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Effect of Temperature and Humidity on the Incidence and Mortality of Covid-19 in World'S Top Five Hottest and Coldest Countries: a Review

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EFFECT OF TEMPERATURE AND HUMIDITY ON THE INCIDENCE AND MORTALITY OF COVID-19 IN WORLD'S TOP FIVE HOTTEST AND COLDEST COUNTRIES: A REVIEW

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ABSTRACT

The COVID-19 pandemic has caused a global public health crisis with social, psychological and long-lasting economical damages. Weather and climate play a significant role in infectious disease transmission, through changes to transmission dynamics, host susceptibility and virus survival in the environment. Weather-related dynamics have an impact on the pattern of human health and disease. Exploring the association of weather variables and COVID-19 transmission is vital in understanding the potential for seasonality and future outbreaks and developing early warning systems. The present study aimed to investigate the impact of heat and humidity on daily basis incidence and mortality due to COVID-19 pandemic in five of the world's hottest countries compared to five of the coldest ones. Studies eligible for inclusion used ecological methods to evaluate associations between weather (i.e., temperature, humidity, wind speed and rainfall) and COVID-19 transmission. According to our results, countries are anticipated to see a reduction in new COVID- 19 cases during summer and recovery during winter. Still, our results do not suggest that the disease will disappear during hot weather or will not affect countries close to the tropics. Rather, the excessive temperatures and more severe ultra violate radiation in summer are likely to support public health measures to contain SARS-CoV-2. For this review article, epidemic readiness & management strategies under contrast were obtained from the centers for disease control and prevention (CDC) & world health organization (WHO) frameworks and guidelines. Other data related to COVID-19 and reported cases were taken from more than 25 official public health organization reports and relevant articles using various databases (e.g., Google Scholar, PubMed and Science Direct).

Keywords: Covid-19, Pandemic, Public health, Climate, Humidity, Temperature

INTRODUCTION

A new epidemic of severe acute respiratory syndrome (SARS) corona virus has appeared since December 2019, known as SARS-CoV-2 or COVID-19, in Wuhan, the capital of Hubei Province, China (1). COVID-19 an outbreak of atypical pneumonia caused by this virus has been reported (2, 3). Human to human transmissibility pattern of the virus has occurred nationally and internationally (4). Corona viruses in human have been related with a wide spectrum of respiratory disease in different studies (5). Influenza viruses have been kept to follow a seasonal pattern (6) and SARS-Cov-1 was also found to lose its ability to survive at higher temperature and due to the breakdown their lipid layer at higher temperature (7,8). Some seasonality has also been observed for other corona viruses (9) but it remains uncertain that how COVID-19 will

differ with changes in climatic conditions, since it is differ first time that is appeared in the human population. Initial reports from china found incompatible results on the relationship of weather patterns with COVID-19 cases (10, 11).

The etiological agents have been confirmed as a new subset of corona viruses. Communicability of SARS-CoV-2, like other respiratory viruses, namely its precursor SARS-CoV, may be due to spread by droplets & contact, exposing the virus to external environmental conditions (12, 13). This epidemic has caused a collapse on health care services and economies of affected countries, and the overall mortality rate was estimated to be 4.7%, but in elderly patients, aged 60 or above, it can increase to up 14.8% (14). A notable feature of SARS-CoV-2 is its predilection for transmission in the health care setting and to close family and social contacts by different manners, such as droplets, close direct or indirect contact, but the relative importance of these routes of transmission is still unclear (15). The transmission can be affected by a number of factors, including population density, migratory flow, host immunity, medical care quality and, presumably, climate conditions such as temperature, humidity and rain fall (16, 17). Little studies have considered climate parameters as important factors that could affect the SARS-CoV-2 spread. The seasonal nature in the outbreaks of respiratory virus infections is a common phenomenon, with peaks often occurring in low temperatures, during the winter months (18). The corona virus can retain its infectivity up to 2 weeks in a low temperature and low humidity environment, which might facilitate the virus transmission in a community located in a subtropical climate (19). The mechanism under these patterns of climate determination that lead to infection and possible disease transmission is associated with the ability of the virus to survive external environmental conditions before staying in a host (20). Many etiological factors such as changes in host physiological susceptibility, immune system function, social behavior, and weather conditions have been suggested in this context (21).

It is supposed that high temperature, rainfall & humidity, together, have a combined effect on inactivation of corona viruses while the opposite weather condition can support prolonged survival time of the virus on surfaces and facilitate the transmission & susceptibility of the viral agent (22). This fusion may activate an impairment of the local and systemic antiviral defense mechanisms, leading to increased host susceptibility to the respiratory viruses in winter (23). However, there is still divergence in the literature about the effects of temperature and humidity on the viability and transmissibility of the corona virus infection that appeared in 2019. Chaos faced with this pandemic of COVID-19, declared by World Health Organization on March 11th 2020 (24), & the need to understanding the seasonal behavior of this virus, our team has lead this systematic review to narrate current knowledge about the emergence and replicability of the virus and its connection with different weather factors such as temperature, relative humidity and rainfall. This study could be useful to develop and apply an effective health information system with public involvement to control the incidence, and to curb the spread of COVID-19 in the world.

METHOD OF STUDY:

Eligibility criteria

Manuscripts that evaluated the effects of different climatic conditions of temperature, humidity and rainfall on the spread ability of COVID-19 were included. The search strategy was defined based on the following aspects: Population, Humans diagnosed with COVID-19, Exposition different weather conditions like humidity, temperature, rainfall. Outcome of SARS-CoV-2 (COVID-19) spread ability and study design of observational studies, prospective or retrospective, case reports, case-series.

Information sources

The following electronic databases were searched: PubMed, Scopus, web of Science, library, worldometer, weather report and Google Scholar. A hand search was also conducted by reading the references list of the included articles. No restriction on language has been applied. Date of publication has been limited to the years 2019 and 2020. The search was conducted up to October 2021 in all databases, and until December 2021 only in Google Scholar.

Search strategy and study selection

The electronic searches were performed independently by the authors. In case of disagreements, a third author was consulted. The search strategy was developed through a combination of entry terms and keywords related to the weather conditions like humidity, temperature and rainfall, hot and cold criteria basis places, outcomes and study design. The full search strategies for each database are illustrated in supporting informations. The citations were saved in a reference manager. After removing duplicates, titles and abstracts were analyzed according to the eligibility criteria. The selected articles were evaluated by full text, and a final selection was conducted.

Data extraction

Two three collected the data independently (P.S, B.N and K.K.), extracting the following items: authors, year, location and type of study, date of COVID-19 data collection, date of meteorological data collection, sample location, weather variables, COVID-19 data sources, meteorological data sources, statistical analysis and main results.

RESULT:

WORLD'S TOP FIVE COLDEST COUNTRY					WORLD'S TOP FIVE HOTTEST COUNTRY			
S. no.	Name of country	Temperature (^{o}C)	Humidity (%)	Rain Fall (mm)	Name of country	Temperature (^{o}C)	Humidity (%)	Rain Fall (mm)
1	Green land	-3.5	90	54	Mali	34.3	18	1
2	Russia	-3	85	52	Mauritania	29.1	24	2
3	Canada	1.4	81	48	Qatar	29.5	71	12.1
4	Finland	-4.5	88	58	Senegal	26.3	59	1
5	China	3.7	49	49	Djibouti	27.2	69	6

Table No. 1. World's top five coldest and hottest countries with weather variables

Source: https://weather.com/en, https://www.worldometers.info/

CORONA VIRUS CASES IN WORLD'S FIVE COLDEST COUNTRIES

Name of country	Month/year	Corona cases	Mortality cases
Coldest countries			
Green land	December/2019	0	0
	January/2020	0	0
	February/2020	0	0
	March/2020	10	0
	April/2020	11	0
	May/2020	13	0
	June/2020	13	0
	July/2020	14	0
	August/2020	14	0
	September/2020	14	0
	October/2020	17	0
	November/2020	18	0
	December/2020	27	0

Table No. 2. Active and Mortality cases in green land

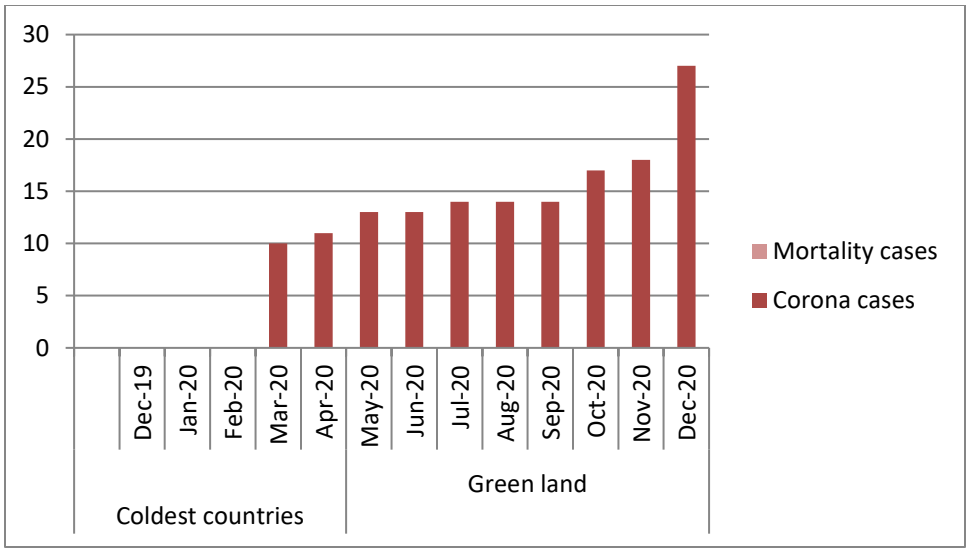

Figure No. 1. Mortality and corona cases in Greenland

Total corona virus cases in Greenland
Total cases- 731
Death- 0
Recovered- 641

Name of country	Month/year	Corona cases	Mortality cases
Coldest countries			
Russia	December/2019	0	0
	January/2020	0	0
	February/2020	02	0
	March/2020	2337	17
	April/2020	99399	1073
	May/2020	405843	4693
	June/2020	647849	9320
	July/2020	834499	13963
	August/2020	995319	17176
	September/2020	1176286	20385
	October/2020	1599976	27990
	November/2020	2295654	39527
	December/2020	3159297	57019

Table No. 3. Active and Mortality cases in green land

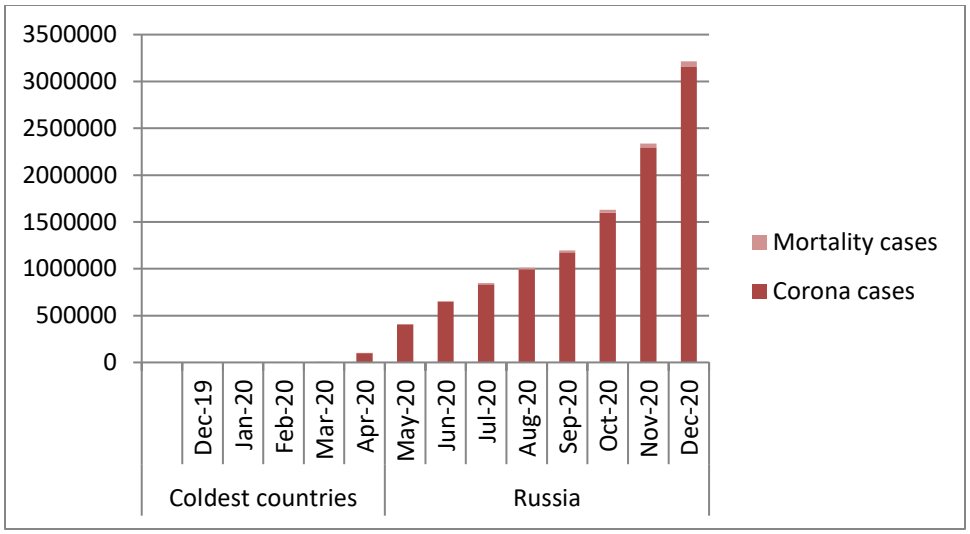

Figure No. 2. Mortality and corona cases in Russia

Total corona virus cases in Russia
Total cases- 8,241,643
Death- 230,600
Recovered- 7,165,921

Name of country	Month/year	Corona cases	Mortality cases
Coldest countries			
Canada	December/2019	0	0
	January/2020	0	0
	February/2020	15	0
	March/2020	8612	101
	April/2020	53236	2996
	May/2020	90947	7073
	June/2020	104204	8566
	July/2020	116312	8935
	August/2020	128948	9126
	September/2020	158758	9297
	October/2020	231999	10136
	November/2020	378139	12130
	December/2020	581395	15472

Table No. 4. Active and Mortality cases in green land

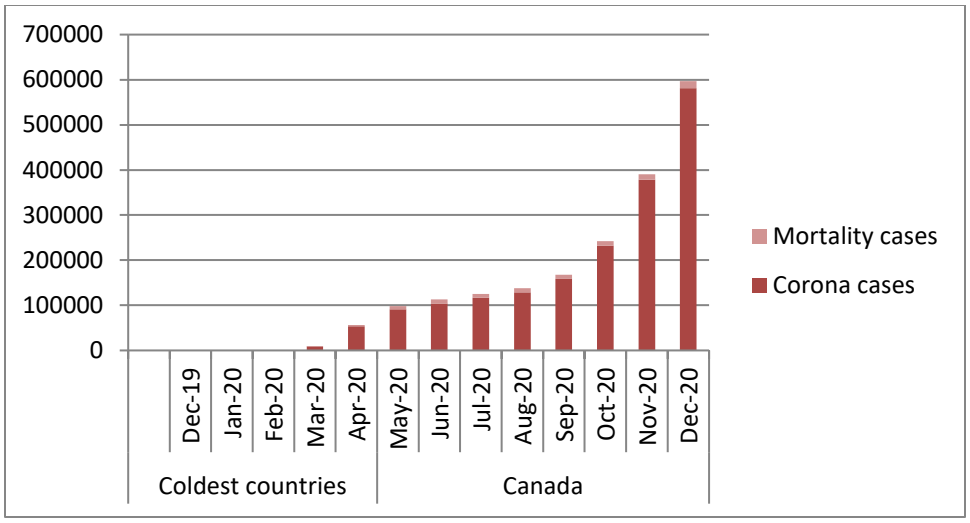

Figure No. 3. Mortality and corona cases in Canada

Total corona virus cases in Canada
Total cases- 1,697,036
Death- 28,745
Recovered- 1,639,081

Name of country	Month/year	Corona cases	Mortality
Coldest countries			
Finland	December/2019	0	0
	January/2020	0	0
	February/2020	03	0
	March/2020	1352	17
	April/2020	4995	211
	May/2020	6826	316
	June/2020	7214	328
	July/2020	7432	329
	August/2020	8086	336
	September/2020	9892	344
	October/2020	16113	358
	November/2020	24912	399
	December/2020	36107	561

Table No. 5. Active and Mortality cases in Finland

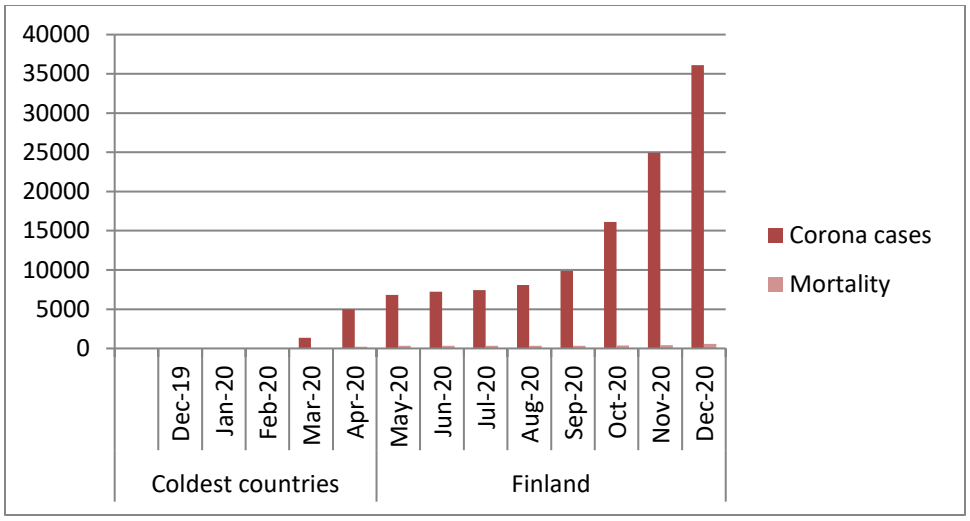

Figure No. 3. Mortality and corona cases in Finland

Total corona virus cases in Finland
Corona virus cases- 153156
Deaths- 1139
Recovered- 46000

Name of country	Month/year	Corona cases	Mortality
Coldest countries			
China	December/2019	0	0
	January/2020	7711	213
	February/2020	79824	2835
	March/2020	81554	3312
	April/2020	82862	4633
	May/2020	83001	4634
	June/2020	83512	4634
	July/2020	84292	4634
	August/2020	85048	4634
	September/2020	85372	4634
	October/2020	85940	4634
	November/2020	86530	4634
	December/2020	87052	4634

Table No. 6. Active and Mortality cases in China

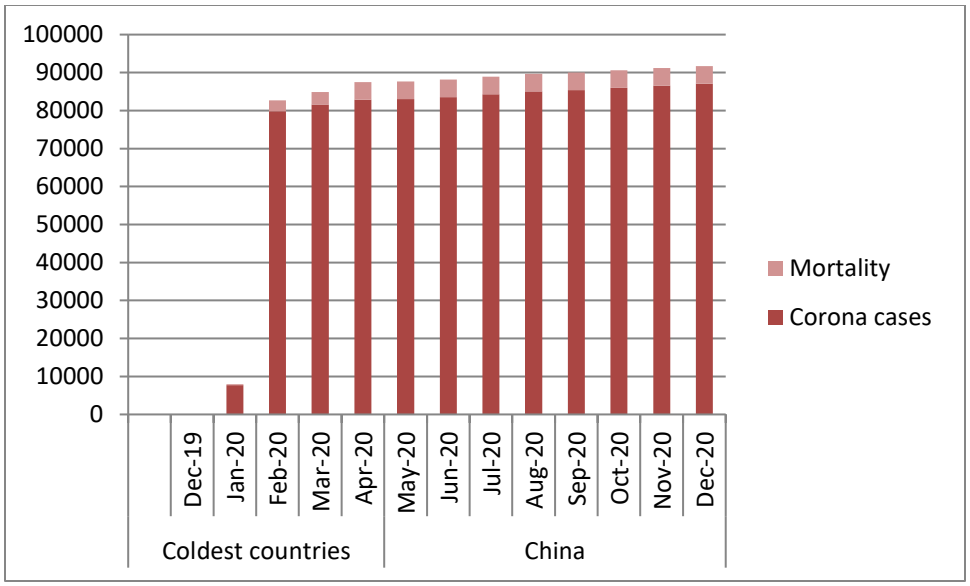

Figure No. 4. Mortality and corona cases in China

Total corona virus cases in china
Corona virus cases- 96758
Deaths- 4,636
Recovered- 91,558

CORONA VIRUS CASES IN WORLD'S FIVE HOTTEST COUNTRIES

Name of country	Month/year	Corona cases	Mortality
Hottest countries			
Mali	December/2019	0	0
	January/2020	0	0
	February/2020	0	0
	March/2020	25	02
	April/2020	490	26
	May/2020	1265	77
	June/2020	2181	115
	July/2020	2535	124
	August/2020	2773	126
	September/2020	3118	131
	October/2020	3545	136
	November/2020	4710	152
	December/2020	7029	269

Table No. 7. Active and Mortality cases in Mali

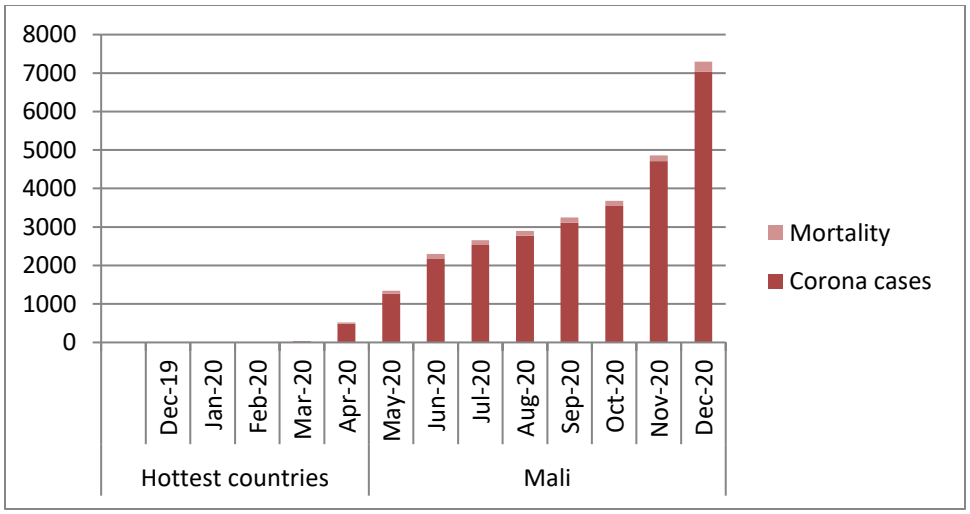

Figure No. 5. Mortality and corona cases in Mali

Total corona virus cases in Mali
Corona virus cases- 15,809
Deaths- 558
Recovered- 14,572

Name of country	Month/year	Corona cases	Mortality
Hottest countries			
Mauritania	December/2019	0	0
	January/2020	0	0
	February/2020	0	0
	March/2020	6	01
	April/2020	8	01
	May/2020	530	20
	June/2020	4363	129
	July/2020	6310	157
	August/2020	7016	159
	September/2020	7502	161
	October/2020	7700	163
	November/2020	8601	177
	December/2020	14191	347

Table No. 8. Active and Mortality cases in Mauritania

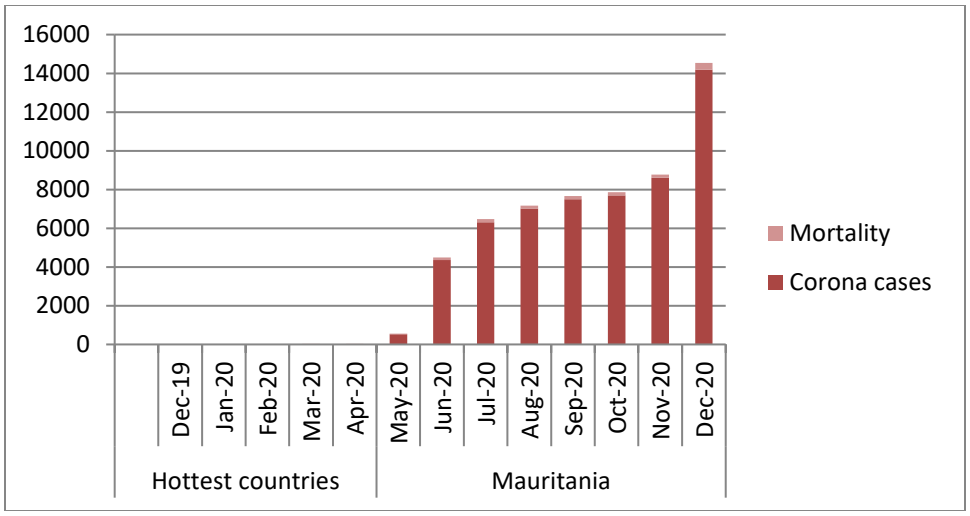

Figure No. 6. Mortality and corona cases in Mauritania

Total Corona virus cases in Mauritania
Corona virus cases- 36910
Deaths- 792
Recovered- 35,652

Name of country	Month/year	Corona cases	Mortility
Hottest countries			
Qatar	December/2019	0	0
	January/2020	0	0
	February/2020	0	0
	March/2020	6	01
	April/2020	8	10
	May/2020	530	38
	June/2020	4363	113
	July/2020	6310	174
	August/2020	7016	197
	September/2020	7502	214
	October/2020	7700	232
	November/2020	8601	237
	December/2020	14191	245

Table No. 9. Active and Mortality cases in Qatar

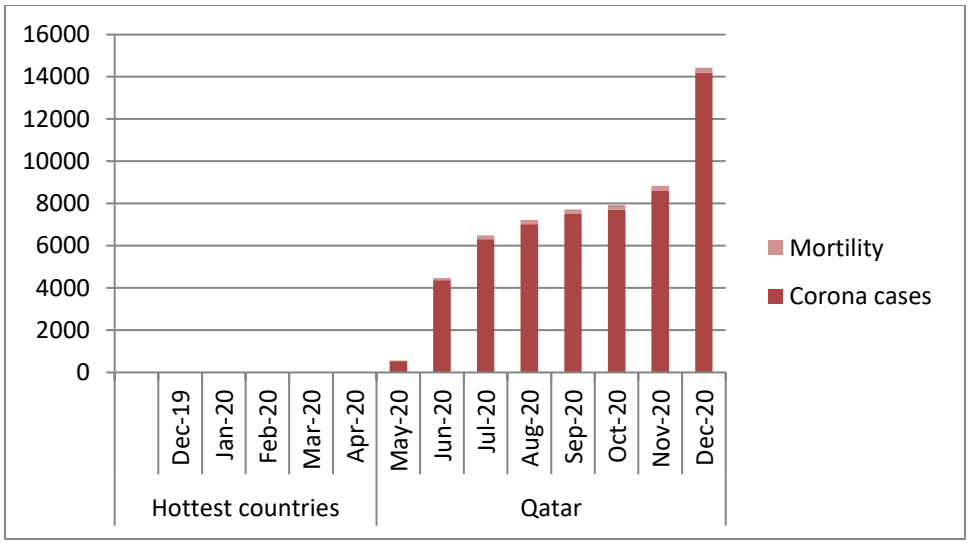

Figure No. 7. Mortality and corona cases in Qatar

Total corona virus cases in Qatar
Corona virus cases- 238,518
Deaths- 609
Recovered- 236,906

Name of country	Month/year	Corona cases	Mortality
Hottest countries			
Senegal	December/2019	0	0
	January/2020	0	0
	February/2020	0	0
	March/2020	162	0
	April/2020	933	09
	May/2020	3535	42
	June/2020	6793	112
	July/2020	10232	205
	August/2020	13611	284
	September/2020	14945	311
	October/2020	15616	324
	November/2020	16089	333
	December/2020	19140	410

Table No. 10. Active and Mortality cases in Senegal

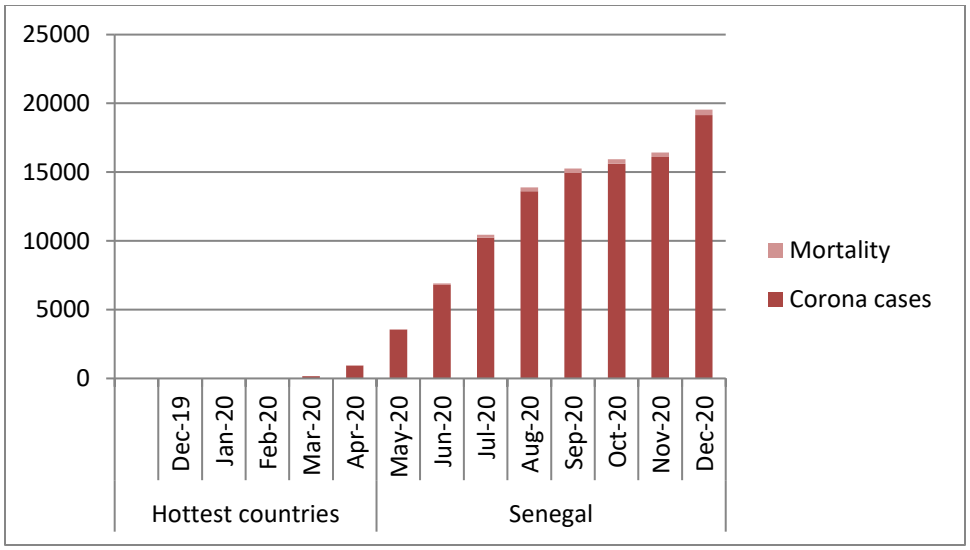

Figure No. 8. Mortality and corona cases in Senegal

Total corona virus cases in Senegal
Corona virus cases- 73,893
Deaths- 1878
Recovered-71993

Name of country	Month/year	Corona cases	Mortality
Hottest countries			
Djibouti	December/2019	0	0
	January/2020	0	0
	February/2020	0	0
	March/2020	18	0
	April/2020	1089	02
	May/2020	3354	24
	June/2020	4682	53
	July/2020	5084	58
	August/2020	5385	60
	September/2020	5416	61
	October/2020	5559	61
	November/2020	5679	61
	December/2020	5824	61

Table No. 11. Active and Mortality cases in Djibouti

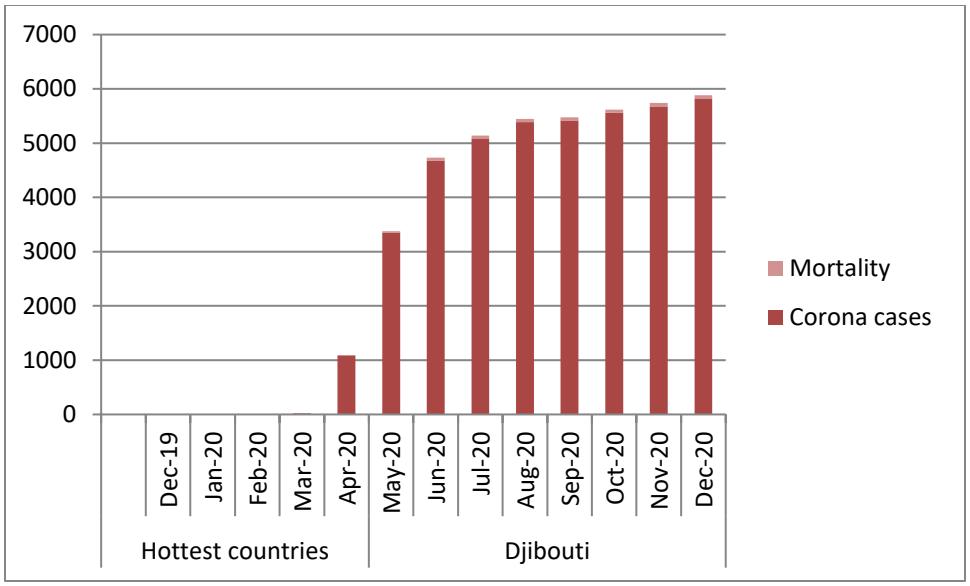

Figure No. 9. Mortality and corona cases in Djibouti

Total corona virus cases in Djibouti
Corona virus cases- 13,451
Deaths- 181
Recovered-13,207

Name of country	Month/year	Corona cases	Mortality
Hottest countries			
Russia	December/2019	0	0
	January/2020	0	0
	February/2020	2	0
	March/2020	1534	9
	April/2020	99399	1073
	May/2020	396575	4693
	June/2020	634437	8969
	July/2020	839981	13802
	August/2020	990326	17093
	September/2020	1176286	20722
	October/2020	1618116	27990
	November/2020	2242633	39895
	December/2020	3131550	57019

Table No. 12. Active and Mortality cases in Russia

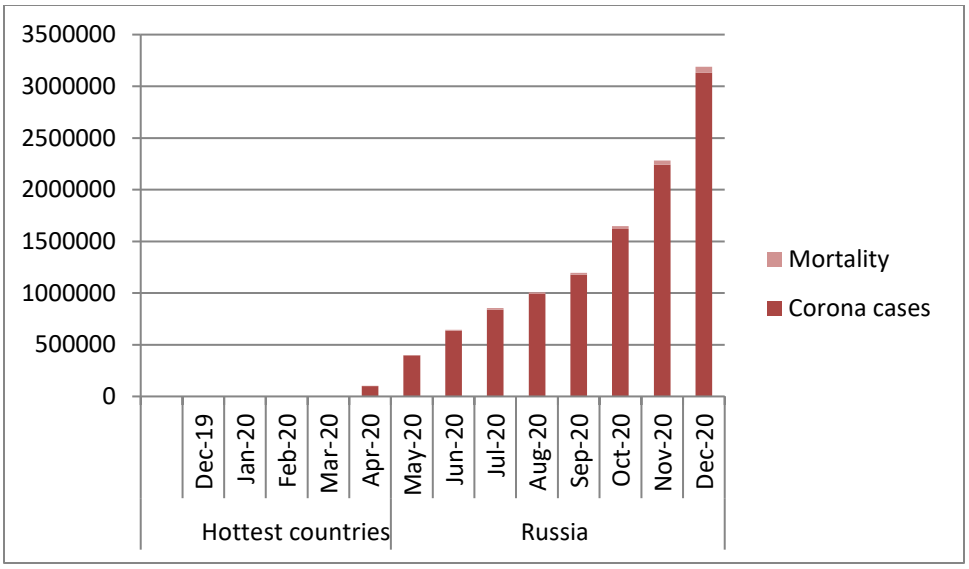

Figure No. 10. Mortality and corona cases in Russia

Total corona virus cases in Russia
Corona virus cases- 9,736,037
Deaths- 278,857
Recovered- 8,436,631

Name of country	Month/year	Corona cases	Mortality
Hottest countries			
Canada	December/2019	0	0
	January/2020	0	0
	February/2020	20	0
	March/2020	7448	101
	April/2020	51,597	3184
	May/2020	90,190	7295
	June/2020	104,271	8566
	July/2020	115,470	8,917
	August/2020	128,948	9,113
	September/2020	158,758	9,297
	October/2020	234,511	10,136
	November/2020	378,139	11,976
	December/2020	572,982	15,606

Table No. 13. Active and Mortality cases in Canada

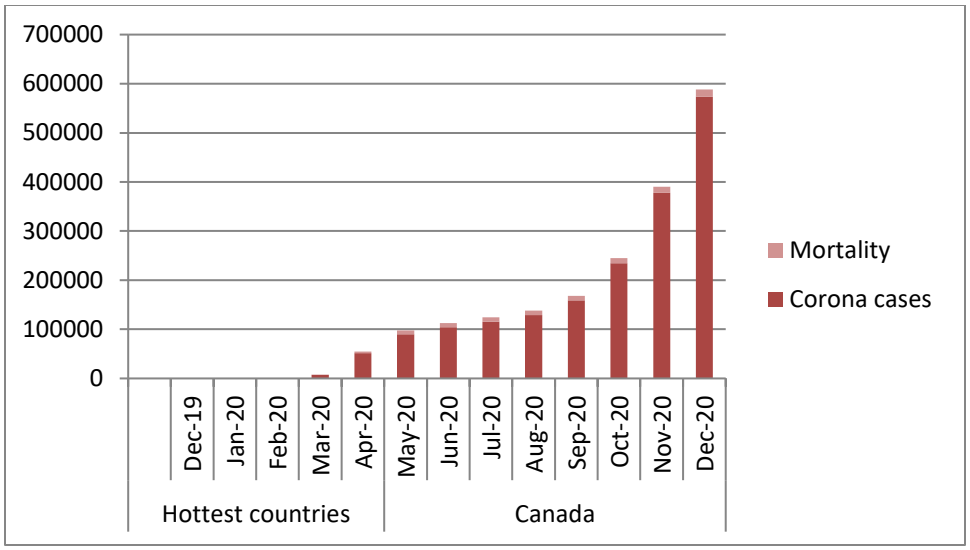

Figure No. 11. Mortality and corona cases in Canada

Total corona virus cases in Canada
Corona virus cases- 1,798,872
Deaths- 29,737
Recovered- 1,742,524

DISCUSSION

According to the effect of weather fluctuating on COVID-19, the results of previously published studies that used measurements from single countries were incompatible. Notably, most analyses divulge a negative correlation between temperature, humidity and the number of COVID-19 cases, while many analyses revealed a positive correlation instead. Taking into consideration the findings from global analyses, the relation between weather (i.e. temperature, humidity and rain falling) and COVID-19 is the most likely scenario. The effect of environmental variables, as recommended in the past for other corona viruses or influenza virus, cannot be excluded, although, under the conditions of the first pandemic wave where so many measures were applied, it might be difficult to be exposed. It has been appeared that containment measures have a much stronger impact than the environmental variables, which can explain only the 18% of the inequality in COVID-19 doubling time (25). The effect of climate variables was also shown in a single study focused in Mexico, where data on COVID-19 cases was collected before the effect of containment measures, in this case temperature was found to be negatively associated with local cases (27). Other important variables for COVID-19 spreading are human mobility and the effect of imported cases, as evaluated in several studies assessing the impact of climate to SARS-CoV-2 transmission.
Conversely, during summer session 2020 some specific countries in the Northern hemisphere experienced a notable increase in the number of daily COVID-19 cases which named a second

pandemic wave (28). The remarkable increase in the number of cases suggests that COVID-19 is efficient of producing outbreaks at high ambient temperatures such as during summer period in Southern Europe (e.g. Spain, Greece, Bulgaria). This discovery focus that in the absence of public health measures weather conditions cannot reduce SARS-CoV-2 outbreaks and that the seasonality of SARS-CoV-2 differs much compared to common cold corona viruses or influenza. The periodic pattern of the latter pathogens is due to a fusion of weather and immunological variables like duration of immunity, cross-immunity.

The other pollutant like air pollution can also affect the COVID-19 transmission. Specifically, an important parameter associated with virus transmissibility is ventilation and air changes rate in an area. Ventilation rate in high population and building density areas is limited and certain measures are needed for the improvement of public health. Air pollution can likely affect the COVID-19 case death rate, though, due to several limitations in earlier published studies, more study is needed to take out conclusions about the effect of these variables on COVID-19.

CONCLUSION

Although the impact of weather and climate variables to the COVID-19 transmission rate seems likely, a solid conclusion on the degree of impact needs further investigation. On the conflicting, it can be expressed that the rise in the number of COVID-19 cases during summer time period in countries with high climate temperatures, hinted that in the absence of public health measures, weather and climate variable cannot alleviate the recovery of outbreaks. Considering the existing scientific proof, warm and wet weather condition seem to reduce the spread of COVID-19. Still, these variables alone could not explain most of the changeability in disease transmission.

Emerging appears data to suggest that weather condition may facilitate the spread of COVID 19. Our conclusions are based on the previous past one year available data and evolving, case fatality ration, reproductive numbers and direct and indirect transmissions. The relation between temperature, humidity and rainfall and the spread of COVID -19 cases should be closely monitored and studied under different climatic conditions. If a strong environmental vulnerability in the spread of COVID-19 appears, then it should be used to develop the COVID-19 easing strategies. Our result not suggests that COVID-19 would not increase in warm humid regions and effective public health mediation should be applied across the world to decrease the transmission of COVID-19.

At the end, further study is needed to accurately assess the impact of weather variables to the COVID-19 transmission rate and to the resulting number of cases, mainly in the absence of public health measures.

Acknowledgments

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References

1. Zhou P, Yang XL, Wang XG, et al. A pneumonia outbreak associated with a new corona virus of probable at origin. Nature. 2020; 579: 270–3. https://doi.org/10.1038/s41586-020-2012-7 PMID: 32015507.

2. Mecenas Paulo, Renata Travassos da Rosa Moreira Bastos, Vallinoto Rosario A. C., N. David. Effects of temperature and humidity on the spread of COVID-19: A systematic review. 2020; 1-21. https://doi.org/10.1371/journal.pone.0238339.

3. Li Q, Guan X, Wu P, et al. Early transmission dynamics in Wuhan, China, of novel corona virus-infected pneumonia. N Engl J Med. 2020; 382: 1199–207. https://doi.org/10.1056/NEJMoa2001316 PMID:31995857.

4. Esper, F.; Weibel, C.; Ferguson, D.; Landry, M.L.; Kahn, J.S. Evidence of a Novel Human Corona virus That Is Associated with Respiratory Tract Disease in Infants and Young Children. J. Infect. Dis. 2005, 191, 492–498. [CrossRef].

5. Barreca, A.I.; Shimshack, J.P. Absolute Humidity, Temperature, and Influenza Mortality: 30 Years of County-Level Evidence from the United States. Am. J. Epidemiol. 2012, 176, S114–S122. [CrossRef] .

6. Chan, K.H.; Peiris, J.S.M.; Lam, S.Y.; Poon, L.L.; Yuen, K.-Y.; Seto,W.H. The Effects of Temperature and Relative Humidity on the Viability of the SARS Coronavirus. Adv. Virol. 2011, 2011, 1–7. [CrossRef] [PubMed].

7. Schoeman, D.; Fielding, B.C. Coronavirus envelope protein: Current knowledge. Virol. J. 2019, 16, 69. [CrossRef] [PubMed]

8. A Neher, R.; Dyrdak, R.; Druelle, V.; Hodcroft, E.B.; Albert, J. Potential impact of seasonal forcing on a SARS-CoV-2 pandemic. Swiss Med. Wkly. 2020, 150, w20224. [CrossRef]

9. Xie, J.; Zhu, Y. Association between ambient temperature and COVID-19 infection in 122 cities from China. Sci. Total Environ. 2020, 724, 138201. [CrossRef] [PubMed].

10. Ma, Y.; Zhao, Y.; Liu, J.; He, X.; Wang, B.; Fu, S.; Yan, J.; Niu, J.; Zhou, J.; Luo, B. E_ects of temperature variation and humidity on the death of COVID-19 inWuhan, China. Sci. Total Environ. 2020,724,138226. [CrossRef] [PubMed].

11. Andersen KGR A, Lipkin WL, Holmes EC, Garry RF. The proximal origin of SARS-CoV-2. Nat Med. 2020; 26:450–452. https://doi.org/10.1038/s41591-020-0820-9 PMID: 32284615.

12. Araujo MB, Naimi B. Spread of SARS-CoV-2 Coronavirus likely to be constrained by climate. medRxiv: 20034728v1 [Preprint]. 2020 [cited 2020 March 24]. Available from: https://www.medrxiv.org/ content/10.1101/2020.03.12.20034728v1.full.pdf.

13. Coronavirus Resource Center. 2020 [accessed 2020 March 24]. Available from: https://coronavirus.jhu.edu/ https://doi.org/10.1155/2011/734690 PMID: 22312351.

14. Chan KH, Peiris JS, Lam SY, Poon LL, Yuen KY, Seto WH. The effects of temperature and relative humidity on the viability of the SARS coronavirus. Adv Virol. 2011; 2011: 734690.

15. Dalziel BD, Kissler S, Gog JR, et al. Urbanization and humidity shape the intensity of influenza epidemics in U.S. cities. Science. 2018; 362: 75–9. https://doi.org/10.1126/science.aat6030 PMID: 30287659.

16. Hemmes JH, Winkler KC, Kool SM. Virus survival as a seasonal factor in influenza and poliomylitis. Antonie van Leeuwenhoek. 1962; 28: 221–33. https://doi.org/10.1007/BF02538737 PMID: 13953681.

17. Mourtzoukou EG, Falagas ME. Exposure to cold and respiratory tract infections. Int J Tuberc Lung Dis.2007; 11: 938–43. PMID: 17705968.
18. Chan KH, Peiris JS, Lam SY, Poon LL, Yuen KY, Seto WH. The effects of temperature and relative humidity on the viability of the SARS coronavirus. Adv Virol. 2011; 2011: 734690. https://doi.org/10.1155/2011/734690 PMID: 22312351.
19. Arau´ jo MB, Naimi B. Spread of SARS-CoV-2 Coronavirus likely to be constrained by climate. medRxiv: 20034728v1 [Preprint]. 2020 [cited 2020 March 24]. Available from: https://www.medrxiv.org/content/10.1101/2020.03.12.20034728v1.full.pdf.
20. Dowell SF, Ho MS. Seasonality of infectious diseases and severe acute respiratorysyndrome-what wedon't know can hurt us. Lancet Infect Dis. 2004; 4: 704–8. https://doi.org/10.1016/S1473-3099(04)01177-6 PMID: 15522683.
21. Chan KH, Peiris JS, Lam SY, Poon LL, Yuen KY, Seto WH. The effects of temperature and relative humidity on the viability of the SARS coronavirus. Adv Virol. 2011; 2011: 734690. https://doi.org/10.1155/2011/734690 PMID: 22312351.
22. Moriyama M, Hugentobler WJ, Iwasaki A. Seasonality of respiratory viral infections. Annu Rev Virol. 2020.
23. WHO Director-General's opening remarks at the media briefing on COVID-19–11 March 2020. 2020. Available from: https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-atthe- media-briefing-on-covid-19—11-march-2020 [cited 2020 March 29]
24. Oliveiros, B., Caramelo, L., Ferreira, N.C., Caramelo, F., 2020. Role of Temperature and Humidity in theModulation of the Doubling Time of COVID-19 Cases. medRxiv. https:// doi.org/10.1101/2020.03.05.20031872.
25. Méndez-Arriaga, F., 2020. The temperature and regional climate effects on communitarian COVID-19 contagion in Mexico throughout phase 1. Sci. Total Environ. 735, 139560.
26. https://www.who.int/publications-detail-redirect/strengthening- preparedness-for-covid-19-in-cities-and-urban-settings.
27. https://weather.com/en 30.
28.IN/weather/monthly/l/c45316f6ca650838e1c9c4b5f9aa90eb79336b10bdfa09a2d61db067e7fa58d5f589a71bf3a4dbfd519dd021fd5a2bc0
29. https://www.weather-atlas.com/en/united-arab-emirates/dubai-weather-december#climate_text_1
30. https://www.who.int/news/item/27-04-2020-who-timeline---covid-19
31. https://www.worldometers.info/