*	0.96	0.61*	0.78*	0.94	0.61	0.80	0.36*	0.60	0.77*
Age Group	-	-	-	-	-	-	-	-	-	-
18-29	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
30-39	0.92	0.88	2.12*	0.88	0.76	1.33	1.10	0.73	0.90	0.80
40-49	0.97	0.53*	1.21	1.09	0.98	0.95	2.10	0.75	1.00	0.80

(Table 2) contd.....

-	National	EC	FS	GP	KZN	LP	MP	NW	NC	WC
Socio-Demographics	**OR**	**OR**	**OR**	**OR**	**OR**	**OR**	**OR**	**OR**	**OR**	**OR**
50-59	1.07	1.13	2.07	1.08	0.85	1.01	3.00	0.73	1.40	0.81
60+	0.76*	1.14	2.37	0.76	0.67	1.26	0.40	0.45	0.90	0.49*
Employment Status	-	-	-	-	-	-	-	-	-	-
Employed full-time	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Employed informally/part-time	1.21	1.20	0.55	1.21	1.40	0.62	1.50	1.35	3.50	1.31
Student	1.07	0.82	0.81	1.24	1.04	0.71	2.00	1.16	0.70	1.22
Unemployed	1.21*	0.90	0.84	1.16	1.32	0.76	2.40	1.70	2.00	1.17
Self-employed	0.78*	0.75	0.54	0.85	0.76	0.33*	1.00	1.03	2.00	0.74*
Knowledge	-	-	-	-	-	-	-	-	-	-
Knowledge score	0.89*	0.89	0.68*	0.88*	0.90*	0.99	0.90	1.04	0.80	0.86*
Risk Perception	-	-	-	-	-	-	-	-	-	-
Low	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Moderate	0.82*	1.02	0.62	0.81*	0.75*	0.73	0.80	0.97	0.50	0.94
High	0.87	0.94	0.59	0.90	0.82	0.64	0.90	0.9	0.50	0.95
Self-Isolation or Quarantine Possibility	-	-	-	-	-	-	-	-	-	-
No	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Yes	0.65*	0.54*	0.9	0.60*	0.86	0.76	0.60	0.41*	0.60	0.69*

*$p \leq 0.05$; Ref=Reference; EC=Eastern Cape; FS=Free State; GP=Gauteng; KZN=KwaZulu-Natal; LP=Limpopo; MP=Mpumalanga; NW=North West; NC=Northern Cape; WC=Western Cape.
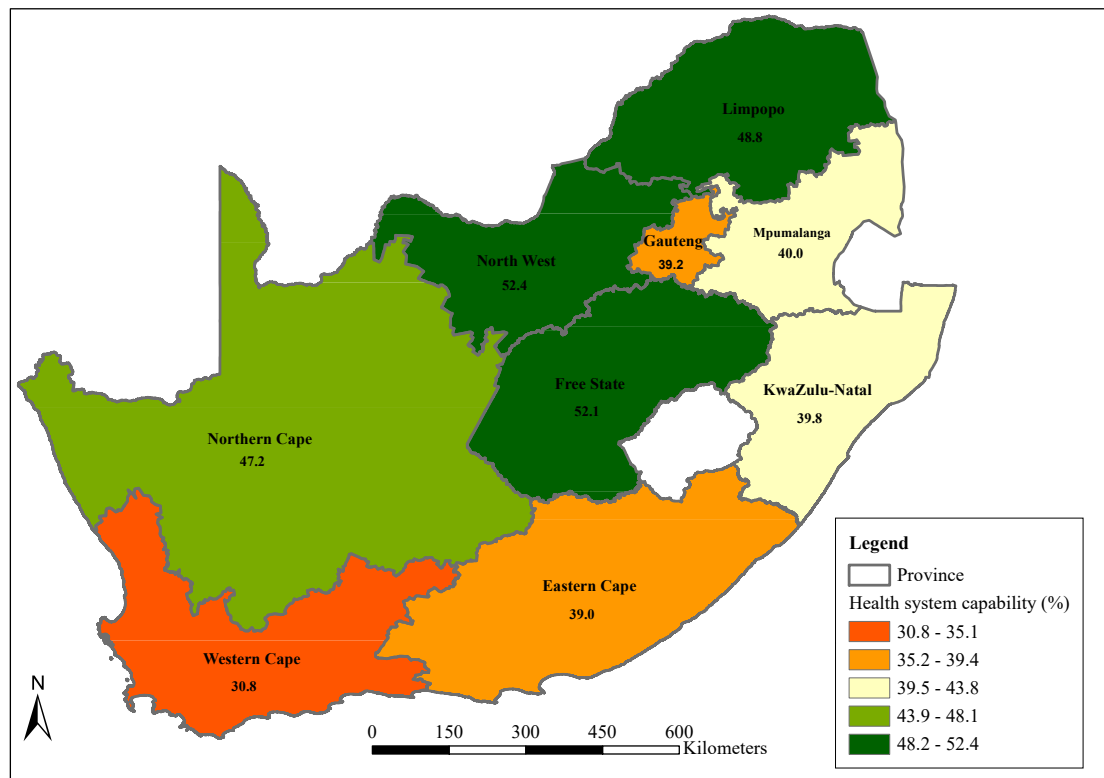

Fig. (1). Percentage of people who indicated they believe that the health system was able to manage the COVID-19 outbreak.

Multivariate logistic regression models shows that at the national level age (compared with 18-29 years: 60 years and older, OR=0.76, 95% CI: [0.59-0.99]), being female (OR=0.75 [0.67-0.83]), employment status (compared with full-time employed: unemployed, OR=1.21 [1.02-1.44] and self-employed, OR=0.78 [0.64-0.96]), knowledge score (OR=0.89 [0.85-0.93]), risk perception (compared with low risk perception: moderate, OR=0.82 [0.72-0.93]), and perception of self-isolation or quarantine possibility (OR=0.65 [0.58-0.72]) were significantly associated with the perception that the health system was capable of managing the COVID-19 pandemic (Table **2**).

Table 3. Population, hospitals, hospital beds, and ICUs beds by province.

Province	Total Population	Public Hospitals	Private Hospitals	Total Hospitals	Public Hospital Beds	Private Hospitals Beds	Total Hospital Beds	Public ICU Beds	Private ICU Beds	Total ICU Beds
Eastern Cape	6 712 276	91	17	108	13 200	1 723	14 923	93	110	203
Free State	2 887 465	34	13	47	4 798	2 337	7 135	109	114	223
Gauteng	15 176 116	39	83	122	16 656	14 278	30 934	330	1 132	1 462
KwaZulu-Natal	11 289 086	77	12	89	22 048	4 514	26 562	273	305	578
Limpopo	5 982 584	42	10	52	7 745	600	8 345	34	28	62
Mpumalanga	4 592 187	33	13	46	4 745	1 252	5 997	25	63	88
North West	4 027 160	22	14	36	5 132	1 685	6 817	54	87	141
Northern Cape	1 263 875	16	2	18	1 523	293	1 816	21	27	48
Western Cape	6 844 272	53	39	92	12 241	4 385	16 626	222	291	513
South Africa	58 775 021	407	203	610	85 362	31 067	119 155	1 178	2 140	3 318

Data sources [4, 28, 29]:

At provincial level, the models show that in the Eastern Cape, perception of self-isolation or quarantine possibility (OR=0.54 [0.37-0.8]) and age 40-49 years (OR=0.53 [0.31-0.91] compared to 18-29 years) were significantly associated with decreased odds of perceiving that the health system was capable. In the Free State, females (OR=0.61 [0.37-0.99]) and knowledge score (OR=0.68 [0.55-0.85]) were significantly associated with decreased odds of perceiving that the health system was capable while age 30-39 years (OR=2.12 [1.05-4.28] compared to 18-29 years) was significantly associated with increased odds of this perception. In Gauteng, females (OR=0.78 [0.69-0.89]), knowledge score (OR=0.88 [0.83-0.94]) and moderate risk perception (OR=0.81 [0.7-0.93] compared to low risk perception) were significantly associated with decreased odds of the perception. In KwaZulu-Natal, knowledge score (OR=0.90 [0.82-0.99]) and moderate risk perception (OR=0.75 [0.56-1.0] compared to low risk perception) were significantly associated with decreased odds of perception. In Limpopo being self-employed (OR=0.33 [0.13-0.81] compared with being in full-time employment) was significantly associated with decreased odds of perception. In the North West, females (OR=0.36 [0.20-0.67]) and perception of self-isolation or quarantine possibility (OR=0.41 [0.23-0.72]) were significantly associated with decreased odds of perception. In the Western Cape, females (OR=0.77 [0.65-0.92]), 60 years and older (OR=0.49 [0.35-0.68] compared to 18-29 years), being self-employed (OR=0.74 [0.56-0.97] compared to being in full-time employment), knowledge score (OR=0.86 [0.80-0.93]) and perception of self-isolation or quarantine possibility (OR=0.69 [0.58-0.81]) were significantly associated with decreased odds of perceiving that the health system was capable of managing the COVID-19 pandemic.

3.3. Health System Capacity

Table **3** shows secondary data on total population, hospitals, hospital beds, and ICU beds by province. Gauteng, the most populated province (smallest by geographic area) had the highest number of hospitals, however, these were mainly private hospitals (83) compared to 39 public hospitals. There were more hospital beds in public hospitals than in private hospitals, whereas the opposite was the case with regard to ICU beds across the country.

Fig. (**2**) shows the results from the spatial density analysis of hospitals and hospital beds per population. KwaZulu-Natal, Gauteng, Limpopo and North West had the lowest number of hospitals per 100 000 people with 0.79, 0.80, 0.87 and 0.89 respectively (Fig. **2a**). All the remaining provinces had more than one hospital per 100 000 people. Free State had the highest with 1.63 hospitals per 100 000 people. Gauteng had the highest number of hospital beds, followed by Western Cape, KwaZulu-Natal and Eastern Cape, with more than 10 000 beds in their hospitals. Mpumalanga, Limpopo and Northern Cape had the lowest number of hospital beds per 10 000 people (Fig. **2b**). Gauteng, which was among those with the lowest number of hospitals per 100 000 people, fell under the second-highest category with 20 hospital beds per 10 000 people. Free State, KwaZulu-Natal and Western Cape had the highest number of hospital beds per 10 000 people with 25, 24 and 24 respectively. Fig. (**2b**) also shows the broad spatial distribution of private and public hospitals across different provinces.

With regard to the number of ICU beds per 10 000 people, Limpopo and Mpumalanga fell in the lowest category of 0.10 to 0.28 ICU beds per 10 000 people (Fig. **3a**). Gauteng, Free State and Western Cape, had the highest ICU beds per 10 000 people. Fig. (**3a**) further depicts the spatial distribution of hospitals earmarked to attend to COVID-19 patients. Almost all provinces, except Gauteng, seems to have an unbalanced location of the COVID-19 hospitals. The authors are not aware of the factors that were considered when selecting the current COVID-19 hospitals. From a geographic point of view, it appears that the hospitals in each province are often located in some major cities which are not necessarily centrally located within their province. Therefore, these hospitals are not easily accessible to a large proportion of a province's population, especially if the patients will be transported by road. Hence, at least two hospitals per province could have resolved the skewness of this spatial distribution. KwaZulu-Natal in particular, has all three COVID-19 hospitals around Pietermaritzburg, which raises some spatial concern in terms of physical accessibility of these COVID-19 hospitals. For the vulnerable population, the elderly, a similar pattern was noticed, except for the Eastern Cape, which ranked in the second-lowest category of numbers of ICU beds per 10 000 people but had one of the lowest numbers of ICU beds per 10 000 elderly people. Limpopo, Mpumalanga and the Eastern Cape had between 1.17 and 3.24 ICU beds per 10 000 elderly people (Fig. **3b**).
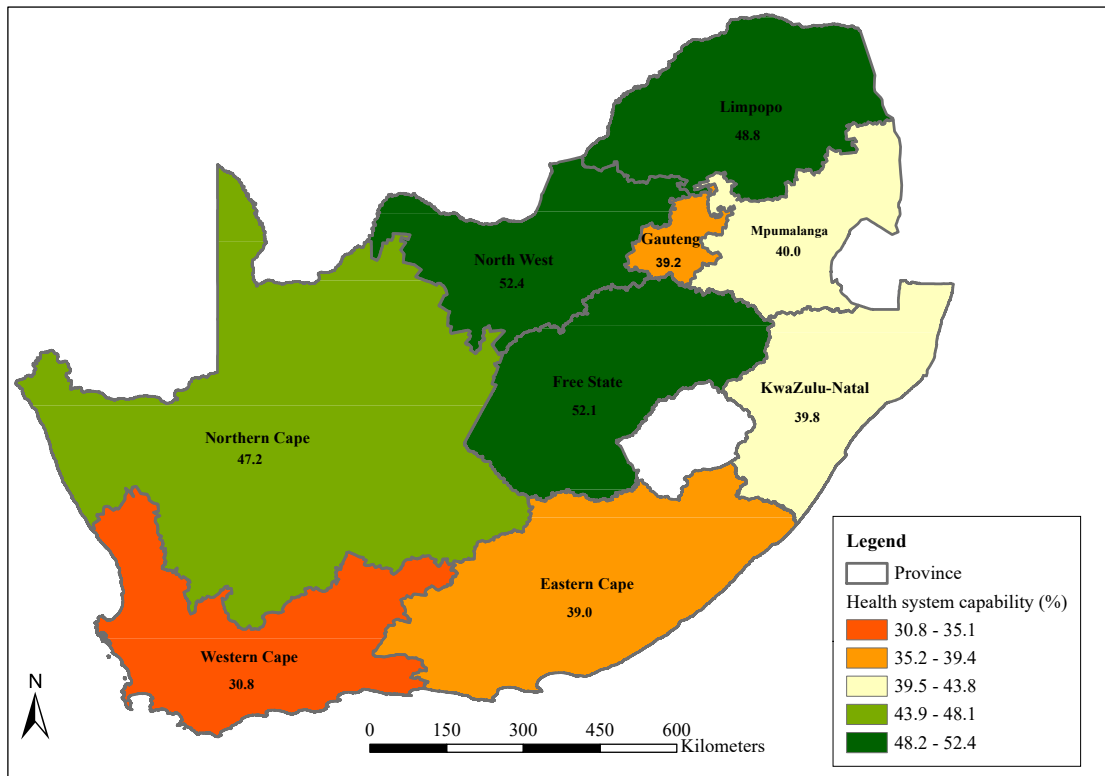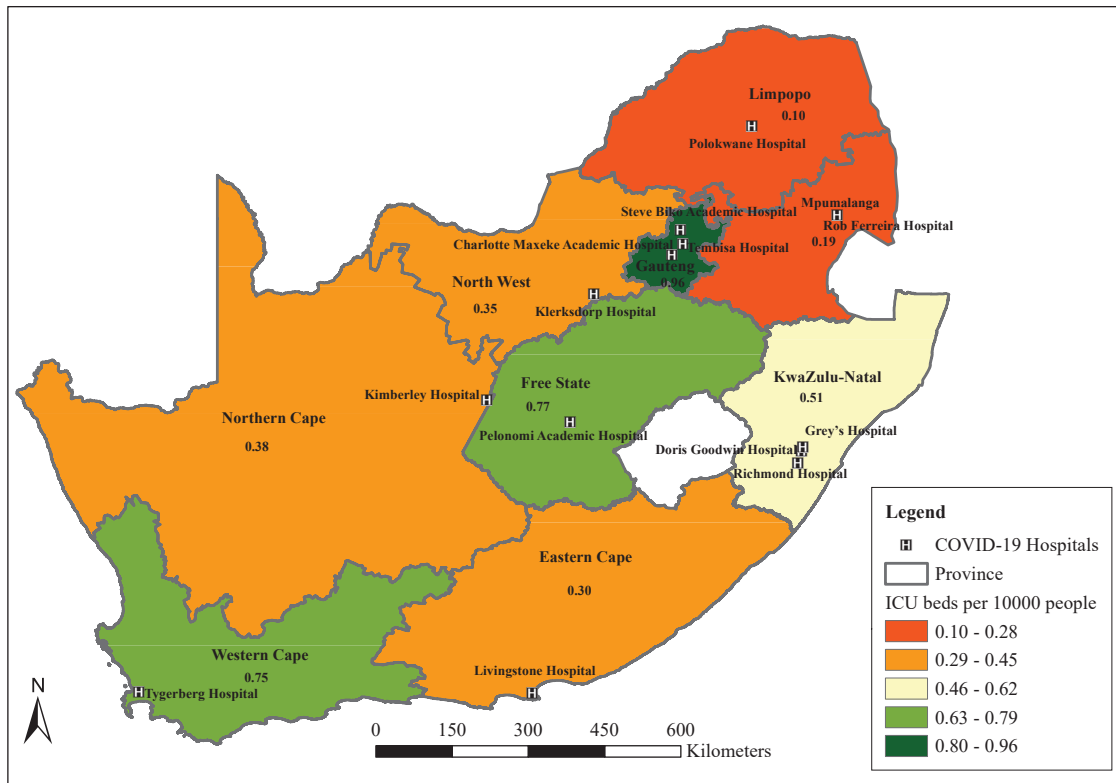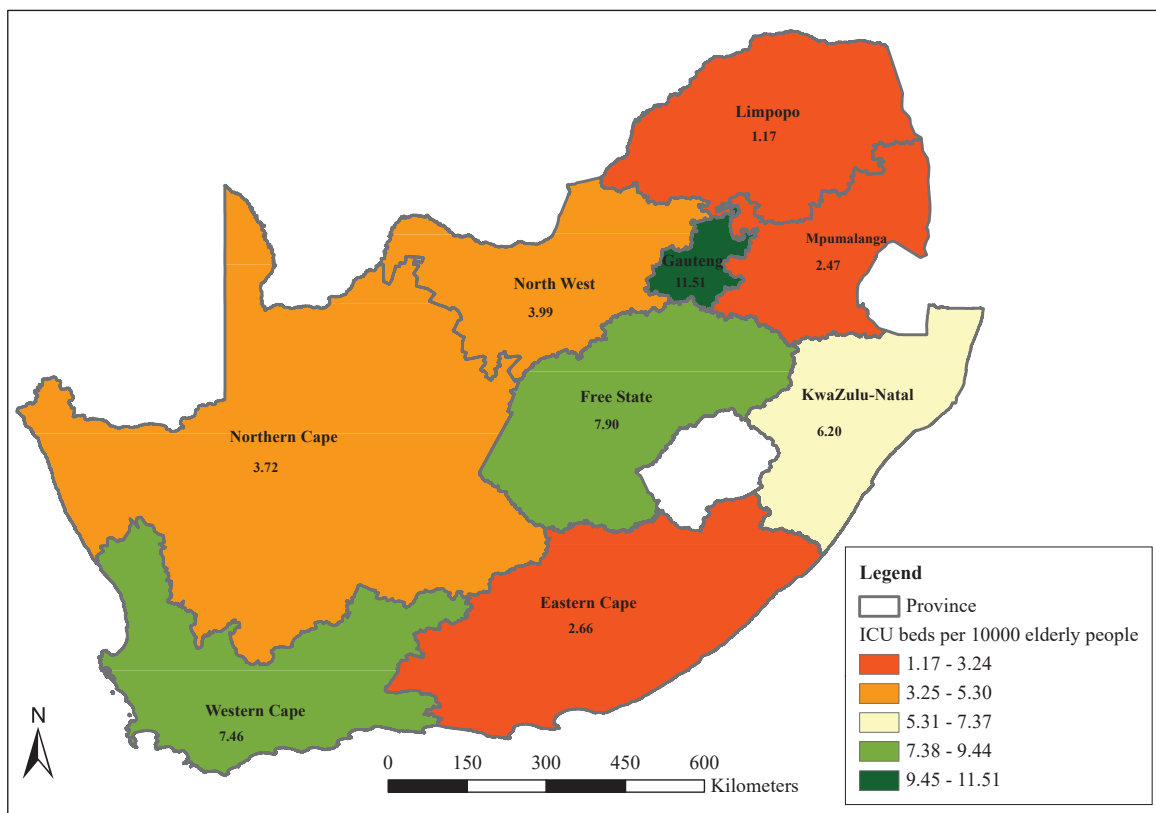
(a)
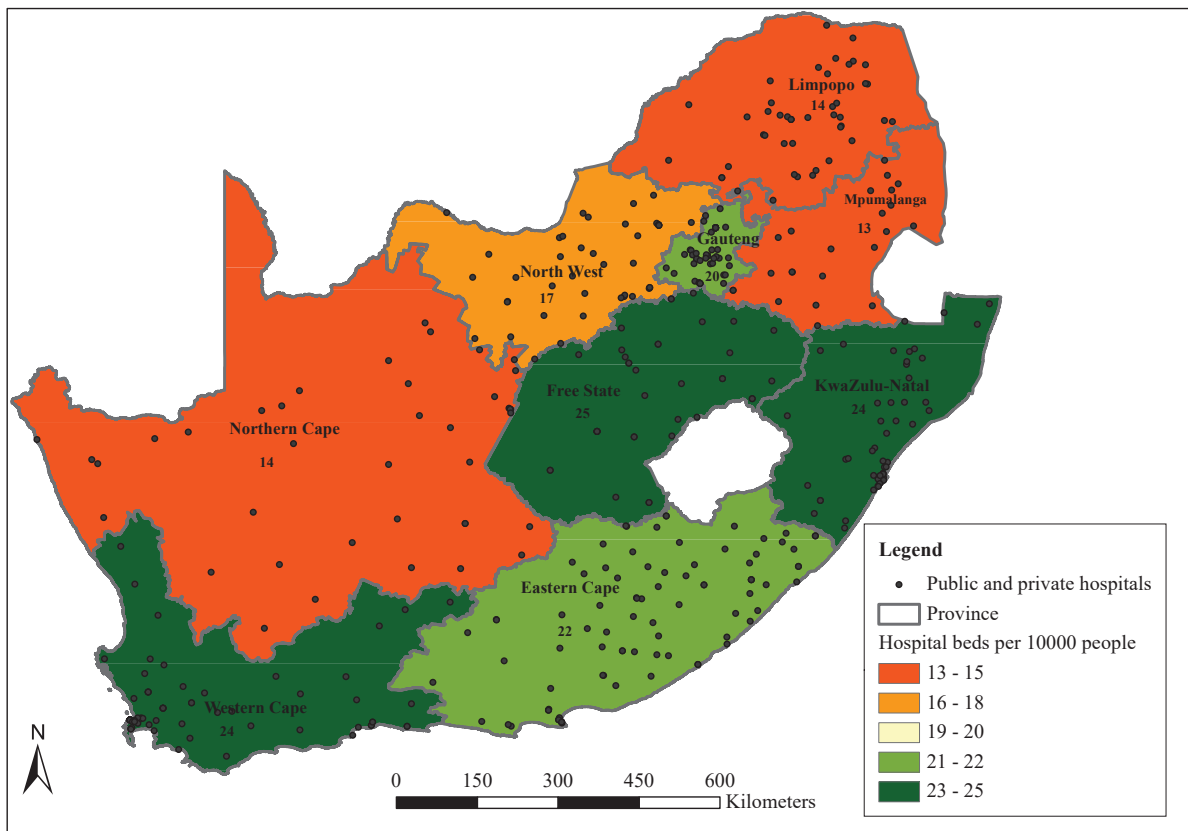
(b)

Fig. (2). Hospitals and hospital beds densities, **a**) number of hospitals per 100 000 people and **b**) number of hospital beds per 10 000 people.

(a)

(b)

Fig. (3). ICU beds densities, **a**) number of ICU beds per 10 000 people and **b**) number of ICU beds per 10 000 elderly people.

4. DISCUSSION

Overall the study findings show that people had low confidence in the South African health system, with only two out of five people indicating they thought the health system would be able to manage the COVID-19 pandemic. In similar studies conducted in Denmark and Finland, respondents reported high rates of confidence in their health systems capability to manage COVID-19 with 86% and 78% respectively [30, 31]. Black Africans, those employed part-time or informally and informal dwellers had higher confidence in the health system capability while the White population group, self-employed and those residing in formal dwellings had lower confidence in health system capability to manage the COVID-19 pandemic. This demonstrates clear divisions based on socio-economic status, geolocation as well as some racial differences in peoples' perceptions. The majority of the Black Africans rely on the public health system almost exclusively, therefore, this increased confidence could well be due to the fact that they would not have alternative options in terms of access to healthcare, traditional forms of treatments aside. The lower confidence shown here by White respondents could be directed at the public health system and not the private which is usually very well resourced. The majority of the White population group have access to medical insurance and, therefore private medical care.

Furthermore, the older persons (70 years and above), those who perceived themselves at high risk of contracting COVID-19 and those who thought they might end up in self-isolation or quarantine had the lowest confidence in the health system capacity to manage the COVID-19 pandemic. This is concerning since people in older age groups are among those that are classified as highly vulnerable to the COVID-19 pandemic around the world, both in terms of infections and fatalities [32].

Sex and knowledge on COVID-19 were significantly associated with the perception of the health system's capability to manage the pandemic at the national level and in four of the nine provinces. Females were less likely to have confidence in the health system capability to manage the COVID-19 pandemic than their male counterparts. The finding that men have more confidence in the healthcare system is surprising since previous studies reported that men generally access healthcare services much less than women do [33]. It is possible that women lacking confidence in the health system's capability could be associated with how they perceive the quality thereof. Future research needs to examine people's perceptions of health system capability in conjunction with the quality of care received. Age and self-isolation or quarantine possibility were key factors at the national level and in three provinces, while employment and risk perception were significant predictors at the national level and in two provinces. The vulnerable group, elderly (60 years and older), was a key determinant of people's confidence in the health system capability to manage the COVID-19 pandemic at the national level and in the Western Cape. People's risk perceptions (which are influenced by age and degree of perceived vulnerability) and knowledge about a public health problem often result in lower confidence in managing the problem.

Spatial accessibility has been previously reported to represent an important barrier to accessing healthcare services [17]. Spatial access to COVID-19 hospitals in our findings raises some concerns regarding the readiness to manage the COVID-19 pandemic, especially considering that most patients might have to be transported by road. These could be addressed by at least adding extra temporary hospitals earmarked for COVID-19 in each province that has only one COVID-19 hospital. Provinces have already started setting up additional healthcare facilities in preparation for the expected surge in the number of cases and the potential need for hospitalisation across the country. Predominantly rural provinces such as the Eastern Cape and KwaZulu-Natal should also undertake special context-specific planning for the provision which addresses challenges such as long distances between villages and available hospitals as well as poor road infrastructure. These extra hospitals should be allocated based on the geographic location and population distribution as well as the emerging trends of the pandemic whereby the number of cases and epicentres have been shifting since the outbreak of the COVID-19 pandemic. The Western Cape initially only had one hospital earmarked for COVID-19 in the early stages of the epidemic when our study was conducted. This later changed dramatically, with the province now being regarded as one of the epicentres for the pandemic with a high number of confirmed cases and number of deaths. This had to be revisited and more hospitals were allocated, as well as temporary hospitals being setup at the Cape Town International Convention Centre in the fight against the COVID-19 pandemic. Other provinces with big urban metros such as the Eastern Cape, Gauteng, and KwaZulu-Natal had to also readjust their plans as they all initially had three hospitals each that were earmarked for the response.

Our study findings show that the number of hospitals per population and the number of hospital beds per population across the country are generally lower compared to some international statistics from both public and private hospitals in Canada, Italy and Japan [34]. The current national average of 5.6 ICU beds per 100 000 in South Africa is slightly lower compared to those of some European countries such as the United Kingdom (6.6), France (9.7) and Italy (12.5). Turkey and Germany had the highest reported numbers with 46 and 29.2 ICU beds per 100 000 population [32].

Findings from this paper show that there were some similarities between people's perceptions of health system capability and the actual health system capacity to manage the COVID-19 pandemic in some provinces. For instance, Free State was predominantly at the upper band in terms of the proportion of people who had confidence in the health systems capability and the actual health system capacity to manage the pandemic. Eastern Cape, on the other hand was at the lower end with regard to people's confidence in health systems capability and health system capacity. Eastern Cape appeared at the upper bound only on the number of hospitals per 100 000 population and the number of hospital beds per 10 000 population. Surprisingly, Western Cape had the lowest score of people's confidence in the health system capability to manage the COVID-19 pandemic, yet it was among the top for almost all density indicators of health system capacity except for the density on number of ICU beds per 10 000 elderly people where it was in the middle range. Western Cape also had the highest significant proportion of elderly people based on the online survey results. In addition, results showed that the

elderly (60 years and above) was a significant predictor of people's confidence in health system capability. This might have attributed to the lowest confidence in the health system capability in this province. Although North West and Limpopo had the highest proportions of people who felt that the health system was capable to deal with the COVID-19 pandemic, they were among the lowest in all health system capacity indicators.

The COVID-19 pandemic demonstrated and highlighted the urgency and the importance of the implementation of the NHI, especially in addressing the inequity of access to healthcare that exists between private and public health care. The COVID-19 pandemic has laid bare the health disparities that exists between different communities in the country due to historical structural systems brought about by both colonialism and the apartheid race based spatial planning and service provision. This pandemic provides the first and best opportunity for South Africa to reengineer the country's health system to be united and integrated as much as possible between the public and private health systems. The COVID-19 block exemption for the health sector is an important step towards the testing the implementation of NHI. The government and all role players in the country should embrace this opportunity by ensuring that all systems that are necessary for the implementation of the NHI are put in place and expanded upon.

This study does have some limitations. One of the main limitations was that there was no clarity in the online questionnaire on whether the definition of the South African health system included both private and public sector. The survey relied on self-report which is prone to social desirability bias, which could have led to underestimation or overestimation of the people's confidence in health systems capability to deal with the COVID-19 pandemic depending on how they understood and experience the health system. Respondents may also have been responding on their perceptions of the health system regardless of whether they utilise those services or not. Other than the above mentioned limitations, findings from this study contributes to the body of evidence on people's perceptions about the South African health system capability and the state of health system capacity to manage the COVID-19 pandemic across the country.

CONCLUSION

To the best of our knowledge, this paper was the first to investigate people's perception of the South African health system capability and the actual health system capacity to respond to the COVID-19 pandemic and its subsequent spread. Overall, most people had low confidence in the health system capability in managing the COVID-19 pandemic and that may be due to having the wrong perceptions or may be due to prior poor experiences in their interaction with healthcare facilities and/or services. Sex and knowledge on COVID-19 were significantly associated with the perception of the health system's capability to manage the pandemic at the national level and in four of the nine provinces. Females were less likely to have confidence in the health system capability to manage the COVID-19 outbreak pandemic as compared to their male counterparts. Overall, the findings of this study clearly highlights the challenges of the country's health system, both perceived or real that needed to be addressed as part of the preparation for the COVID-19 pandemic. Urgent policy

interventions and implementations are recommended for continued increase in the number of ICU beds across the country with particular focus in Western Cape, Eastern Cape, KwaZulu-Natal and Gauteng. Timeous implementation of a countrywide NHI system is now more critical than ever in improving healthcare outcomes of the South African population even beyond the existence of the COVID-19 pandemic. Future research need to examine people's perception of health system capability in conjunction with the quality of care received. Future research should also explore the country's readiness for NHI implementation as well as preparedness for future waves of COVID-19 and other pandemics. People's perception of NHI should also be explored, especially during and after the COVID-19 pandemic.

AUTHORS' CONTRIBUTIONS

SPR conceived the study and TM conceptualised the paper. TM and RS conducted the analysis and interpreted the results. TM drafted the manuscript. TM, RS, SS, GWS, SD, TMa, IN, WP, ND, SJ, SP, KZ, MMo, MM, SPR contributed to interpreting the results and editing the manuscript. All authors read and approved the final manuscript before submission.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethics approval was received from the Human Sciences Research Council (HSRC) Research Ethics Committee (REC); (REC 5/03/20).

HUMAN AND ANIMAL RIGHTS

No Animals were used in this research. All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013.

CONSENT FOR PUBLICATION

All participants provided electronic informed consent.

FUNDING

AVAILABILITY OF DATA AND MATERIALS

All data generated or analysed during this study are available on request from the corresponding author [TM].

CONFLICTS OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

REFERENCES

[1] Jenberg L. Health E-News COVID-19 pandemic: Panic or preparation? 2020. Available online: https://health-e.org.za/2020/02/27/covid-19-pandemic-panic-or-prepar ation/

[2] Zhang J, Dong X, Cao Y, *et al.* Clinical characteristics of 140 patients infected with SARS-CoV-2 in Wuhan, China. Allergy: European J Allergy Clinical Immunol 2020; 1-12.
[http://dx.doi.org/10.1111/all.14238]

[3] Du Toit P, Cowan K. 2020.SA government plans for COVID-19 to peak in September but questions about data remain Available from: https://m.news24.com/SouthAfrica/News/sa-government-plans-for-cov id-19-to-peak-in-september-but-questions-about-data-remain-20200411

[4] Van der Heveer A. COVID-19 Bed supply. Johannesburg: Dataset 2020.

[5] Rosero-Bixby L. Spatial access to health care in Costa Rica and its equity: A GIS-based study. Soc Sci Med 2004; 58(7): 1271-84.
[http://dx.doi.org/10.1016/S0277-9536(03)00322-8] [PMID: 14759675]

[6] Benatar SR. The challenges of health disparities in South Africa. S Afr Med J 2013; 103(3): 154-5.
[http://dx.doi.org/10.7196/SAMJ.6622] [PMID: 23472690]

[7] Hu R, Dong S, Zhao Y, Hu H, Li Z. Assessing potential spatial accessibility of health services in rural China: A case study of Donghai County. Int J Equity Health 2013; 12(1): 35.
[http://dx.doi.org/10.1186/1475-9276-12-35] [PMID: 23688278]

[8] Guerrero EG, Kao D. Racial/ethnic minority and low-income hotspots and their geographic proximity to integrated care providers. Subst Abuse Treat Prev Policy 2013; 8(34): 34.
[http://dx.doi.org/10.1186/1747-597X-8-34] [PMID: 24059252]

[9] Mansour S. Spatial analysis of public health facilities in Riyadh Governorate, Saudi Arabia: A GIS-based study to assess geographic variations of service provision and accessibility. Geo Spat Inf Sci 2016; 19(1): 26-38.
[http://dx.doi.org/10.1080/10095020.2016.1151205]

[10] Burger R, Christian C. Access to health care in post-apartheid South Africa: Availability, affordability, acceptability. Health Econ Policy Law 2020; 15(1): 43-55.
[http://dx.doi.org/10.1017/S1744133118000300] [PMID: 29996951]

[11] Robin TA, Khan MA, Kabir N, *et al.* Using spatial analysis and GIS to improve planning and resource allocation in a rural district of Bangladesh. BMJ Glob Health 2019; 4(e000832)(Suppl. 5).e000832
[http://dx.doi.org/10.1136/bmjgh-2018-000832] [PMID: 31321091]

[12] Gradín C. Occupational segregation by race in South Africa after apartheid. Rev Dev Econ 2019; 23(2): 553-76.
[http://dx.doi.org/10.1111/rode.12551]

[13] Nkonki L, Fonn S. Decisive and strong leadership and intersectoral action from South Africa in response to the COVID-19 virus. S Afr Med J 2020; 110(5): 339-40.
[http://dx.doi.org/10.7196/SAMJ.2020.v110i5.14739] [PMID: 32657709]

[14] Competition Act (89/1998), as amended: COVID-19 block exemption for the healthcare sector, 2020 Department of Trade and Industry. Pretoria: DTI 2020.

[15] Black M, Ebener S, Aguilar PN, Vidaurre M, El Morjani Z. 2004.Using GIS to measure physical accessibility to health care Available from: http://www.who.int/kms/initiatives/Ebener_et_al_2004a.pdf

[16] Mokhele T, Weir-Smith G, Labadarios D. Development of health density indicators in South Africa using GIS. *GeoInformation Society of South Africa (GISSA)* Conference Proceedings. 110-6.

[17] Huerta Munoz U, Källestål C. Geographical accessibility and spatial coverage modeling of the primary health care network in the Western Province of Rwanda. Int J Health Geogr 2012; 11(40): 40.
[http://dx.doi.org/10.1186/1476-072X-11-40] [PMID: 22984920]

[18] Khashoggi BF, Murad A. Issues of healthcare planning and GIS: A review. International Journal of Geo-Information 2020; 9(352): 1-27.
[http://dx.doi.org/10.3390/ijgi9060352]

[19] Siegel M, Koller D, Vogt V, Sundmacher L. Developing a composite index of spatial accessibility across different health care sectors: A German example. Health Policy 2016; 120(2): 205-12.
[http://dx.doi.org/10.1016/j.healthpol.2016.01.001] [PMID: 26831039]

[20] Ma L, Luo N, Wan T, Hu C, Peng M. An improved healthcare accessibility measure considering the temporal dimension and population demand of different ages. Int J Environ Res Public Health 2018; 15(11)E2421
[http://dx.doi.org/10.3390/ijerph15112421] [PMID: 30384482]

[21] Chatterje P. Gaps in India's preparedness for COVID-19 control: Under-investment in public health-care system poses a challenge to India's COVID 19 containment plans. Lancet 2020; 20: 544.
[http://dx.doi.org/10.1016/S1473-3099(20)30300-5]

[22] Reddy SP, Sewpaul R, Mabaso M, *et al.* South Africans' understanding of and response to the COVID-19 outbreak: An online survey. S Afr Med J 2020; 110(9): 894-902.
[http://dx.doi.org/10.7196/SAMJ.2020.v110i9.14838] [PMID: 32880275]

[23] Sifunda S, Mokhele T, Manyaapelo T, *et al.* Preparedness for self-isolation or quarantine and lockdown in South Africa: results from a rapid online survey. BMC Public Health 2021; 21(1): 580.
[http://dx.doi.org/10.1186/s12889-021-10628-9] [PMID: 33757461]

[24] Nooh HZ, Alshammary RH, Alenezy JM, *et al.* Public awareness of coronavirus in Al-Jouf region, Saudi Arabia. J Public Health (Bangkok) 2020; 1-8.
[http://dx.doi.org/10.1007/s10389-020-01209-y] [PMID: 32206545]

[25] Ipsos. Coronavirus: Opinion and reaction results from a multi-country poll 12 - 14 March 2020. Available from: https://www.ipsos.com/sites/default/files/ct/news/documents/2020-03/t racking-the-coronaviruswave-4-ipsos.pdf Accessed 25 March 2020.

[26] Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC 2017.

[27] Stats SA. Mid-year population estimates 2019. Pretoria: Statistics South Africa 2019.

[28] Naidoo K, Singh J, Lalloo U. A critical analysis of ICU/HC beds in South Africa: 2008-2009. S Afr Med J 2013; 103(10): 751-3.
[http://dx.doi.org/10.7196/SAMJ.6415] [PMID: 24079628]

[29] Makombo T. Fast Facts: Public health sector in need of an antidote. Fast Facts 2016; 6(298): 6.

[30] Norrestad F. Trust in the handling of the COVID-19 outbreak of the health system in Denmark 2020. Available from: https://www.statista.com/statistics/1105447/trust-in-the-handling-of-th e-covid-19-outbreak-of-the-health-system-in-denmark/

[31] Norrestad F. Trust in the handling of the COVID-19 outbreak of the health system in Finland 2020. Available online: https://www.statista.com/statistics/1105457/trust-in-the-handling-of-th e-covid-19-outbreak-of-the-health-system-in-finland/

[32] WHO. Strengthening the health system response to COVID-19: Recommendations for the WHO European Region. Policy brief (1 April 2020) World Health Organization 2020.

[33] Van Heerden A, Msweli S, Van Rooyen H. Men don't want things to be seen or known about them: A mixed-methods study to locate men in a home based counselling and testing programme in KwaZulu-Natal, South Africa. Afr J AIDS Res 2015; 14(4): 353-9.
[http://dx.doi.org/10.2989/16085906.2015.1121881]

[34] Wilson DM, Brow R, Playfair R, Errasti-Ibarrondo B. What is the "right" number of hospital beds for palliative population health needs? Societies (Basel) 2018; 8(108): 1-7.
[http://dx.doi.org/10.3390/soc8040108]