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The impact of the Omicron epidemic on the health behavior in Cape Town, South Africa

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ABSTRACT

Background: South Africa was the first country with a case of Omicron variant infection diagnosed; therefore, this study aimed to elucidate the impact of the Omicron mutant strain outbreak on the health behavior of the South African population and encourage the population to adopt timely protective behaviors against Omicron mutant strain infection.

Study design and methods: This was a population-based, cross-sectional study conducted in Cape Town, South Africa, in December 2021. We distributed 300 questionnaires to adults aged >18 years, and they were all returned.

Results: Of the South African population, 60.3% expressed a high level of concern regarding Omicron; 89.3% improved on at least one of the following three health behaviors: mask-wearing, washing hands, and reducing socialization; and only 10.7% exhibited no improvement in health behaviors. Of these, 71.3% and 57.0% increased the length of time they wore a mask and washed their hands, respectively, and 47% decreased the number of times they socialized. Age, residence, education level, chronic disease, and whether they had received the COVID-19 vaccine were significantly different ($p < 0.05$) between the presence and absence of enhanced health behaviors. The levels of concern and knowledge regarding the Omicron virus significantly influenced health-behavior change (all $P < 0.05$).

Conclusion: There has been a positive change in the South African population toward adopting mask-wearing, hand washing, and reducing socialization in response to the Omicron virus strain epidemic. Based on one health approach, it is important to focus on populations with chronic diseases, those who have not yet received the COVID-19 vaccine, and other populations with low rates of health behavior change.

1. Introduction

Since the novel coronavirus pneumonia was first reported in 2019, it has rapidly spread globally. As of January 19, 2022, over 330 million people have been infected with new coronaviruses worldwide, and over 5.9 million have died. The constant mutation of the new coronavirus is a great challenge for the prevention and control of the new coronavirus pandemic. On November 11, 2021, the first case of omicron sequencing was reported in Botswana. The earliest known case of omicron in South Africa was a patient diagnosed with COVID-19 on November 9, 2021 [1]. This variant became the overwhelmingly dominant variant among new coronavirus infections in Gauteng, South Africa, exhibiting rapid growth in the following two weeks. [2]. On November 26, 2021, the World Health Organization (WHO) identified variant B.1.1.529 of NCCV, first reported in South Africa, as the fifth "variant of concern" and named it after the Greek letter Omicron, the most severely mutated variant to date, which has rapidly spread throughout South Africa, the United States, and Europe, becoming the major NCC epidemic. It has

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emerged as the predominant strain of the coronavirus pneumonia pandemic. According to preliminary studies, the Omicron virus has greatly increased its ability to spread [3]. Some studies have demonstrated that the Omicron variant has a mutation in the structure of the spike glycoprotein, which potentially alters the transmissibility and infectivity of COVID-19 (coronavirus disease 2019), leading to neutralizing antibody escape and cases of breakthrough infection [3]; thus, Omicron is potentially more infectious than other variants and partially resistant to existing vaccines [4]. Undoubtedly, the Omicron virus poses a significant threat to the development of the global pandemic.

The One Health approach supports global health security by focusing on interdisciplinary collaboration to improve coordination at the human-animal-environment interface. [5]. One of the most important host factors for the emergence/re-emergence of infection and disease are those associated with human behavior [6]. Health behavior is also an important component of public health. Since the emergence of the global COVID-19 pandemic, several preventive measures have been implemented in various countries to control the outbreak [7]. The effective prevention of virus transmission through healthy behaviors, such as wearing masks, hand washing, maintaining social distance, and reducing socialization by staying at home, is an important strategy to control the COVID-19 pandemic [8]. Considering the advent of the Omicron variant strain epidemic, this strategy is particularly important in low- and middle-income countries with limited medical and hospital resources [9].

Following an Omicron variant strain epidemic, more aggressive WHO-recommended prevention and control measures are required, and encouraging the population to adopt timely protective behaviors against Omicron variant infections is important for the prevention and control of the epidemic. South Africa was the first country with a case of Omicron variant infection diagnosed; hence, we conducted this study to elucidate the impact of the Omicron variant strain epidemic on the health behavior of the South African population.

2. Methods

2.1. Study design and data collection

This was a cross-sectional, population-based study conducted in Cape Town, South Africa, in December 2021. The population surveyed here included adults aged >18 years. A total of 300 questionnaires were distributed, and all were returned. Participants provided written informed consent, and approval for this study was obtained from the Ethics Committee of Taizhou Hospital, Zhejiang Province, China (approval number: K20210705). All procedures were performed in accordance with the guidelines of the Ethics Committee.

2.2. Structured questionnaire and measurement

The questionnaire comprised three parts. The first part was a survey of respondents' basic information, including age, sex, place of residence, education, occupation, and chronic disease status. The second part predominantly interrogated the respondents' knowledge of and attitude toward the Omicron variant virus. For example, (1) their "level of concern regarding Omicron, a new coronavirus variant strain currently prevalent in South Africa and other countries?" (options: "high" and "low"); (2) "intensity of infectiousness of the new Omicron coronavirus variant strain?" (options: "stronger" and "not stronger"); (3) "How do you think the new Omicron coronavirus variant strain affects the disease?" (options: "more severe" and "not more severe"); and (4) "How effective do you think the COVID-19 vaccine is in preventing the Omicron variant virus?" (Options: "high" and "low"). The third section investigated changes in the respondents' health behaviors since the Omicron variant strain became prevalent. We investigated health behaviors, including wearing masks, hand washing, and participating in social activities, with the following options: "increased," "no change," and "decreased."

2.3. Statistical analysis

The main survey outcomes were changes in the frequency of wearing masks, hand washing, and participation in social activities. Differences in health-behavior changes were compared across groups and among people with different perceptions of the Omicron variant virus. Categorical variables were compared using the χ^2 test. All data were analyzed using IBM SPSS Statistics software (version 26.0; SPSS Inc., Chicago, IL, USA). All tests were two-tailed, and P values <0.05 were considered statistically significant.

3. Results

Table 1 summarizes the basic characteristics of the surveyed population and analysis of the 300 questionnaires. In the surveyed population, 56% were men, and 44% were women. Most participants were under 50 years of age, 13.7% were aged >50 years, and there were no

Table 1
Demographic characteristics of the study population, $N = 300$.

Independent Variables	Categories	Total Sample, *N* (%)
Total		300 (100%)
Sex	Male	168 (56.0%)
	Female	132 (44.0%)
Age	<30	82 (27.3%)
	30–39	142 (47.3%)
	40–49	35 (11.3%)
	50+	41 (13.7%)
Residence	Rural/ Town	206 (68.7%)
	Urban	94 (31.3%)
Education level	Junior high school and below	61 (20.3%)
	High school/vocational high school/ vocational secondary school	127 (42.3%)
	Junior College and above	112 (37.3%)
Occupation	Farmer	56 (18.7%)
	Workman	120 (40.0%)
	Teacher	16 (5.3%)
	Healthcare worker	18 (6.0%)
	Civil servant	22 (7.3%)
	Other	68 (22.7%)
Chronic disease	No	124 (41.3%)
	Yes	176 (58.7%)
Risk perception of COVID-19 infection	Very high	48 (16.0%)
	High	88 (29.3%)
	General	117 (39.0%)
	Low	36 (12.0%)
	Very low	11 (3.7%)
Have you received the COVID-19 vaccine?	No	62 (20.7%)
	Yes (only received one dose)	65 (21.7%)
	Yes (already received two doses)	130 (43.3%)
	Yes (already received the booster dose)	43 (14.3%)
Concern for Omicron	High	181 (60.3%)
	Low	119 (39.7%)
Perception of the infectious intensity of omicron	Stronger	140 (46.7%)
	Not stronger	160 (53.3%)
Perception of the effect of omicron on the condition	More severe	128 (42.7%)
	Not more severe	172 (57.3%)
Confidence in the effectiveness of COVID-19 vaccine against Omicron	High	190 (63.3%)
	Low	110 (36.7%)

older people aged >60 years. A total of 68.7% lived in rural areas, 58.7% had chronic diseases, and 79.3% had received at least one dose of the COVID-19 vaccine. Table 1 also shows respondents' attitudes toward and perceptions of the Omicron variant virus. A total of 45.3% considered themselves to be at a high risk of contracting Omicron, and 60.3% were highly concerned about Omicron. Furthermore, 46.7% considered Omicron to be more infectious, and 42.7% considered it to make the disease more severe. Moreover, 63.3% believed that the COVID-19 vaccine was effective in preventing Omicron infection.

Fig. 1 illustrates the changes in respondents' health behaviors. After the emergence of the Omicron strain epidemic, 89.3% improved on at least one of the following three health behaviors: mask wearing, washing hands, and reducing socialization, and only 10.7% exhibited no improvement in health behaviors. Of these, 71.3% and 57.0% increased the duration of mask wearing and hand washing, respectively, and 47% decreased socialization. Table 2 summarizes the results of the chi-square analysis of health-behavior change by population and according to perceptions and attitudes toward the Omicron virus. Age, residence, education level, chronic disease, and whether they had already received the COVID-19 vaccine were significantly different ($p < 0.05$) between the presence and absence of enhanced health behaviors. Individuals who considered themselves at a high risk of infection and those who had already received the COVID-19 vaccine were more likely to engage in enhanced health behaviors. Those with high levels of (1) concern regarding Omicron; (2) knowledge regarding the intensity of Omicron transmission and the degree of its impact on the COVID-19-disease condition; and (3) confidence in the effectiveness of the COVID-19 vaccine in preventing the Omicron virus were more likely to engage in enhanced health behaviors (all $P < 0.05$).

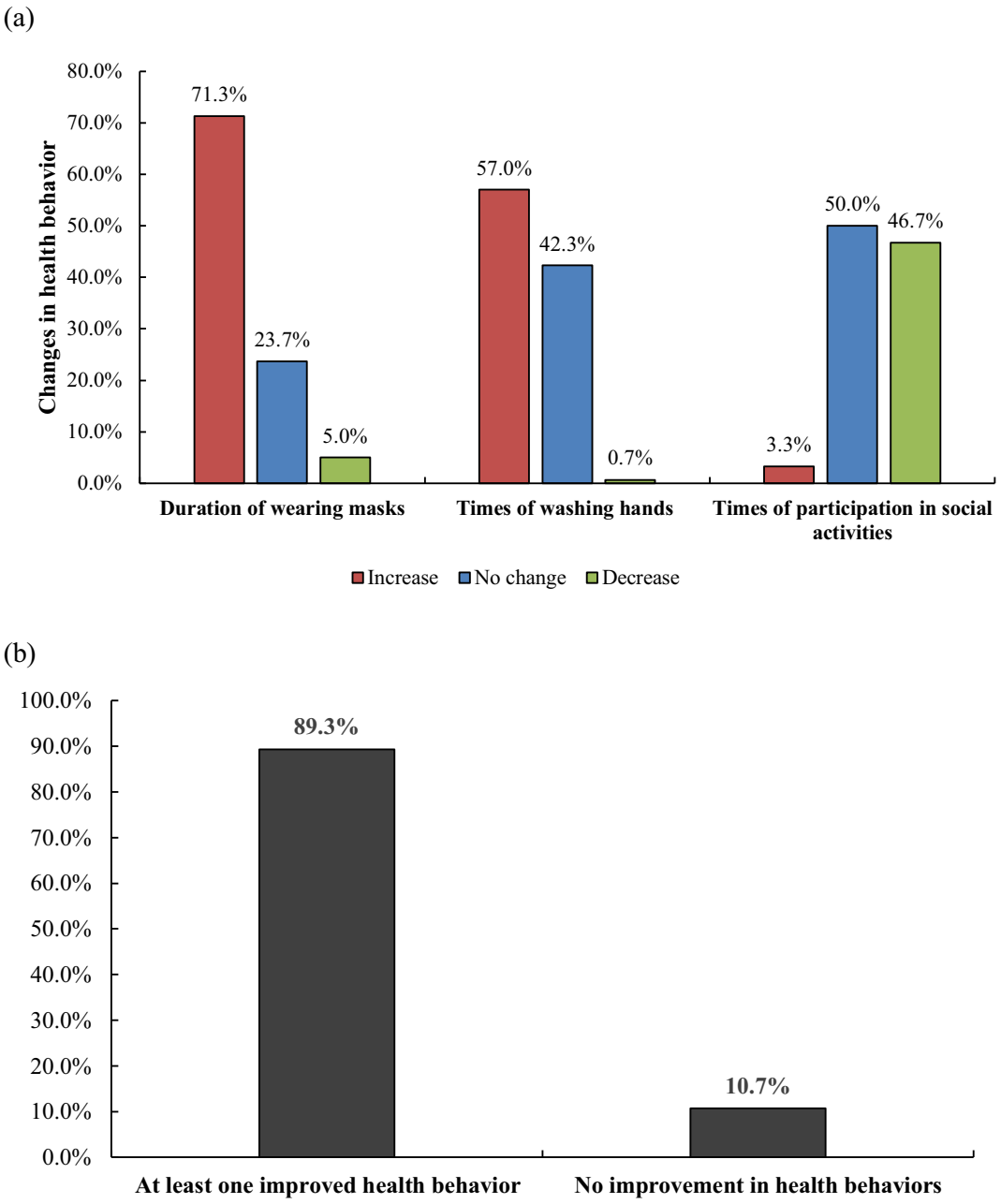

Fig. 1. Changes in health behavior in the South African population after the Omicron variant strain epidemic, N = 300.

Table 2
A chi-square analysis of potential factors underlying changes in health behavior in the South African population following the Omicron variant strain epidemic.

Variables	Categories	Duration of wearing masks		χ^2	P	Times of washing hands		χ^2	P	Times of participation in social activities		χ^2	P
		Increase	Not increase			Increase	Not increase			Decrease	Not decrease		
Sex	Male	119 (70.8%)	49 (29.2%)	0.047	0.829	95 (56.5%)	73 (43.5%)	0.03	0.858	79 (47.0%)	89 (53.0%)	0.02	0.889
	Female	95 (72.0%)	37 (28.0%)			76 (57.6%)	56 (42.4%)			61 (46.2%)	71 (53.8%)		
Age	<40	166 (74.1%)	58 (25.9%)	3.327	0.068	133 (59.4%)	91 (40.6%)	2.04	0.154	92 (41.1%)	132 (58.9%)	11.12	0.001
	40+	48 (63.2%)	28 (36.8%)			38 (50.0%)	38 (50.0%)			48 (63.2%)	28 (36.8%)		
Residence	Rural/ Town	143 (69.4%)	63 (30.6%)	1.18	0.277	106 (51.5%)	100 (48.5%)	8.24	0.004	93 (45.1%)	113 (54.9%)	0.61	0.434
	Urban	71 (75.5%)	23 (24.5%)			65 (69.1%)	29 (30.9%)			47 (50.0%)	47 (50.0%)		
Education level	Junior high school and below	30 (49.2%)	31 (50.8%)	27.91	< 0.001	18 (29.5%)	43 (70.5%)	26.33	< 0.001	13 (21.3%)	48 (78.7%)	22.62	< 0.001
	High school/ vocational high school/ vocational secondary school	87 (68.5%)	40 (31.5%)			75 (59.1%)	52 (40.9%)			61 (48.0%)	66 (52.0%)		
	Junior College / Undergraduate and above	97 (86.6%)	15 (13.4%)			78 (69.6%)	34 (30.4%)			66 (58.9%)	46 (41.1%)		
Chronic disease	No	119 (96.0%)	5 (4.0%)	62.73	< 0.001	92 (74.2%)	32 (25.8%)	25.49	< 0.001	63 (50.8%)	61 (49.2%)	1.46	0.228
	Yes	95 (54.0%)	81 (46.0%)			79 (44.9%)	97 (55.1%)			77 (43.8%)	99 (56.3%)		
Risk perception of COVID-19 infection	High	120 (88.2%)	16 (11.8%)	34.76	< 0.001	85 (62.5%)	51 (37.5%)	3.07	0.080	63 (46.3%)	73 (53.7%)	0.01	0.914
	Low	94 (57.3%)	70 (42.7%)			86 (52.4%)	78 (47.6%)			77 (47.0%)	87 (53.0%)		
Have you received the COVID-19 vaccine?	No	8 (2.9%)	54 (87.1%)	140.9	< 0.001	22 (35.5%)	40 (64.5%)	20.92	< 0.001	19 (30.6%)	43 (69.4%)	24.85	< 0.001
	Already received one dose	56 (86.2%)	9(13.8%)			47 (72.3%)	18 (27.7%)			24 (36.9%)	41 (63.1%)		
	Already received two doses	121 (93.1%)	9 (6.9%)			72 (55.4%)	58 (44.6%)			64 (49.2%)	66 (50.8%)		
	Already received the booster dose	29 (67.4%)	14 (32.6%)			30 (69.8%)	13 (30.2%)			33 (76.7%)	10 (23.3%)		
Concern for Omicron	High	154 (85.1%)	27 (14.9%)	42.19	< 0.001	122 (67.4%)	59 (32.6%)	20.15	< 0.001	72 (39.8%)	109 (60.2%)	33.68	< 0.001
	Low	60 (50.4%)	59 (49.6%)			49 (41.2%)	70 (58.8%)			88 (73.9%)	31 (26.1%)		
Perception of the infectious intensity of omicron	Stronger	121 (86.4%)	19 (13.6%)	29.25	< 0.001	96 (68.6%)	44 (31.4%)	14.34	< 0.001	75 (53.6%)	65 (46.4%)	5.03	0.025
	Not stronger	93 (58.1%)	67 (41.9%)			75 (46.9%)	85 (53.1%)			65 (40.6%)	95 (59.4%)		
Perception of the effect of omicron on the condition	More severe	117 (91.4%)	11 (8.6%)	43.99	< 0.001	96 (75.0%)	32 (25.0%)	29.51	< 0.001	62 (48.4%)	66 (51.6%)	0.28	0.596
	Not more severe	97 (56.4%)	75 (43.6%)			75 (43.6%)	97 (56.4%)			78 (45.3%)	94 (54.7%)		
Confidence in the effectiveness of COVID-19 vaccine against omicron	High	161 (84.7%)	29 (15.3%)	45.53	< 0.001	121 (63.7%)	69 (36.3%)	9.45	0.002	97 (51.1%)	93 (48.9%)	4.01	0.045
	Low	53 (48.2%)	57 (51.8%)			50 (45.5%)	60 (54.5%)			43 (39.1%)	67 (60.9%)		

4. Discussion

Omicron was first detected in South Africa, where it accounted for the largest number of cases (96%). Subsequently, cases of the SARS-CoV-2 Omicron variant were reported in 138 countries, including Norway, Korea, Canada, China, and Denmark [10–13]. Omicron is rapidly spreading in Europe, the United States, and other countries, causing a backlash against the COVID-19 epidemic. For South Africa, the first reported country, elucidating the changes in the health behavior of its population after the advent of the Omicron epidemic has important implications on the adjustment of future prevention and control policies.

Since the Omicron epidemic, 60.3% of the South African population has demonstrated a high level of concern regarding Omicron; additionally, 46.7% believed that the Omicron strain was more infectious,

and 42.7% believed that Omicron made the disease more severe. Furthermore, 63.3% of the population exhibited a high level of confidence in the effectiveness of existing vaccines in preventing Omicron infection. Moreover, the South African population demonstrated a more positive behavior toward outbreak prevention and control. The number of people who wore masks more often and washed their hands increased by 71.3% and 57.3%, respectively, and 46.7% reported preventing the spread of the virus by reducing social interaction. In addition, 89.3% of the population improved on at least one health behavior to prevent Omicron infection. One study compared health behaviors across continents. Before the emergence of the Omicron variant strain, 80–90% of the population in Asia and 80% of the American population adopted healthy behaviors; however, positive attitudes toward COVID-19 prevention measures declined significantly over time. The proportion of African people who adopted health behaviors, such as wearing masks and washing hands, in response to the COVID-19 pandemic was 50–60% [14], proving that the South African population became more positive about adopting health behaviors after the Omicron strain epidemic.

Different populations have demonstrated varying health behaviors in response to the omicron strain epidemic. South African populations older than 40 years, living in urban areas, and with higher levels of education exhibited more positive health behaviors in response to the Omicron epidemic. Some studies have suggested that people living in rural areas and those with lower levels of education may be less cognizant of the epidemic and less likely to implement preventive behaviors [15]. Notably, individuals with chronic diseases and those not vaccinated against COVID-19 exhibited lower improvement rates in the washing of hands, wearing of masks, and reduction of socialization after the Omicron epidemic. However, since they constitute a high-risk group for infection, they should be educated and guided on healthy behaviors.

Our study reveals that perceptions of the Omicron variant virus influence responses in population health behavior. Interdisciplinary, integrated research and capacity building are core elements in building One Health interventions that address COIVD-19 [16]. People with high perceptions of outbreak risk and high levels of concern regarding Omicron exhibited more positive health behaviors. People with high-risk perceptions tend to consult multiple sources to obtain information regarding the outbreak [17]. In addition, people with a greater awareness of the virus demonstrated a more positive health-behavior performance. Knowledge of COVID-19 is an important factor in behavioral change [18]. There was a significantly positive correlation between knowledge and practice [14]. Results from a survey in Africa suggest that populations with adequate knowledge of COVID-19 are more likely to adopt good preventive behaviors [19]. Therefore, while further research on Omicron is being conducted, the knowledge and prevention experience accumulated to date regarding COVID-19 can be extended to preventive behaviors against Omicron-variant viruses [20]. Proper dissemination of knowledge about Omicron; increasing the proportion of people adopting effective health behaviors; and messages encouraging social distancing, hand washing, and mask wearing are essential to preventing the transmission of COVID-19.

Notwithstanding, our study has certain limitations. First, the evaluation of Omicron perceptions and health behaviors did not use scales, and the evaluation was not comprehensive. Second, the geographic location of the survey population was limited to one city, thus not fully representing the entire South African population. Thirdly, the age composition of our survey population did not include people over 60 years of age. What's more, the findings of this study are based on a relatively short time frame and have a limited caseload. Next, we will conduct a second survey to assess whether behavioral changes are maintained or abolished in the South African population during different periods of the Omicron epidemic. However, this survey was anonymous, and we were unable to investigate and compare before and after changes in health behaviors in the same individual.

5. Conclusion

There has been a positive change in the South African population in terms of adopting mask wearing, hand washing, and reducing socialization following the emergence of the Omicron strain epidemic. Living in a rural area, having a low level of education, and having limited awareness of Omicron-variant viruses affect health-behavior changes. Two population subgroups, that is, individuals with chronic diseases and those who have not yet been vaccinated against COVID-19, exhibited low rates of health-behavior improvement; thus, they need to be prioritized. Based on one health approach, our study provides validity to provide quality risk-related information to the population as an effective way to reduce transmission of infection.

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Declaration of interest

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

Author contributions

J.S. Z. and T.H.T. conceived the study. M.X.Z., J.S. Z. and T.H.T. designed the questionnaire. J.S. Z. collected the data. X.Q.L was responsible for the coding of the analyses. X.Q.L analyzed and interpreted the data, and wrote the first draft of the paper. L.L,Y.C. and C.H. D. searched, sorted and interpreted the relevant literature. All authors edited and approved the final manuscript.

Ethics approval and consent to participate

This study was exempted from informed consent and approved by the Ethics Committee of Taizhou Hospital of Zhejiang Province (Approval number: K20210705) in China.

Author statement

This manuscript has not been published or presented elsewhere in part or in entirety and is not under consideration by another journal. All study participants provided informed consent, and the study design was approved by the appropriate ethics review board. We have read and understood your journal's policies, and we believe that neither the manuscript nor the study violates any of these. There are no conflicts of interest to declare.

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References

[1] S.S.A. Karim, Q.A. Karim, Omicron SARS-CoV-2 variant: a new chapter in the COVID-19 pandemic, Lancet 398 (10317) (2021) 2126–2128.

[2] Science Brief: Omicron (B.1.1.529) Variant, CDC COVID-19 Science Briefs, Atlanta (GA), 2020.

[3] S.K. Saxena, S. Kumar, S. Ansari, et al., Characterization of the novel SARS-CoV-2 Omicron (B.1.1.529) variant of concern and its global perspective, J. Med. Virol. 94 (4) (1738–1744) (Apr 2022).
[4] I.J.B. Torjesen, Covid-19: Omicron may be more transmissible than other variants and partly resistant to existing vaccines, Sci. Fear 375 (2021), n2943.
[5] J.R. Sinclair, Importance of a one health approach in advancing global health security and the sustainable development goals, Rev. Sci. Tech. 38 (1) (2019) 145–154.
[6] D.M. Morens, A.S. Fauci, Emerging pandemic diseases: how we got to COVID-19, Cell 182 (5) (2020) 1077–1092.
[7] C. Sohrabi, Z. Alsafi, N. O'Neill, et al., World Health Organization declares global emergency: a review of the 2019 novel coronavirus (COVID-19), Int. J. Surg. 76 (2020) 71–76.
[8] T. Jefferson, C.B. Del Mar, L. Dooley, et al., Physical interventions to interrupt or reduce the spread of respiratory viruses, Cochrane Database Syst. Rev. 11 (2020) CD006207.
[9] E. Petersen, F. Ntoumi, D.S. Hui, et al., Emergence of new SARS-CoV-2 variant of concern omicron (B.1.1.529) - highlights Africa's research capabilities, but exposes major knowledge gaps, inequities of vaccine distribution, inadequacies in global COVID-19 response and control efforts, Int. J. Infect. Dis. 114 (2022) 268–272.
[10] L.T. Brandal, E. MacDonald, L. Veneti, et al., Outbreak caused by the SARS-CoV-2 Omicron variant in Norway, November to December 2021, Euro Surveill. 26 (50) (2021).
[11] J.J. Lee, Y.J. Choe, H. Jeong, et al., Importation and transmission of SARS-CoV-2 B.1.1.529 (Omicron) variant of concern in Korea, November 2021, J. Korean Med. Sci. 36 (50) (2021) e346.
[12] H. Gu, P. Krishnan, D.Y.M. Ng, et al., Probable transmission of SARS-CoV-2 omicron variant in quarantine hotel, Hong Kong, China, November 2021, Emerg. Infect. Dis. 28 (2) (2021).
[13] L. Espenhain, T. Funk, M. Overvad, et al., Epidemiological characterisation of the first 785 SARS-CoV-2 Omicron variant cases in Denmark, December 2021, Euro Surveill. 26 (50) (2021).
[14] B.N. Siddiquea, A. Shetty, O. Bhattacharya, A. Afroz, B. Billah, Global epidemiology of COVID-19 knowledge, attitude and practice: a systematic review and meta-analysis, BMJ Open 11 (9) (2021), e051447.
[15] X. Chen, H. Chen, Differences in preventive behaviors of COVID-19 between urban and rural residents: lessons learned from a cross-sectional study in China, Int. J. Environ. Res. Public Health 17 (12) (2020).
[16] A.A. Aguirre, T. Longcore, M. Barbieri, et al., The one health approach to toxoplasmosis: epidemiology, control, and prevention strategies, Ecohealth 16 (2) (2019) 378–390.
[17] P.W. Wang, Y.L. Chen, Y.P. Chang, C.F. Wu, W.H. Lu, C.F. Yen, Sources of COVID-19-related information in people with various levels of risk perception and preventive behaviors in Taiwan: a latent profile analysis, Int. J. Environ. Res. Public Health 18 (4) (2021).
[18] J.M. Clements, Knowledge and behaviors toward COVID-19 among US residents during the early days of the pandemic: cross-sectional online questionnaire, JMIR Public Health Surveill. 6 (2) (2020), e19161.
[19] B. Gutu, G. Legese, N. Fikadu, et al., Assessment of preventive behavior and associated factors towards COVID-19 in Qellam Wallaga Zone, Oromia, Ethiopia: a community-based cross-sectional study, PLoS One 16 (4) (2021), e0251062.
[20] X. Wang, C.A. Powell, How to translate the knowledge of COVID-19 into the prevention of Omicron variants, Clin. Transl. Med. 11 (12) (2021), e680.