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Environmental Influences on SARS-CoV-2: Temperature, Humidity, and Far-Infrared Radiation

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Abstract. Countries under study here can be grouped into three Groups. Group A countries including, Hong Kong, Taiwan, Singapore, Malaysia, India, Bangladesh and Thailand and others to be classified experienced high Temperature, high Humidity and high Far Infrared Irradiation during the months of December 2019, January 2020, February 2020, March 2020 and April 2020, and have low IP 10000 (Infectivity) and low DP 10000 (Virulence) for SARS-COV-2. Group B countries, including Finland and Germany, and others to be classified experienced low Temperature, relatively high Humidity and relatively low Far Infrared Irradiation during those months, and have intermediate IP 10000 (Infectivity) and intermediate DP 10000 (Virulence) for SARS-COV-2. Group C countries, including Netherlands, United Kingdom, Belgium, France, Italy, Spain and Sweden and others to be classified experienced low Temperature, relatively low Humidity and low Far Infrared Irradiation, and are associated with very high IP 10000 (Infectivity) and very high DP 10000 (Virulence) for SARS-COV-2. There were reverse correlations between IP 10000 (Infectivity) and DP 10000 (Virulence), and Temperature, Humidity and Virulence. There was no correlation between Infectivity and Virulence. It is submitted that IP 10000 (Infectivity) and DP 10000 (Virulence) for SARS-COV-2 in different countries are determined in large part by environmental factors, including Temperature, Humidity and Far Infrared Irradiation, and that high Temperature, high Humidity and high Far Infrared Irradiation during the months of December 2019, January 2020, February 2020, March 2020 and April 2020 are associated with low IP 10000 (Infectivity) and low DP 10000 (Virulence) It is also submitted that elevated Temperature, high Humidity and high Far

Infrared Irradiation will significantly lower the Viability, Infectivity and Virulence of SARS-COV-2.

Introduction.

SARS-COV-2 is the etiologic agent of COVID-19 which is now considered a Pandemic [1-4]. Currently, while various prophylactics and oxygenation have helped the recovery from severe illnesses, the only effective means of avoiding morbidity due to infections by SARS-COV-2 is through population control and contact restriction which appear to be quite effective in some parts of the world and not others [5]. The DP10000 Number or Number of Deaths Per 10000 Individuals Infected with SARS-COV-2 in various populations and regions of the world are not uniform [5]. Although the Medical Infrastructure and Response Strategy and Protocol play an important role in mitigating illnesses and deaths as a result of SARS-COV-2 infections, the possibility that variability in the DP10000 Numbers for SARS-COV-2 in various populations and regions of the world may be due to SARS-COV-2 mutations cannot be ruled out [5]. There is some evidence showing that the biochemistry (molecular biology) of SARS-COV-2 sub-strains may be different in various populations and regions of the world [5-7].

The Strategy for the control of SARS-COV-2 Infections and Virulence of the World's governmental and scientific leaderships consists entirely of coming up with a vaccine and a chemically based cure. Unfortunately, considering the record with other infectious viruses that cause diseases of the respiratory system and associated complications, the development, testing and use of an effective vaccine for the control of SARS-COV-2 Infections and Virulence for the foreseeable future is not very obvious. The same can be said for the development of an effective drug for the treatment of SARS-COV-2 associated diseases. It is therefore legitimate and wise to explore other avenues for the control of SARS-COV-2 Infections and Virulence in populations around the world. The Viability, Infectivity and Virulence of Viruses that infect human, including SARS-COV-2 are highly dependent upon environmental factors, including Temperature, Humidity and level of

Radiation. This study explores the correlation between Infectivity and Virulence, and Temperature Humidity and Far Infrared Irradiation during the months of December 2019, January 2020, February 2020, March 2020 and April 2020. In this study, we devised a method of measuring the Infectivity (IP 10000) and Virulence (DP 10000) of SARS-COV-2 at the population level in various countries to achieve that aim.

Method.

Data for the total number of individuals infected with SARS-COV-2 and total number of deaths due to SARS-COV-2 infections for each country was curated from the World Health Organization, Department of Health of each countries. IP 10000, a measure of Infectivity is defined as the Number of Individuals Infected with SARS-COV-2 Per 10000 Population. DP 10000, a measure of Virulence is defined as the Number of Deaths Per 10000 Individuals Infected with SARS-COV-2. IP 10000 and DP 10000 were calculated based on the total number of individuals infected with SARS-COV-2 and total number of deaths due to SARS-COV-2 infections.

Temperature, Humidity and Far Infrared Irradiation values were curated from the Meteorological Readings and forecasts of each country.

Data was analyzed for correlations by the Pearson method [8,9]. Differences between groups were determined by the student t-test [10,11] or one way anova test [12,13] with $p < 0.05$ accepted as statistically significant.

Results.

Figure 1 shows the Total Number of Individuals Infected with SARS-COV-2 in different countries and locations (Figure 1A), the total number of deaths due to SARS-COV-2 infection (Figure 1B), DP 10000 Number or Number of Deaths per 10000 Individuals infected with SARS-COV-2 (Figure 1C). The IP 10000 Number is a measure of Infectivity while the DP 100000 is a measure of virulence. A plot of DP10000 v. Total Number of Individuals Infected with SARS-COV-2 in each countries with various different locations reveals that there is no correlation between Infectivity and Virulence (Figure 1D).

On the other hand, there is moderate reverse correlation (r = -.42 between Infectivity and Temperature (Figure 2A) and high reverse corelation (r = -.71) between Virulence and Temperature (Figure 2B). There is relatively high reverse correlation (r = -.65) between Infectivity and Humidity (Figure 3A) and moderate reverse correlation (r = -.43) between Virulence and Humidity (Figure 3B). There is some but weak reverse correllation (r = -.15) between Infectivity and Far Infrared Irradiation (Figure 4A) and relatively good correlation (r = -55) between Virulence and Far Infrared Irradiation (Figure 4B).

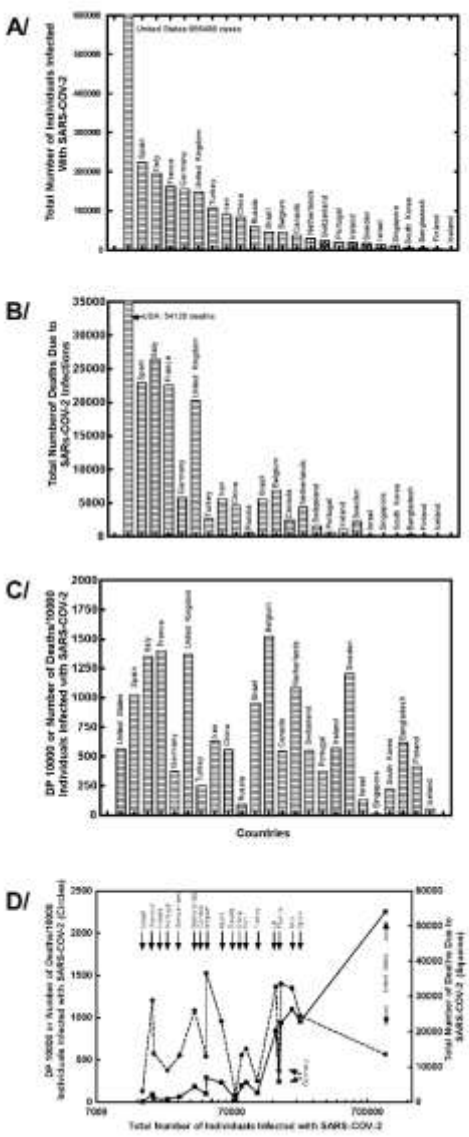

Figure 1. No correllation between SARS-COV-2 Infectivity and Virulence. The values for Total Number of Individuals Infected with SARS-COV-2 for each countries were obtained from the World Health Organization (WHO), Center For Disease Control and Prevention (CDC), and each State's Department of Health. The values are for April 23, 2020. Panel D: $p = > 0.05$.

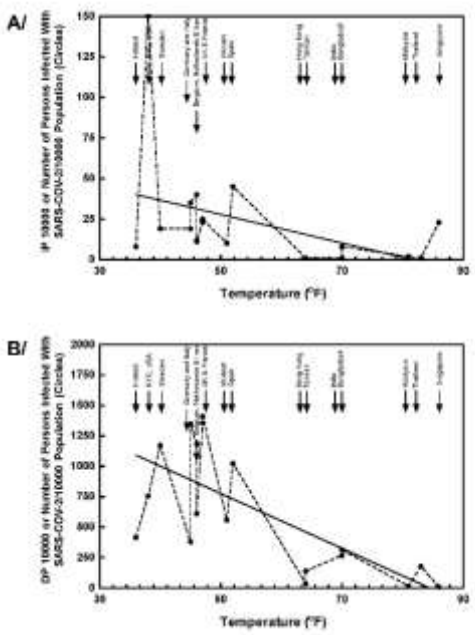

Figure 2. Reverse correllation between Temperature and Infectivity and Virulence. IP 10000 or Number of Infected Individuals Per 10000 Population (Panel A) and DP 10000 or Number of Deaths Per 10000 Infected Individuals (Panel B) were calculated from the data of Figure 1 and plotted against average temperature for the months of December 2019, January 2020, February 2020, March 2020 and April 2020 for each country. The data for average temperature was calculated from data available from each country's meteorological historical readings and forecasts. *p* = < 0.05.

Countries, including Hong Kong, Taiwan, Singapore, Malaysia, India, Bangladesh and Thailand and others to be classified, which usually have high temperatures (average of ~67 ^{0}F), high humidity (average of ~79%) and high Far Infrared Radiation (average of ~4.7 x 10^8 Joules/Km^2) have low IP 10000 Numbers (average of 3) and low DP Numbers (average of 118) (Figure 5) can be grouped together as Group A

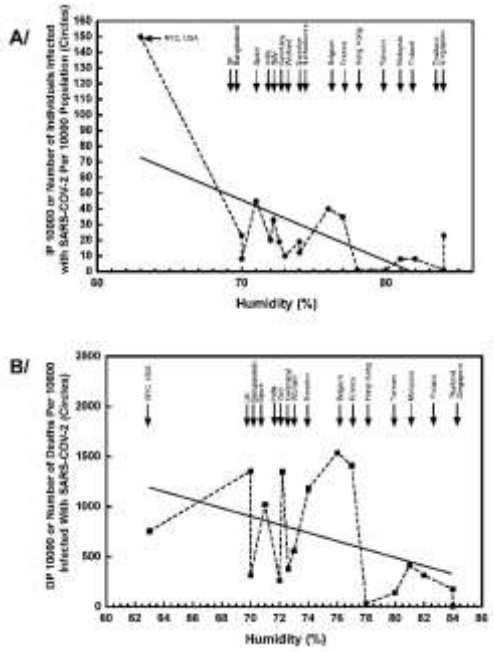

Figure 3. Reverse correllation Between Humidity and Infectivity and Virulence. IP 10000 or Number of Infected Individuals Per 10000 Population (Panel A) and DP 10000 or Number of Deaths Per 10000 Infected Individuals (Panel B) were determined from the data of Figure 1 and plotted against average Humidity for the months of December 2019, January 2020, February 2020, March 2020 and April 2020 for each country. The data for average Humidity was calculated from data available from each country's meteorological historical readings and forecasts. *p* = < 0.05.

countries. The country, Finland usually experiences high humidity (~81 %) during the months of December 2019, January 2020, February 2020, March 2020 and April 2020 has low IP 10000 Number (Number of Infected Individuals per

10000 population) and low DP 10000 Number (Number of Deaths per 10000 Individuals infected with SARS-COV-2) (Figure 3). Although, Finland also received low Far Infrared Radiation

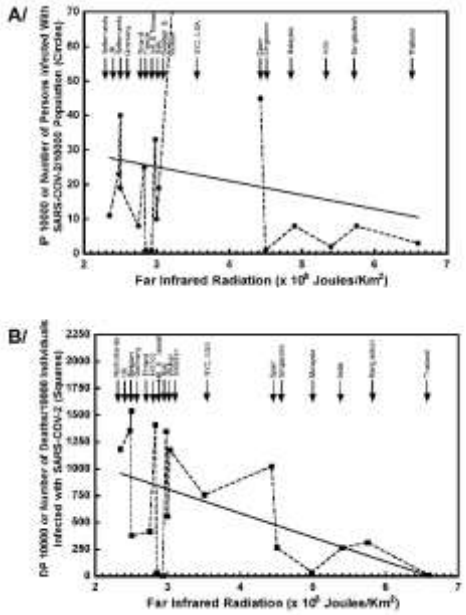

Figure 4. Reverse correllation Between Far Infrared Radiation (FIR) and Infectivity and Virulence. IP 10000 or Number of Infected Individuals Per 10000 Population (Panel A) and DP 10000 or Number of Deaths Per 10000 Infected Individuals (Panel B) were determined from the data of Figure 1 and plotted against average FIR for the months of January 2020, February 2020, March 2020 and April 2020 for each country. The data for average FIR was calculated from the average monthly sunlight data available from each country's meteorological historical readings and forecasts. (p = < 0.05).

during the months of December 2019, January 2020, February 2020, March 2020 and April 2020, the effects of low Far Infrared Radiation appears to have been counterbalanced by the effects of high humidity as there is relatively high reverse correlation (r= -.65) between Infectivity and Humidity (Figure 3A) and moderate reverse correlation (r= -.43) between Virulence and Humidity (Figure 3B). The IP 10000 (Infectivity)

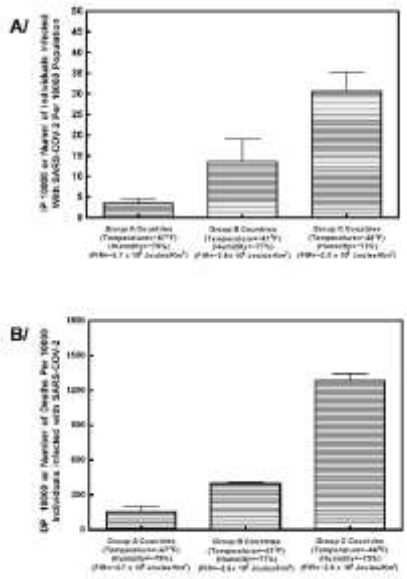

Figure 5. Significant Differences of IP 10000 (Infectivity) (Panel A) and DP 10000 (Virulence) (Panel B) between Group A Countries (Singapore, Malaysia, India, Bangladesh, Hong Kong and Taiwan), Group B Countries (Finland and Germany) and Group C countries Netherlands, United Kingdom, Belgium, France, Italy, Spain and Sweden). The data for Infectivity and Virulence was calculated from the data of Figure 1. (p values between Groups were less than 0.05).

and DP 10000 (Virulence) of SARS-COV-2 in Finland and Germany are very similar (Figures 2-4). Finland and Germany which both are localized in the perimeter of the Baltic Sea can therefore be grouped together (Group B countries). [Group B includes countries in the perimeter of the Baltic Sea, Tung, H.Y.L. and Limtung, P., unpublished data]. United States represented by New York City currently occupies the top position with respect to IP 10,000 Number

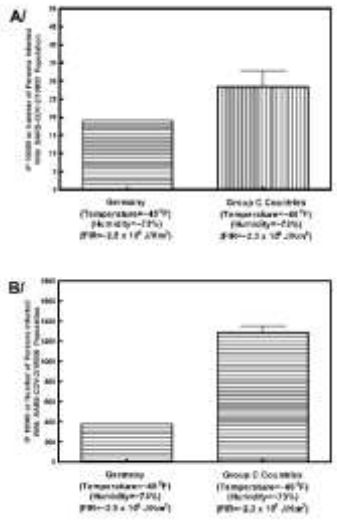

Figure 6. Differences of Infectivity (Panel A) and Virulence (Panel B) between Germany and Group C Countries (Netherlands, United Kingdom, Belgium, France, Italy, Spain and Sweden). The data for Infectivity and Virulence was calculated from the data of Figure 1.

(Number of Infected Individuals per 10000 population) with also a very high DP 10000 Number of 756. During the months of December 2019, January 2020, February 2020, March 2020, and April 2020, New York City experienced low Temperature, very low Humidity and relatively low Far Infrared Irradiation. The very low humidity observed was quite unusual. SARS-COV-2 Infection and Virulence in New York City which offers a very challenging study will be described elsewhere. Preliminary study shows that countries in the North American continent including, the United States and Canada form a different Group [Tung, H.Y.L. and Limtung, P., work in progress].

Discussion.

This study has shown that there is reverse correlation between Infectivity, as measured by IP 10000 and Virulence, as measured by DP 10000, and Temperature, Humidity and Far Infrared Irradiation. This study has also shown that countries can be grouped based on their associated Temperature, Humidity and Far Infrared Irradiation. Group A countries, including Hong Kong, Singapore, Malaysia, India, Bangladesh and Thailand, and other under study experienced high Temperature, high

Humidity and high Far Infrared Irradiation, and are associated with low IP 10000 (Infectivity) and low DP 10000 (Virulence). Group B countries, including Finland and Germany, and others under study which experienced low Temperature, relatively high Humidity and relatively low Far Infrared Irradiation respectively are associated with moderate IP 10000 (Infectivity) and moderate DP 10000 (Virulence) of SARS-COV-2. On the other hand, Group C countries, including Netherlands, United Kingdom, Belgium, France, Italy and Sweden which experienced low Temperature, relatively low Humidity and low Far Infrared Irradiation are associated with high IP 10000 (Infectivity) and high DP 10000 (Virulence) It is submitted that Environmental factors, including Temperature, Humidity and Far Infrared Irradiation play important roles in SARS-COV-2 Infections and Virulence.

Three countries deserve further analysis. The average temperature, humidity and Far Infrared Radiation during the months of December 2019, January 2020, February 2020, March 2020, and April 2020 for the country, Germany were 45 ^{O}F, 72.6 % and 2.5 x 10^{8} Joules/Km^{2} respectively. Thus, the difference between Germany and group C countries was at the level of Far Infrared Irradiation (2.5 Joules /Km^{2} v. 2.3). Can these numbers explain significantly lower IP Number (19) and low DP Number (379) that Germany experienced (Figure 6). It has been argued that Germany adopted a very different response strategy than the Group B countries (Netherlands, United Kingdom, Belgium, France, Italy, Spain and Sweden) in that Germany systematically tested individuals at an early stage and had a policy of strict isolation of individuals infected with SARS-COV-2. However, the above results do not explain the non-correlation between Infectivity and Virulence (See also Figure 1D). It is submitted that the biochemistry (molecular biology) of SARS-COV-2 strain in Germany may be different from SARS-COV-2 strains in Netherlands, United Kingdom, Belgium, France, Italy, Spain and Sweden. There is evidence of many mutations of SARS-COV-2 in different populations and locations [5, Tung, H.Y.L., manuscript in preparation]. The country, Finland which usually experiences high humidity (~81 %) during the months of December 2019, January 2020, February 2020, March 2020 and

April 2020 has low IP 10000 Number (Number of Infected Individuals per 10000 population) and low DP 10000 Number (Number of Deaths per 10000 Individuals infected with SARS-COV-2). Although, Finland also received low Far Infrared Radiation during the months of December 2019, January 2020, February 2020, March 2020 and April 2020, the effects of low Far Infrared Radiation appears to have been counterbalanced by the effects of high humidity as there is relatively high reverse correlation (r= -.65) between Infectivity and Humidity (Figure 3A) and moderate reverse correlation (r= -.43) between Virulence and Humidity (Figure 3B).

In this study United States, represented by New York City occupied the top position with respect to IP 10,000 Number, with also a very high DP 10000 Number of 756. During the months of December 2019, January 2020, February 2020, March 2020, and April 2020, New York City experienced low Temperature, very low Humidity and relatively low Far Infrared Irradiation. The very low humidity observed was quite unusual. The inverse correlation between Infectivity and Temperature, Low Humidity and Low Far Infrared Radiation does not appear to be co-incidental. It appears to have a scientific basis that is most probably due to unusual seasonal change as a result of global climate change. The Principles of the Theory of Chaos inform us that very small but significant change in chaotic events usually precedes Irreversible and Complete Chaos. In this case, Irreversible and Complete Chaos happens to be in form of Deaths of Individuals [14].

It was Lwoff and co-workers who first coined the termed "Prophage" to describe an entity which was not yet a full-fledged "Bacteriophage" which is the equivalent of a Virus in Bacteria [15]. Lwoff and co-workers realized that a "Prophage" could be induced by irradiating the host Bacteria with Ultraviolet Radiation and concluded that Ultraviolet Radiation was the agent that induced or unleash the pathogenicity of the "Bacteriophage" (the equivalent of Virus in mammals including humans). that was dormant but always there in the form of a "Prophage" [16]. The importance of Virus Induction was recognized and generalized in Viruses that infect mammalian cells, including humans [17,18]. Lwoff [17,18] used the example of Herpes Simplex Virus to illustrate Viral

Induction in humans. Herpes Simplex Virus is associated with what is termed Latent Infection which does not cause any disease and which does not produce Infectious Viruses. The fact that no Viruses can be detected does not mean that there are no Viruses. The Viruses could be present at very low levels or in a latent form just like in the case of the Bacterial Virus, the "Bacteriophage". There are many Agents of Viral Induction, including Temperature, pH, Humidity, Viscosity and Radiation [17,18]. High temperature is also a negative controller of Viral Development and Replication. Quoting the work of Thompson and Coates [19] who showed the effect of temperature on viral development, Lwoff [18,19] lamented that "The temperature problem did not succeed in capturing the attention of scientists, as exemplified by the fact that the subject is hardly mentioned or not mentioned at all in textbooks or treatises of animal virology. Why this work did not develop is a mystery. A scientist must not only have the right idea, do the right experiments, and give birth to a paper. He also must build a coherent doctrinal corpus and must force it into reviews and textbooks (And must force it also into the brains of his colleagues.)". Subsequent studies by Armstrong [20] showed that that mice infected with Herpes Simplex Virus died at room temperature and not at higher temperature. Lwoff and Lwoff [21] and Lwoff et al [22] described the effects of hyperthermia on Polio Virus Virulence and showed that 10/25 mice infected with Polio Virus Type II survived when they were kept at 36.5^0 C whereas none survived when they were kept at 20^0 C (which is room temperature), and proposed that "hyperpyrexia may save an animal infected intra-cerebrally by a high dose of a virulent strain of poliovirus, or transform a hyper-acute disease into a latent infection". Morikawa et al. [23] reported that they could identify several viruses associated with Respiratory Tract Diseases in asymptomatic individuals, including human parechovirus, adenovirus, enterovirus, rhinovirus, coronavirus 229E and HKU1, suggesting Virus Dormancy or Latency. Allen et al [24] observed that an outbreak of common colds occurred in an isolated station in Antarctica after a sudden change in weather that brought the temperature down from a high of $1\text{-}2^0$ C to a low of -24^0 C and reduced the relative outside humidity from 93 % to 79 % and

postulated that the sharp decrease of temperature may explain "the persistence of large number of rhinovirus serotypes". Muchmore et al. [25] related that Parainfluenza virus types 1 and 3 could be recovered from both asymptomatic and symptomatic subjects throughout winter in an isolated station in the South Pole and concluded that the viruses could not have been introduced and were most probably due to "persistence in man". Shaw-Stewart [26] proposed that the "natural temperature sensitivity of respiratory viruses" allows virions to become dormant and viral activation as a result of chilling.

There is a debate concerning the origin of SARS-COV and SARS-COV-2. Until there is definitive proof that SARS-COV and SARS-COV-2 came from animals including bats and other mammals as intermediate carriers [1-3], the possibility that SARS-COV and SARS-COV-2 were dormant or latent viruses that became induced by specific agents including low temperature, low humidity and low radiation cannot be ruled out. In the case of SARS-COV and SARS-COV-2, agents of Viral Induction include Temperature, pH, Viscosity, Low Humidity and Radiation. It is generally accepted that both SARS-COV and SARS-COV-2 emerged during the winter months which provides an ideal environmental condition for the viability and infectivity of SARS-COV and SARS-COV-2 and that low humidity significantly contributed to the emergence of both SARS-COV and SARS-COV-2 [27]. Low sunlight is also accompanied by low level of Far Infrared Radiation (FIR) because approximately 49% of the sun's energy that reaches earth is in the form of Infrared Radiation. Chan et al. [28] showed that at a temperature of ~38^0 C and relative humidity greater than 95%, there was a significant loss of SARS-COV viability and infectivity than at ~33^0 C and relative humidity greater than 95% indicating that SARS-COV preferred a low temperature and low humidity for its viability and infectivity. Sun et al. [27] have reported that both SARS-COV and SARS-COV-2 emerged during winter in 2002 and 2020 respectively after a drought season around Foshun, China and Wuhan, China. Yamaya et al. [29] showed that another Virus, H1N1 which was responsible for the 2009 Pandemic also emerged during winter and were susceptible to temperatures nearing 40^0 C. Specifically, Yamaya et al. [29] showed that at 120

hours post-infection, six different strains of H1N1 exhibited lower titers (i.e infectivity) in cells cultured at 40^0 C than in cells cultured at 37^0 C. Yamaya et al. [29] also reported that levels of inflammatory cytokines (the agents that negatively affect individuals infected with various viruses) in cells infected with H1N1 were lower at 40^0 C than at 37^0 C. Yamaya et al. [29] concluded that exposure to temperature above 39^0 C may reduce the replication of pandemic and seasonal Influenza Virus. However, inexplicably, they did not propose that treatment of infected individuals should include induction of sweating which would not only act to significantly reduce fever but also reduce the viability and infectivity of H1N1.

It is a common laboratory procedure to use Ultra Violet Radiation (UVR) to destroy microorganisms and other biological entities, including viruses [30,31]. However, it is unlikely that low UVR during the months of December 2019, January 2020, February 2020, March 2020 and April 2020 could account for high IP Numbers and DP Numbers as UVR is not known to traverse human skin unless exposed to it directly. Moreover, UVR is generally harmful to humans as it has been shown to cause cell damage [32]. On the other hand, Far Infrared Radiation is known to radiate evenly and to be able to traverse human tissues with thickness up to 30 mm, including the skin [33]. The use of photochemically generated reactive oxygen species (ROS), including singlet oxygen for the inactivation of viruses are very effective [34-36]. However, the common use of Chemotherapy based anti-virals supplanted the use of either UVR or Photodynamic Therapies. Recent advances in the inactivation of viruses via Photodynamic and the fact that there is currently no effective antivirals or vaccines against SARS-COV-2 indicate that Photodynamic Therapies merit further exploration. On the other hand, the effectiveness of Far Infrared Radiation (FIR) in destroying microorganisms and other biological entities, including SARS-COV-2 has been documented [37]. FIR Therapy has also been shown to reduce inflammatory response due to viral infection by enhancing the production of nitrous oxide which is one of the mechanisms to inhibit NFkB, an important regulator of inflammatory response [38,39]. Protocols in various forms exist already to treat humans and can be applied

to combat SARS-COV-2 immediately [40].

Based on the above findings, it is submitted and hypothesized that an environment of high humidity and temperature approaching 39 ^{O}C (or more if it is not too uncomfortable) and constant FIR irradiation will significantly lower the viability and infectivity of SARS-COV-2, and significantly enhance the recovery of individuals infected with SARS-COV-2. It is also hypothesized that the process of steaming up to 70^{0} C - 80^{0} C in a FIR Sauna may not only reduce the viability and infectivity of SARS-COV-2 but also enhance the recovery of individuals infected with SARS-COV-2. It is further hypothesized that Asymptomatic Carriers of SARS-COV-2 will also benefit as the above will reduce the infection of the population by Asymptomatic Carriers of SARS-COV-2. It must be noted that (i) the above hypotheses have not been scientifically validated, (ii) remain untested hypotheses, and (ii) this report does not constitute a prescription. However, it is consistent with the findings of Lwoff and Lwoff [14] and Lwoff et al [15].

The hypothesis that an environment of high humidity and temperature approaching 39 ^{O}C and FIR irradiation will significantly lower the viability and infectivity of SARS-COV-2 and significantly enhance the recovery of individuals infected with SARS-COV-2, and that the process of steaming up to 70^{0} C -80 ^{O}C in a FIR Sauna may not only reduce the viability and infectivity of SARS-COV-2 but also enhance the recovery of individuals infected with SARS-COV-2. is based on common sense and is supported by the findings of Lwoff and co-workers [8,11], Chan et al. [12], Yamaya et al. [14], and Tung [5, Tung, H.Y.L. Manuscript in preparation]. The use of Far Infrared Radiation Therapy is not unlike Radiotherapy first discovered by Marie Curie. Protocol for the requirements of the above hypotheses exist already and can be implemented immediately. It would be foolhardy to rely on the the promise of so-called scientific experts and pundits to deliver effective vaccines and cures in the coming months when all previous experiments showed that in the best case scenario, any effective vaccines or cures are years and not months away, and not to explore different avenues, including the use of elevated

Temperature, Humidity and Far Infrared Irradiation to control and treat SARS-COV-2 Infection and Virulence. Implementation Protocols that will not cost trillions of dollars exist already.

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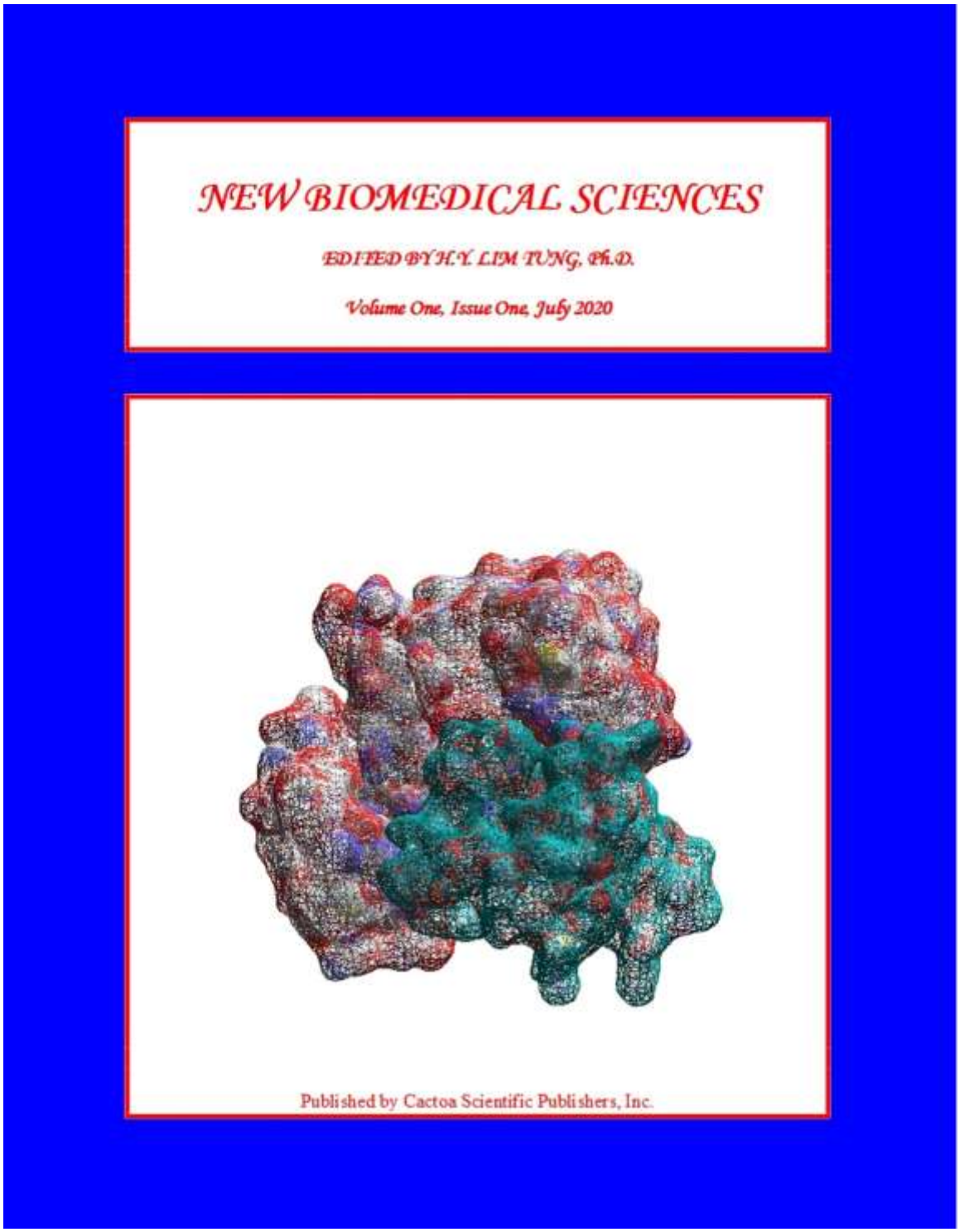
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