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Preliminary Results of a Study on the Impact of Some Simple Thermal Indices on the Spread of COVID-19 in Tbilisi

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ABSTRACT

The results of a study of the influence of diurnal values of separate components of simple thermal indices (temperature and air relative humidity, wind speed) on the infection positivity rate with coronavirus COVID-19 (IR) of the population of Tbilisi from September 1, 2020 to May 31, 2021 are presented. It was found that IR values are inversely correlated with air temperature and wind speed, and positively correlated with air relative humidity.
The effect of four different thermal indices (air effective temperature and Wet-Bulb-Globe-Temperature) on the IR values averaged over the scale ranges of their categories was studied. It has been found that an increase of the air effective temperature leads to a decrease of the IR values. In the latter case, the level of significance of the relationship between thermal indices and IR values is much higher than in the case of the relationship between IR and separate components of these indices.

Key Words: *Bioclimatic index, air effective temperature, meteorological parameters, COVID-19, infection positive rate.*

Introduction

Three years have passed since the outbreak of the new coronavirus (COVID-19) in China, which was recognized on March 11, 2020 as a pandemic due to its rapid spread in the World [1]. During this period of time, despite the measures taken (including vaccination), several strains of this virus appeared (the last one is omicron). The overall level of morbidity and mortality is currently decreasing significantly, although in many countries of the world it remains quite high.

For example, according data to the National Center for Disease Control and Public Health of Georgia [http://data.ncdc.ge/?LangID=en] from February 27, 2020 to September 30, 2022 in Georgia 1785137 new cases of COVID-19 infection were registered; died - 16912 people. Due to the sharp decline in coronavirus infection in Georgia after September 30, 2022, official statistics on COVID-19 are not published.

Scientists and specialists from various disciplines from all over the world, together with epidemiologists and doctors, have joined in intensive research on this unprecedented phenomenon (including in Georgia [2-11]), providing all possible assistance to them. In particular, in our work [9], it was noted works on statistical analysis, forecasting, forecasting systematization, spatial-temporary modelling of the spread of the new coronavirus etc. was actively continuing in 2021. Similar work is also continued in 2022 [10-13].

In our latest work [14] results of a statistical analysis of daily, total by days of the week and monthly data on officially reported deaths cases from the new coronavirus COVID-19 in the countries of the South Caucasus (Armenia, Azerbaijan, Georgia) from March 12, 2020 to May 31, 2022 are presented.

A significant number of papers are devoted to studies of the influence of various meteorological factors on the COVID-19 pandemic [15-21].

In particular, in study [20], the influence of several meteorological factors in the transmission of COVID-19 cases in six cities in Saudi Arabia was investigated using the Spearman and Kendall rank tests. For this purpose, the reported COVID-19 data from these cities in Saudi Arabia for the period between 26 March 2020 to 10 August 2021 was used along with such meteorological factors, as the average, maximum, and minimum values of air temperatures, air pressure, wind speed, relative humidity, dew point temperatures, and the average values of absolute humidity. The results for all the cities revealed that air temperature (average, minimum, and maximum) are positively associated with the daily number of COVID-19 cases reported in these cities. However, relative humidity and atmospheric pressure (averages, minimum, and maximum) are anticorrelated with the number of daily COVID-19 cases. For the rest of the variables, the correlation, strength, and significance with regard to the COVID-19 cases were different from one city to another. The findings presented in this paper are in total agreement with some of the previously established studies and are in contradiction either partially or entirely with others conducted at several locations around the world. The obtained results showed that the meteorological variables, significantly, affect the spread of COVID-19.

In [21] results of modelled the impact of selected meteorological factors on the daily number of new cases of the coronavirus disease 2019 (COVID-19) at the Hospital District of Helsinki and Uusimaa in southern Finland from August 2020 until May 2021 are resented. Authors applied a DLNM (distributed lag non-linear model) with and without various environmental and non-environmental confounding factors. The relationship between the daily mean temperature or absolute humidity and COVID-19 morbidity shows a non-linear dependency, with increased incidence of COVID-19 at low temperatures between 0 to −10 °C or at low absolute humidity (AH) values below 6 g/m³. It is noted that, the outcomes need to be interpreted with caution, because the associations found may be valid only for the study period in 2020–2021. Longer study periods are needed to investigate whether severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has a seasonal pattern similar such as influenza and other viral respiratory infections. The influence of other non-environmental factors such as various mitigation measures are important to consider in future studies. Knowledge about associations between meteorological factors and COVID-19 can be useful information for policy makers and the education and health sector to predict and prepare for epidemic waves in the coming winters.

We are also involved in similar studies. Preliminary results of the study of influence of some simple thermal indices on the positive rate of infection of the population of Tbilisi city with the COVID-19 virus from September 1, 2020 to May 31, 2021 to are presented below.

Material and methods

Data of agency on the environment of Georgia about the daily mean and max values of air temperature - T (°C), air relative humidity – RH (%), and daily mean wind speed - V (m/sec) for Tbilisi during September 1, 2020 to May 31, 2021 were used in the work. For the same days, data of National Center for Disease Control and Public Health of Georgia about infection positivity rate with coronavirus COVID-19 (IR) of the population of Tbilisi were used (IR = Confirmed Coronavirus Cases/Test Number, %).

The paper compares the daily values of the indicated meteorological elements with the IR values, as well as compares four thermal indices (effective air temperature and Wet-Bulb-Globe-Temperature) with the IR values averaged over the scale ranges of their categories. (Table 1, [26]). To calculate thermal indices, data on max daily air temperature, min values of relative air humidity, and average wind speed were used.

Table 1. Four simple thermal indices formula, scales and category.

Equivalent-Effective Temperature [27,28]: EET = $125 \cdot Lg(1+0.02 \cdot T+0.0001 \cdot (T-8) \cdot (RH-60)-0.0045 \cdot (33-T) \cdot V^{0.5})$, °C		Effective Temperature [29,30]: ET = $37-(37-T)/(0.68-0.0014 \cdot RH+1/(1.76+1.4 \cdot V^{0.75})) -0.29 \cdot T \cdot (1-0.01 \cdot RH)$, °C	
<1	Sharply coldly	<1	Very cold
1-8	Coldly	1-9	Cold
9-16	Moderately coldly	9-17	Cool
17-22	Comfortably	17-21	Comfortable
23-27	Warmly	21-23	Warm
>27	Hotly	23-27	Hot
		>27	Very Hot
Effective Temperature [31-33]: TE = $T-0.4 \cdot (T-10) \cdot (1-RH/100)$, °C		Wet-Bulb-Globe-Temperature [34]: WBGT = $0.567 \cdot T+0.393 \cdot e+3.94$, °C	
< 16.1	Cool	<18	Comfortable
16.1-20	Comfortable	18÷24	Warm
20.1-24	Slightly humid	24÷28	Hot
> 24	Humid	28÷30	Very hot
		>30	Extreme hot
T – air temperature, °C; RH – air relative humidity, %; V - wind speed, m/sec; °C in this Table is so-called perceptible temperature.			

Results and discussion

Results in Fig. 1-9 are presented.

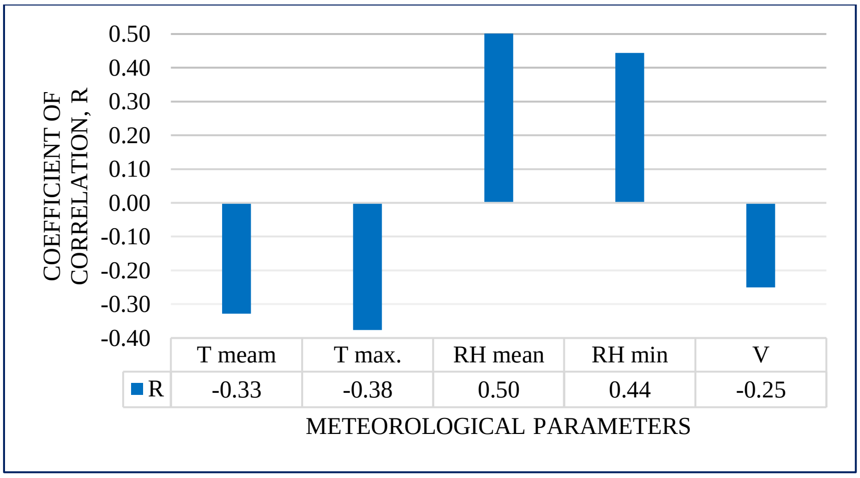

Fig. 1. Linear correlation between daily values of COVID-19 Infection Rate and meteorological parameters in Tbilisi from September 1, 2020 to May 31, 2021 ($\alpha<0.005$).

In Fig. 1 data about coefficient of linear correlation R between daily values of COVID-19 Infection Rate and meteorological parameters in Tbilisi from September 1, 2020 May 31, 2021 are presented.

As follows from Fig. 1, value of coefficient of correlation T mean, T max and V with IR is negative (-0.33, -0.38 and -0.25 respectively). Value of coefficient of correlation RH mean and RH min with IR is positive (0.50 and 0.44 respectively).

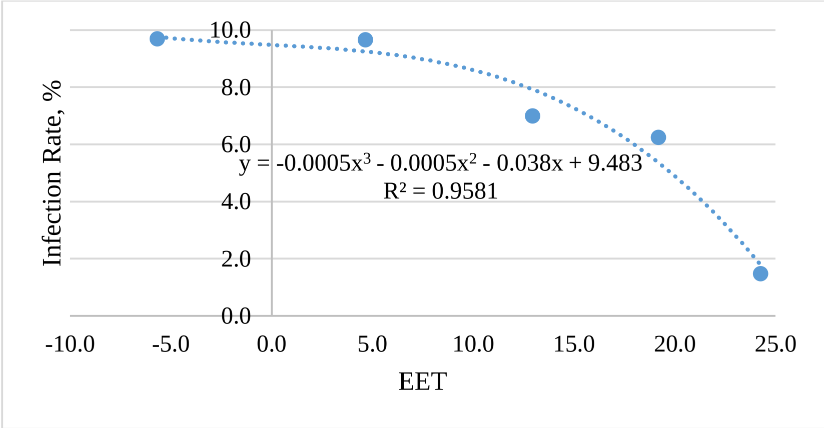

Fig. 2. Connection of COVID-19 Infection Rate with Air Equivalent-Effective Temperature (EET).

Connection of COVID-19 Infection Rate with Air Equivalent-Effective Temperature has the form of a third power polynomial (Fig. 2). As the EET values increase, the IR values decrease non-linearly.

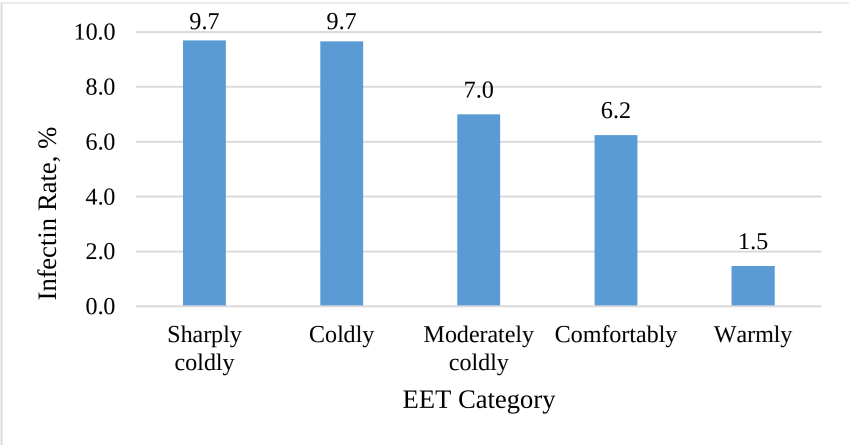

Fig. 3. Values of COVID-19 Infection Rate under different categories of Air Equivalent-Effective Temperature (EET).

As follows from Fig. 3 values of COVID-19 Infection Rate under different categories of Air Equivalent-Effective Temperature (EET) decreases from 9.7% ("Sharply coldly", "Coldly") to 1.5% ("Warmly").

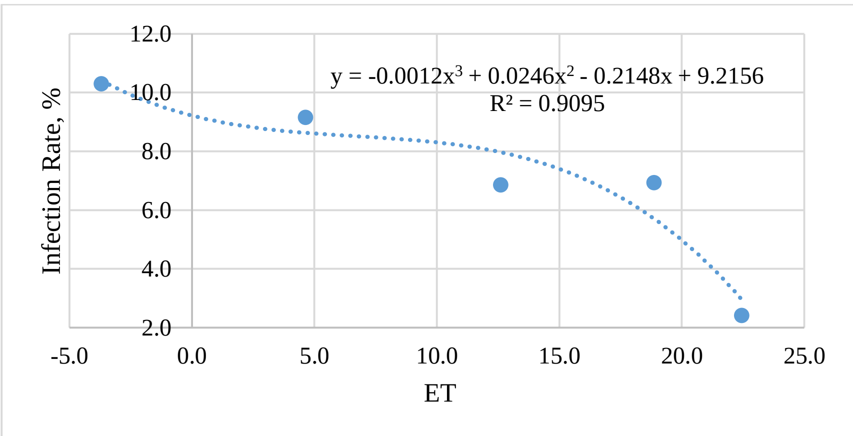

Fig. 4. Connection of COVID-19 Infection Rate with Missenard Air Effective Temperature (ET).

As in the previous case connection of COVID-19 Infection Rate with Missenard Air Effective Temperature has the form of a third power polynomial (Fig. 4).

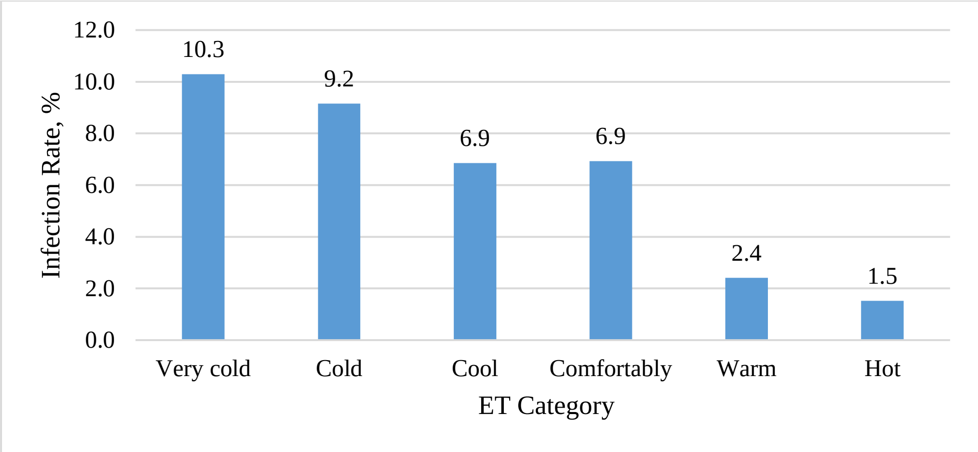

Fig. 5. Values of COVID-19 Infection Rate under different categories of Missenard Air Effective Temperature (ET).

As seen from Fig. 5 values of IR under different categories of Air Effective Temperature (ET) decreases from 10.3% ("Very cold") to 1.5% ("Hot").

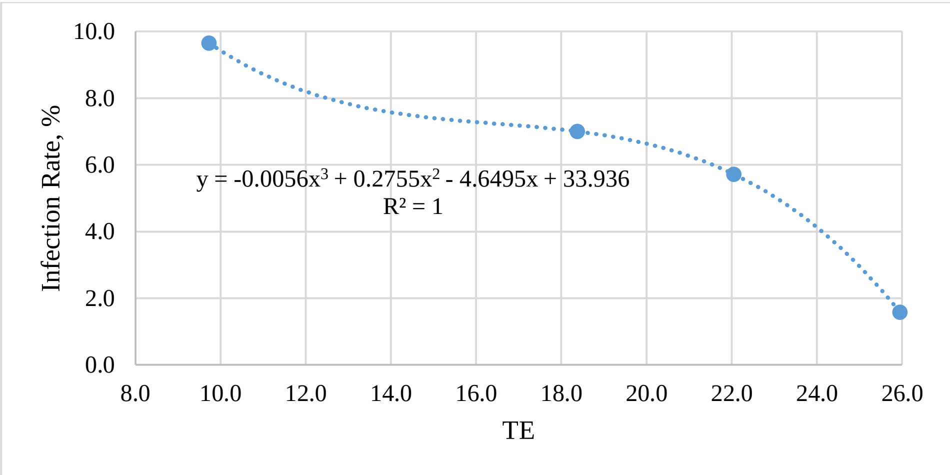

Fig. 6. Connection of COVID-19 Infection Rate with Air Effective Temperature (TE).

Connection of COVID-19 Infection Rate with Air Effective Temperature (TE) also has the form of a third power polynomial (Fig. 6). In this case, the decrease of IR values with increasing TE occurs monotonically.

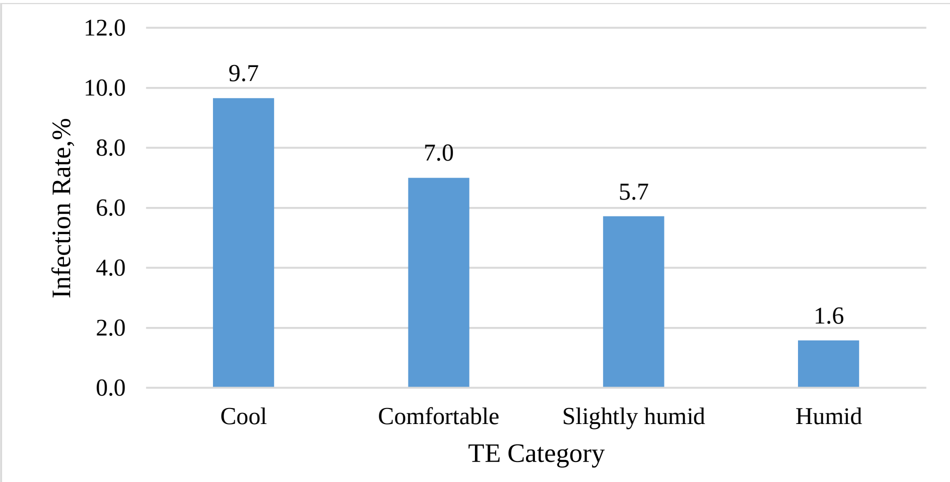

Fig. 7. Values of COVID-19 Infection Rate under different categories of Air Effective Temperature (TE).

Fig. 7 shows that values of IR under different categories TE decrease from 9.7 ("Cool") to 1.6 ("Humid")

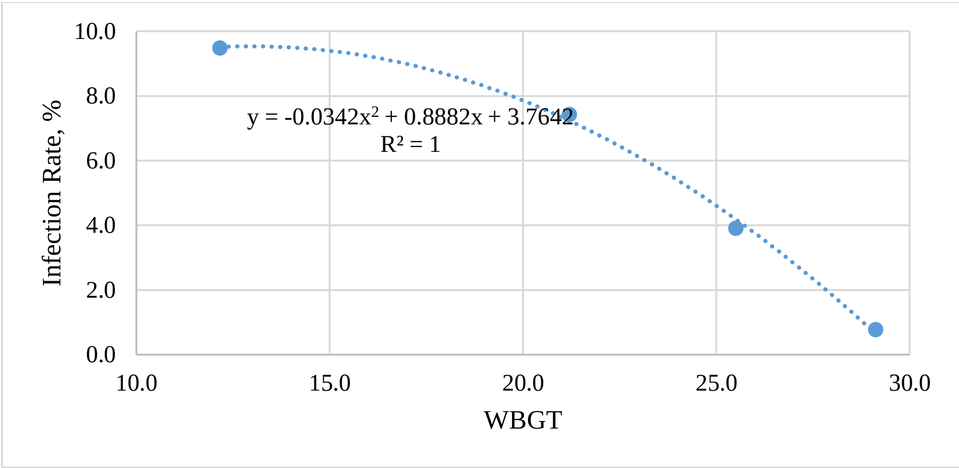

Fig. 8. Connection of COVID-19 Infection Rate with Wet-Bulb-Globe-Temperature (WBGT).

Connection of COVID-19 Infection Rate with Wet-Bulb-Globe-Temperature (WBGT) has the form of a two power polynomial (Fig. 8). As in the previous case the decrease of IR values with increasing WBGT occurs monotonically.

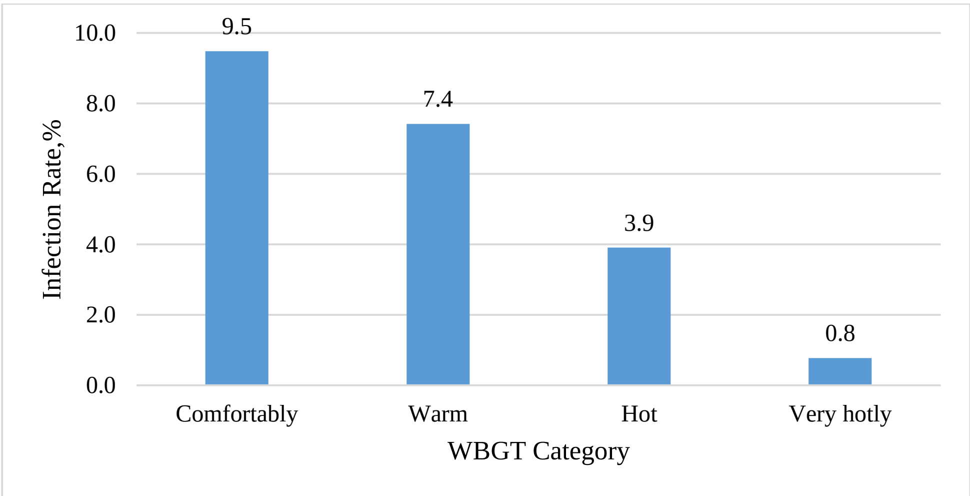

Fig. 9. Values of COVID-19 Infection Rate under different categories of Wet-Bulb-Globe-Temperature (WBGT).

Fig. 9 shows that values of IR under different categories WBGT decrease from 9.5 ("Comfortably") to 0.8 ("Very hotly")

As follows from Fig. 2, 4, 6 and 8 the most significant relationship is noted between IR and TE, IR and WBGT (coefficient of determination $R^2 = 1$, decrease of IR values with increasing of both thermal indexes occurs monotonically).

Thus it has been found that an increase of the air effective temperature leads to a decrease of the IR values. In the latter case, the level of significance of the relationship between thermal indices and IR values is much higher than in the case of the relationship between IR and separate components of these indices (Fig. 1, 2, 4, 6, 8). The reason for this may be that often with a small number of tests, overestimated IR values obtained (testing is carried out only for visitors with coronavirus symptoms). When data are averaged over the values of the categories of thermal indices, these shortcomings are smoothed out. Accordingly, the above results are obtained.

Conclusion

The spread of COVID-19 in Tbilisi, as well as in other locations of the world, significantly depends on both individual meteorological factors and their complexes (thermal indices). As many researchers note, this dependence is often due to local climatic and other specific conditions, the type of virus, etc. In the future, we will continue these studies both for Tbilisi and other regions of Georgia using more extensive material.

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თბილისში COVID-19-ის გავრცელებაზე ზოგიერთი მარტივი თერმული ინდექსის გავლენის კვლევის წინასწარი შედეგები

ა. ამირანაშვილი, ნ. ჯაფარიძე, ლ. ქართველიშვილი,
კ. ხაზარაძე, ა. რევიშვილი

რეზიუმე

წარმოდგენილია მარტივი თერმული ინდექსების ცალკეული კომპონენტების დღე-ღამური მნიშვნელობების (ტემპერატურა და ფარდობითი ტენიანობა, ქარის სიჩქარე) თბილისის მოსახლეობის კორონავირუსით ინფიცირების დადებითობის მაჩვენებელზე COVID-19 (IR) გავლენის კვლევის შედეგები 2020 წლის 1 სექტემბრიდან 2021 წლის 31 მაისამდე. მიღებულია, რომ IR მნიშვნელობები საპირისპირო კორელაციაშია ჰაერის ტემპერატურასა და ქარის სიჩქარესთან და დადებითად არის დაკავშირებული ჰაერის ფარდობით ტენიანობასთან.
შესწავლილი იქნა ოთხი განსხვავებული თერმული ინდექსის (ჰაერის ეფექტური ტემპერატურა და Wet-Bulb-Globe-Temperature) გავლენა IR მნიშვნელობებზე, რომლებიც გასაშუალებული არის მათი კატეგორიების მასშტაბის დიაპაზონში. აღმოჩნდა, რომ ჰაერის ეფექტური ტემპერატურის ზრდა იწვევს IR მნიშვნელობების შემცირებას. ამ უკანასკნელ შემთხვევაში, თერმულ ინდექსებსა და IR მნიშვნელობებს შორის ურთიერთკავშირის ნიშნადობის დონე გაცილებით მაღალია, ვიდრე IR -სა და ამ ინდექსების ცალკეულ კომპონენტებს შორის ურთიერკავშირის შემთხვევაში.

საკვანძო სიტყვები: ბიოკლიმატური ინდექსი, ჰაერის ეფექტური ტემპერატურა, მეტეოროლოგიური პარამეტრები, COVID-19, დადებითობის მაჩვენებელი.

Предварительные результаты исследования влияния некоторых простых термальных индексов на распространение COVID-19 в Тбилиси

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Резюме

Представлены результаты исследования влияния суточных значений отдельных составляющих простых термических индексов (температура и относительной влажность воздуха, скорость ветра) на показатель положительности инфицирования коронавирусом COVID-19 (IR) населения г. Тбилиси с 1 сентября 2020 г. по 31 мая 2021 г. Получено, что значения IR находятся в обратной корреляционной связи с температурой воздуха и скоростью ветра, и положительной – с относительной влажностью воздуха.

Изучено влияние четырех различных термических индексов (эффективная температура воздуха и Wet-Bulb-Globe-Temperature) на значения IR, осредненных по диапазонам шкал их категорий. Получено, что рост эффективной температуры воздуха приводит к уменьшению значений IR. В последнем случае уровень значимости связи термических индексов со значениями IR гораздо выше, чем в случае связи IR с отдельными составляющими этих индексов.

Ключевые слова: биоклиматический индекс, эффективная температура воздуха, метеорологические параметры, COVID-19, показатель положительности.