

Redundancy of Respiratory Humidification & Dysfunction of Defense Mechanisms at Upper Airways of Large Number of People Due to Cumulative Adverse Effects of Climate Change -The Root Cause of the Covid-19 Outbreak - An Engineering Perspective

Abstract:

Purpose:

The Covid-19 has returned in the form of an outbreak of new variants. Viruses have evolved and accompanied mankind from times immemorial but seem to be increasingly threatening the survival of the human race especially in the last four decades. Various theories are available with respect to initial transmissions to humans yet none is endorsed in totality. Similarly *climate change* poses the greatest threat to human health and its effects are more pronounced in the last four decades. The purpose of this perspective is to establish scientifically a correlation between the outbreak of Covid-19 or its variants and *climate change*.

Basis:

This presentation is based on hitherto overlooked yet proven physics and engineering involved in the human respiratory humidification. Respiratory humidification is a uniquely evolved process of *Natural Selection* to withstand complex and dynamic environments. In animals, migration is seasonal and one of its important purposes is a search for *suitable environmental* conditions. But humans who are mainly responsible for *Climate Change* and harm to the environmental balance seem to be bound by occupational compulsions to the extent of threatening their own survival.

Method and Conclusions:

As Covid-19 is a respiratory viral disease, the gas exchange mechanism and human body's normal temperature and alveolar air parameters are first explained to justify its uniqueness. A step by step review of physics and engineering involved in respiratory humidification is also done. It is then analyzed in context of *Climate Change* of a location and its impact on inspired air parameters. Based on *Meteorological Data* of Wuhan; the place of Covid-19 outbreak; it is established that the *Climate Change* resulted in redundancy of respiratory humidification and dysfunction of associated immune defense mechanisms of many inhabitants and facilitated viruses like SARS-CoV-2 an unchallenged access to the lungs. These viruses remained in circulation till the persons with the most weakened defense mechanisms presented an opportunity to breach ACE2 receptors and result in an outbreak.

Key Words: Respiratory Humidification, Climate Change, Redundancy, Dysfunction of Defense Mechanisms, Meteorological Data, Wuhan

Introduction and basis:

All of us know that the normal temperature of the human body is 37°C. We also know that the temperature of the alveolar air is 37°C and that it is fully saturated. This means that it has 100 % relative humidity (RH). It is interesting to know that these are unique parameters of the human body and all

mammals of the animal kingdom. These parameters are an example of a system evolved by *Natural Selection* to withstand a complex and dynamic environment [1].

“What is so special about these parameters?” shall be the obvious question.

It is intriguing to know that there is no place on the earth where ambient air can have temperature above 33°C with 100% RH simultaneously. Record of maximum humidity and maximum temperature occurring simultaneously belongs to Dhahran in Saudi Arabia. On 8th July 2003, the maximum temperature and RH were 42°C and 75% respectively [2]. The ambient air can be as hot as $50^{\circ}\text{C}+$ but there the RH shall be generally very less, at times even less than 10%. Similarly where the RH is as high as 100% the temperatures are very less. The reason is simple. As the air heats up it expands and its capacity to hold moisture increases, which means its RH falls down and vice versa.

Irrespective of the range of inspired air parameters the alveolar air is maintained at 37°C with 100% RH [3]. These unique parameters are achieved by the body through its amazing air *humidification and conditioning process*. As the output is defined, the humidification process programs itself according to continuously changing input parameters of ambient air. Over and above it provides immune defense mechanisms to counter and track viruses and pathogens.

Most of the humidification and conditioning takes place at upper airways. The lower airways and an induced draft from oral salivary moisture account for the saturation of the air. This means that wherever one breathes, whatever place one inhabits or migrates to, the alveolar air is maintained constantly at 37°C with 100% RH [4,5]. Further there will not be any temperature gradient across the gas exchange membrane as the body's normal temperature is also 37°C . The *gas exchange* in lungs is a complex phenomenon [6] and any *temperature gradient* shall make it unpredictable. Comparative values of *partial pressures* and *partial pressure differences* of oxygen and carbon dioxide in atmospheric air and that of alveolar air are given in the tables 1 and 2. Negative sign indicates that carbon dioxide diffuses in a direction opposite to that of oxygen.

Table 1: Partial Pressures of Atmospheric Gasses(760mm)					
Gas	Percent of Total Composition	Partial Pressure (mm Hg)	Partial Pressures of O ₂ and CO ₂ in Pulmonary Capillaries (mm Hg)	Partial Pressure Difference Δp mm Hg	Remarks
Nitrogen	78.6	597.36			Partial Pressure Difference if Alveolar Air was same as Atmospheric Air
Oxygen	20.9	158.84	40	118.84	
Water	0.04	0.304			
CO ₂	0.004	0.0304	45	-44.97	
Others	0.456	3.4656			
Total	100	760			
Standard Figures Available in Science Books					

Table 2: Partial Pressures of Alveolar Gasses(760mm)@37 Deg C 100%RH

Gas	Percent of Total Composition	Partial Pressure (mm Hg)	Partial Pressures of O ₂ and CO ₂ in Pulmonary Capillaries (mm Hg)	Partial Pressure Difference Δp mm Hg	Remarks
Nitrogen	74.9	569.24			Partial Pressure Difference for Alveolar Air
Oxygen	13.6	103.36	40	63.36	
Water	6.2	47.12			
CO ₂	5.3	40.28	45	-4.72	
Others	traces	0			
Total	100	760			

Standard Figures Available in Science Books

At any given instance, the diffusion of oxygen in the blood vessels from the lungs reduces its partial pressure in alveolar air. Similarly when carbon dioxide diffuses in the lungs from the blood vessels, it results in a rise in its partial pressure in alveolar air. The comparison of partial pressure differences of oxygen and carbon dioxide in the atmospheric air and alveolar air clearly shows that the humidification moderates the gas exchange mechanism and thus maintains homeostasis [6, 7]. It is difficult to imagine how humans and mammals could have survived the complexities of a dynamic environment if the alveolar air was the same as ambient air and the humidification mechanism was not there.

However, a location where temperature reads in the range of 30°C to 37°C and RH simultaneously reaches above 75%, is the *most threatening combination* to the inhabitants in the context of the respiratory humidification process and Covid-19. The reasons are explained in the next paragraphs. It is not just a rise in heat but a rise in humidity too in combination, which is the real cause of worry [8]. It is also explained why locations with such combinations are on the rise and why it can lead to further disasters like the ongoing pandemic.

Review of Humidification of Inspired Air: [4, 5]

Now let us review how the humidification of inspired air takes place in the upper and lower respiratory airways. Whatever is the temperature and relative humidity of air inspired; it passes through the convoluted air passages of the naso-pharynx and pharynx of upper airways. Turbulence generates here, which increases contact area for *heat and mass transfer* between air and the mucosa. While the inspired air gets warmed up the mucosa cools down. Depending on the inhaled air parameters an *evaporative* humidification takes place and vaporized molecules of mucosa mix with inhaled air. Here at upper airways, the inspired air attains RH in excess of 75% and temperature up to 33°C. While traveling to the lower respiratory airways, the air creates an induced draft for oral salivary moisture. And at the isothermal saturation boundary, beyond the *Carina* (bottom of trachea where it bifurcates) the inspired air reaches 37°C and 100% RH. During exhalation the hot alveolar air at 37°C, heats up the mucosa to a certain extent. Mucosa thus recovers some heat lost during inspiration. A small amount of vapor also gets condensed [4, 5]. At places where ambient air is dry and the temperature is more than 37°C, humidification by *evaporative cooling* takes place in the upper airways. The mucosal fluid gets latent heat of evaporation from hot and dry inspired air. The temperature of mucosa does not change, but part of it vaporizes to reduce inspired air temperature to 37°C and increase RH to 100% [4, 5].

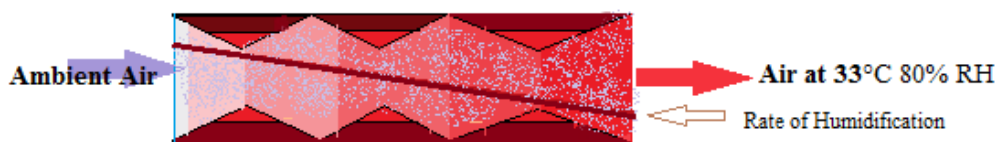
These vaporized molecules have *mucosal defense mechanisms* in form of *IgA* (Immunoglobulin A-the first line of defense) and shall mix with inspired air while it travels through to alveoli [9]. These defense mechanisms have an ability to *track and bind with viruses* and pathogens. Obviously the humidification is a *multitasking* process and is as critical as actual breathing.

Redundancy of Respiratory Humidification and Dysfunction of Defense Mechanisms:

Climate Change and global warming have pushed some places of the world in the zone of *most threatening combination* of 75%RH with temperature concurrently ranging within 33°C to 37°C, for a period it would ultimately matter. It must be noted that unlike solids, *air is a poor conductor of heat* and as the temperature difference between inspired air and mucosa reduces the rate of heat transfer drastically drops and tends to become zero [10]. This means that at such conditions when ambient air has RH above 75% and concurrently the temperature is also in the range of 33°C to 37°C, the humidification and associated immune defense mechanisms in upper respiratory airways shall get *redundant* or *dysfunctional*. This is obvious as the inhaled air shall have parameters the same as what humidification at upper airways can achieve. Neither will there be any reverse heat transfer and condensation during exhalation [10]. A schematic of Normal and Redundant Humidification and Dysfunctional Defense Mechanisms during *inspiration* is shown in Figure 1.

Figure 1: Normal and Redundant Respiratory Humidification and Defense Mechanisms

Schematic of Convuluted Respiratory Track



Normal Evaporative Humidification with Defense Mechanisms



Redundancy Of Respiratory Humidification and Dysfunction of Defense Mechanisms

As the humidification becomes redundant, the *defense mechanisms* also get dysfunctional [9]. An exposure to such climatic conditions will facilitate an unchallenged *access* to all viruses like SARS-CoV-2 to the alveolar space and the period of such exposure shall be critical in severity of its infection. This clearly points to the reason behind *Natural Selection of 37°C* as normal body temperature and a zone of 33°C to 37°C and RH ranging above 75% best choice for humidification [1]. The process of evolution thus ensures that at no point of time, the ambient air will have parameters same as those which are produced during the entire process of respiratory humidification and consequently pose a threat to its

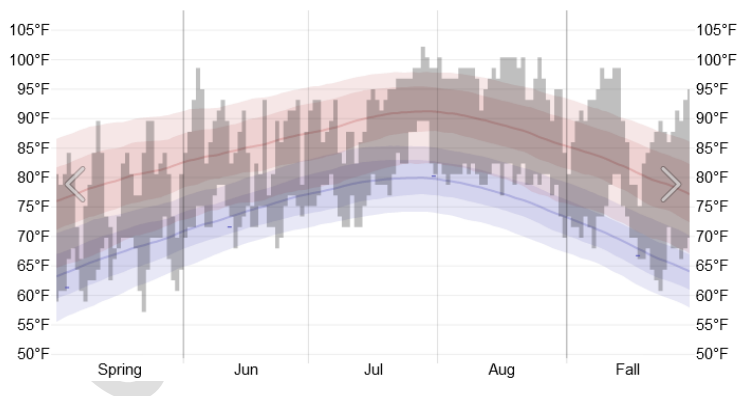
integral defense mechanisms. However, the last four decades have seen a spurt in different respiratory viral pandemics with SARS-COV, evolving in its current SARS-CoV-2 form as the latest one. Adverse effects of *global warming* and *rate of rise in average maximum temperature* have also doubled since 1981 [11]. At certain places or cities the ambient air that people breathe has reached 33°C with humidity in excess of 75% simultaneously as fallout of climate change triggered by *urbanization and industrialization in clusters*. *Occupational compulsions* have forced the inhabitants to ignore these changes which have steadily and stealthily impacted human lives [12]. *Wuhan* is one such example of growth in clusters. The number of such places across the world is on the rise.

Unlike Avian, *human lungs expand and contract*. Further the human lungs always retain some volume of air which is called functional residual volume (*FRV*). This protects all humans and mammals from lung collapse. Whereas Avian lungs are just a stationary flow through the gas exchange surface and its sacks (air bags) expand and contract during inhalation and exhalation. After every breathing cycle there is almost 100% air change. Thus Avian may be carriers of viruses, yet are poor hosts (barring birds and bats) [13]. But in *FRV* of human lungs the viruses may remain in circulation till hosts with weakest immune defense mechanisms provide an opportunity to travel to ACE2 receptors and replicate. This state corresponds to the *detected* outbreak and maybe days apart from the actual redundancy phenomenon.

Meteorological Data of 2019 of Wuhan Indicates to Redundancy of Respiratory Humidification & Dysfunction of Defense Mechanisms at Upper Airways of Large Number of People Due to Cumulative Adverse Effects of Climate Change -The Root Cause of the Covid-19 Outbreak: [14]

From free access meteorological data of Wuhan, it can be noted that average humidity here in the months of *June to August* and part of *September 2019* was above 75% while concurrently maximum temperature was also in the range of 30°C to 35°C during day time. Figure 2: Wuhan Climate (Summer 2019) Courtesy: <https://weatherspark.com/>

Figure 2: Wuhan Climate (Summer 2019)



The daily range of reported temperatures (gray bars) and 24-hour highs (red ticks) and lows (blue ticks), placed over the daily average high (faint red line) and low (faint blue line) temperature, with 25th to 75th and 10th to 90th percentile bands.

Image 1: Hourly Temperature in the summer of 2019 in Wuhan

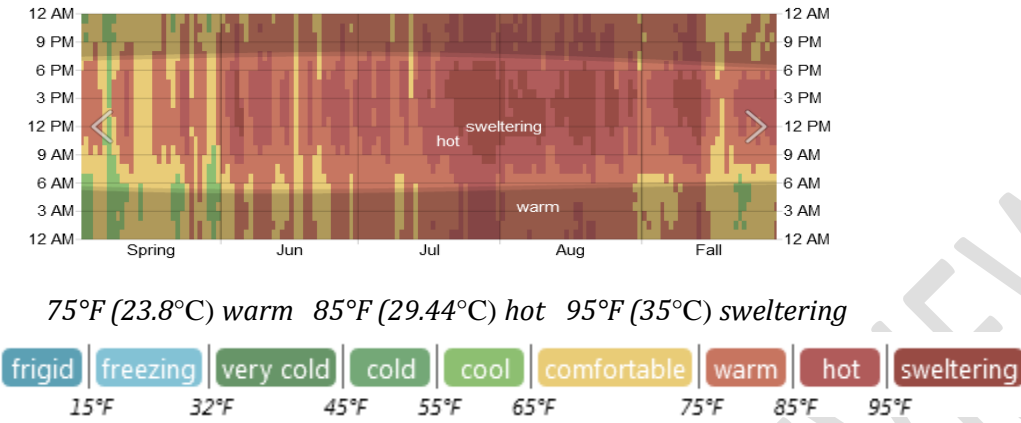
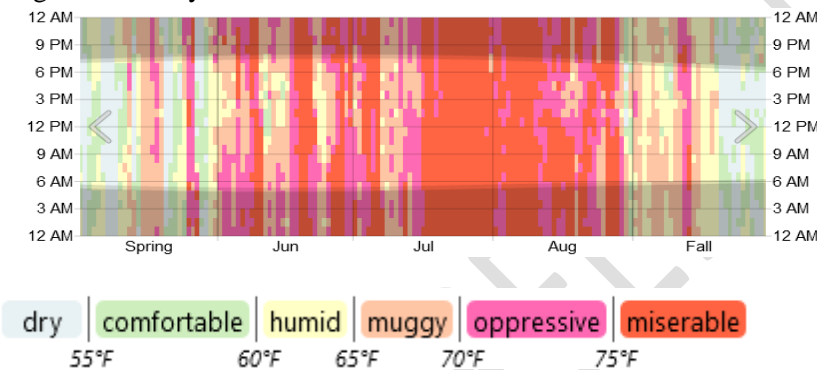


Image 2 Humidity Levels in the summer of 2019 in Wuhan



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The temperature graph shows the range of temperature whereas the humidity graph indicates dew point temperature. Thus when the temperature is in the range of 85°F (29.44°C) hot to 95°F (35°C) sweltering and dew point is 75°F (23.88°C) and above, the corresponding RH is 75% and above.

From scientific explanations given in earlier paragraphs and the meteorological data it can be inferred that Wuhan's ambient air parameters resulted in Redundancy of Respiratory Humidification and Dysfunction of associated Defense Mechanisms of a large population. This facilitated viruses like SARS-CoV-2 present in proximity via primary hosts; an unchallenged access to the lungs of many people of Wuhan, to set off the outbreak of Covid-19 in November 2019.

As the spread of infections of Covid-19 takes place through oral and nasal droplets of infected persons, it is different from an outbreak. It is similar to a short circuit generating a spark, and then the entire warehouse catching fire due to the inflammable nature of goods stored.

Based on similar data available, concurrent occurrences of temperature in the range of 30°C to 37°C and relative humidity in excess of 75% were checked for various cities throughout the world [15]. All such places have figured in the list of severe infections. Yet a probable absence of viruses in proximity via primary hosts could have prevented these places from becoming centers of outbreak. At the same time

Meteorological Data of all the places of outbreaks of new variants indicates that a climatic condition described above prevailed there during previous months. 100% *genome sequencing* of all positive patients shall be needed to eliminate the possibility of *variants* remaining in circulation *undetected* for a longer time [16].

A typical phrase which appears in Epidemiology of all similar diseases like MERS, SARS- COV and H1N1 says “..... years’ later work continues to better understand the disease, prevent it, and prepare for the next pandemic.” It is time we must relook at these diseases from the perspective of the above described phenomenon.

A Little Climate Change Makes Big Impact: [14, 15]

The emergence of *Zoonotic* diseases over the last three to four decades has thus a correlation to climate change. The *Climate Change* has not occurred overnight. It is an outcome of ignorance and total disdain towards the environment coupled with occupational compulsions. We may have now crossed the threshold of environmental balance and entered an unsafe zone.

A comparison of climatic data of Wuhan of the last decade indicates (Ref. Figure 3: Climate Change of Wuhan summer 2011- 2019) how the average values of daytime temperature and relative humidity have drifted into a threatening combination of 33°C and 75% RH.

Figure 3: Climate Change of Wuhan Summer 2011- 2019

Image 3 Hourly Temperature in summer in Wuhan 2011

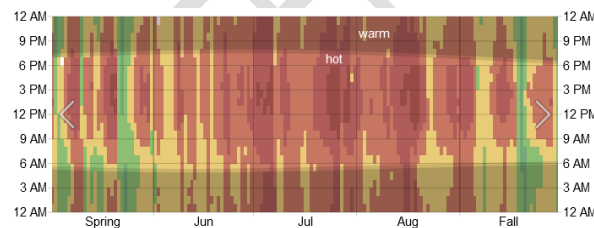


Image 4 Mostly in comfortable to hot zones (65°F=18.33°C to 85°F=29.4°C)



Image 5 Humidity Levels in the summer in Wuhan 2011

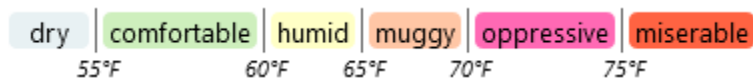
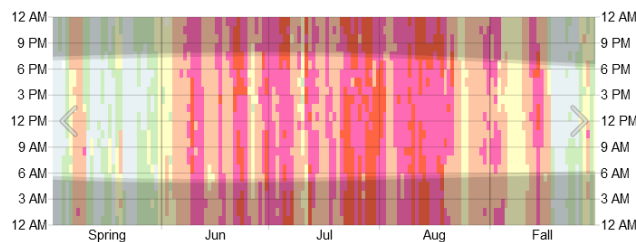


Image 6 Hourly Temperature in summer in Wuhan 2015

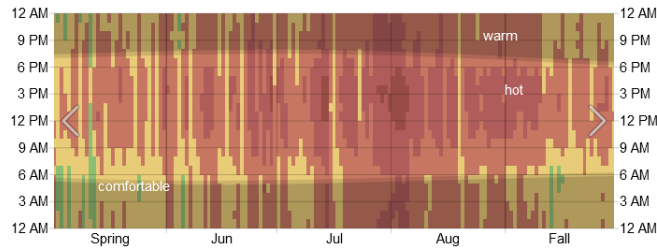


Image 7 Mostly in warm and hot zones (above 75°F =23.88°C and 85°F=29.4°C)

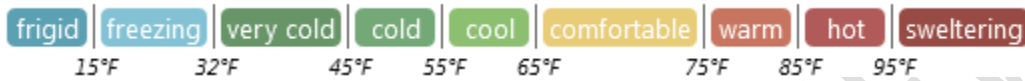


Image 8 Humidity Levels in the summer in Wuhan 2015

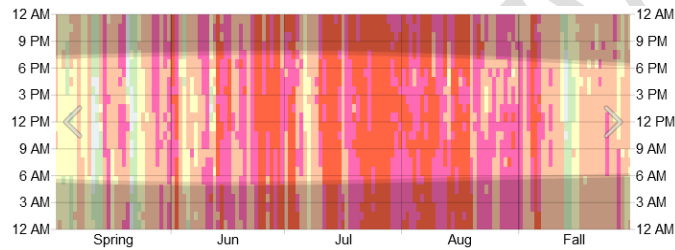


Image 9 Mostly in muggy, oppressive & partly miserable zones

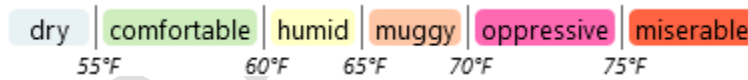


Image 10 Hourly Temperature in summer in Wuhan 2019

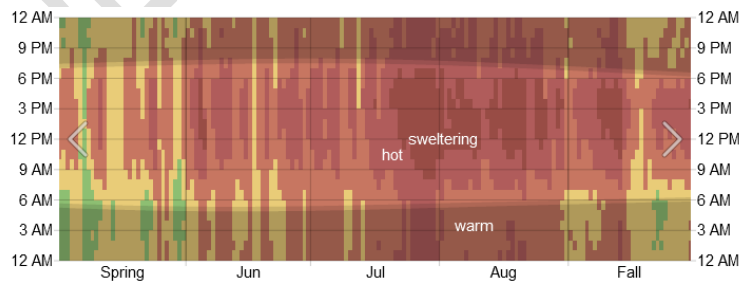


Image 11 Mostly in hot and sweltering zones (above 85°F=29.4°C and 95°F=35°C)



Image 12 Humidity Levels in the summer in Wuhan 2019

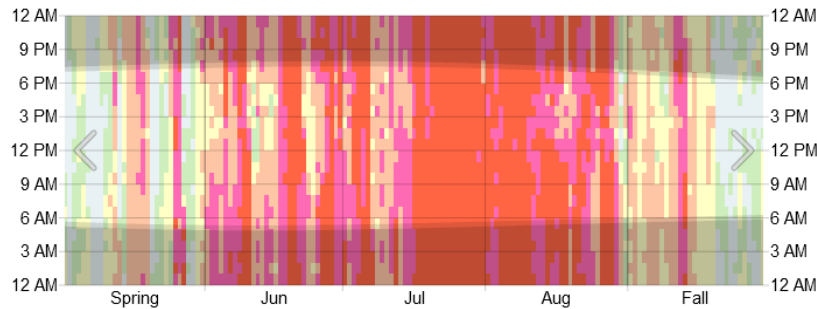
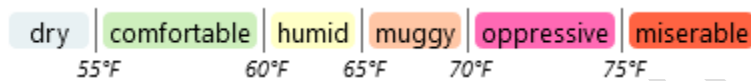


Image 13 Mostly in oppressive & miserable zones with average RH at least above 75%



Above graphs Courtesy [© WeatherSpark.com](https://www.weather-spark.com) for on line submission only

Note on the graphs: The above graphs show how the summer climate of Wuhan has gradually drifted to temperatures above 33°C along with RH concurrently above 75%, over a period of a decade. The Humidification process along with defense mechanisms gets redundant or dysfunctional as its objective of transforming the inspired air to around 33°C at 80% RH is pre achieved. As the heat and mass transfer is not possible the functions of associated defense mechanisms are also stalled.

Additional Discussion Points for Further Research:

Redundant Humidification, a significant factor than Spillover

Viruses and the Spillover agents have accompanied mankind from times immemorial. Latest updates on original host and spillover agents do not particularly endorse any theory, not even the Bat or Pangolins theory [17]. Many viruses may have evolved and spilled over in the past and traveled to our respiratory system but were probably contained by strong immune defense mechanisms. Thus there is no reason why the ‘Spillover’ or any other theory in itself could be considered the reason for the outbreak and subsequent pandemic. The Redundancy of Humidification Process and Dysfunction of Defense Mechanisms due to climate change can be termed as its main cause. We may have contained the current pandemic by vaccination but another novel virus or a mutant may travel to lungs, through dysfunctional airways and *challenge the efficacy of the vaccines*.

Covid-19 Pandemic - Fallout of Climate Change - A Sign of Impending Disaster

We know about five *mass extinctions* of the past. In all the cases one of the main reasons was considered to be a sudden climate change due to some kind of catastrophe. Are we heading slowly towards a similar situation, albeit not due to any catastrophe but a climate change due to human factors?

Conclusions:

Body temperature of 37°C and alveolar air parameters of 37°C with 100% RH are *most significant* in human evolution.

Respiratory humidification is as *critical as respiration*.

If the parameters of inspired air of a location are consistently *within 33°C to 37°C and concurrently with relative humidity (RH) in excess of 75%*, it can cause *Redundancy of humidification and dysfunction of defense mechanisms* at upper airways of many inhabitants and allow unchallenged access to viruses like SARS-CoV-2 or its variant to the lungs and then result into *outbreak of a disease*.

100% genome sequencing of all positive cases is essential for early *tracing of a variant*.

‘Climate Change’ needs to be addressed *globally* from a perspective of possibility of similar pandemics.

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