The NEW ENGLAND JOURNAL of MEDICINE

Modeling New York City's high Covid-19 loses

Journal:	*New England Journal of Medicine*
Manuscript ID	Draft
Article Type:	Original Article
Date Submitted by the Author:	n/a
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Abstract:	Medical Doctors and researchers are the authority of choice once an airborne pathogen has entered the body. This paper is does not discuss medical or clinical issues of respiratory disease; that is the domain of medical doctors and researchers. This paper is about the mechanics of disease spread using openly available government sponsored research and freely available reputable medical information primarily from CDC and NIH sources. The magnitude of Covid-19 growth in New York City (NYC) during their first two months was orders of magnitude greater than other locations. The number of lives lost in two months was remarkable, exceeding the worst full year in Vietnam. The 1968 Vietnam death toll was 16,899 fatalities over 12 months. This paper analyzes the mechanics of Covid-19 as well as unique meteorological and topographical conditions that contributed to the extraordinarily large loss of life. A plausible model of a representative NYC multistory residential block is developed and numerically subjected to actual wind, temperature and humidity conditions. The paper predicts patient responses as described in referenced NIH literature. This paper describes a model of atmospheric and architectural factors that explain the high rate of spread using established and respected clinical research as its foundation This paper describes airflow through the model space of an architectural model of a randomly selected block. Virion viability under actual temperature and humidity conditions are modeled using actual period data.

Modeling New York City's high Covid-19 losses

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Abstract

This paper is does not discuss medical or clinical issues of respiratory disease; that is the domain of medical doctors and researchers. Medical Doctors and researchers are the authority of choice once an airborne pathogen has entered the body.

This paper discusses certain physical mechanics of disease spread using openly available government sponsored research and freely available reputable medical information primarily from CDC and NIH sources.

Covid-19 growth in New York City (NYC) during the first two months of Covid-19 was orders of magnitude greater than other locations. The number of lives lost in two months was astounding, exceeding the worst full year in Vietnam. The 1968 Vietnam death toll was 16,899 fatalities over 12 months.[1]

This paper analyzes the mechanics of Covid-19 spread as well as unique meteorological and topographical conditions that contributed to the extraordinarily large loss of life in New York City and other locations.

The author modeled a random NYC residential block for simulation. Actual recorded conditions of temperature, humidity, wind speed, wind direction and day length existing in March, April and May of 2020 are used. The results are the subject of this paper.

The model accurately predicts mortality responses when presented with actual conditions in New York City during the trial period. The model explains the high rate of mortality using published clinical research data.

Key factors in this analysis are low ambient temperatures and relative humidity. The resulting extended virion viability times combined with wind conditions and surface topology extended Covid-19 virion viability thus increasing the total available virion count and increased probability of disease spread.

However, it was unusual public behavior created that created ideal spread conditions and resulting loss of life.

One goal of this paper is to bridge the gap between esoteric research conversation and common everyday language in an effort to restore credibility between the scientific communities and the public. Thus, one goal of the paper is to provide information in terms easily understood by non-medical personnel as well as using common Imperial units of measure.

For example, this paper concentrates on particle (droplet) count per unit volume (in cubic feet) rather than particle volume distribution eliminating the need to convert between respiratory droplet counts and units of mass as often utilized in molar-based numeric analysis.

A further simplification is the assumption that natural air currents provide sample homogeneity in the model space. While not strictly true due to pockets of low velocity mixing, various topological features such as building features, vehicles, foliage and such provide a reasonable degree of fluid/droplet homogeneity.

Background

On Friday March 13, 2020, one person died in New York City and there were 114 reported cases of Covid-19. A week later on March 20, 2020 there were 23 deaths and 1,942 cases totaling of 54 deaths and 4,419 cases. The next week March 27, 2020 125 died and there were 2,327 new cases. In two weeks, there were 560 deaths and 25,509 cases, a growth rate rivaling any Hollywood thrill script.

This paper will first establish a number of points through pre-pandemic research papers. The paper will then describe a model of a New York residential block section. The residential block section consists of both sides of an apartment wide section (50') of street. The buildings facing this apartment-sized section of the block are four and five stories tall. We will use actual New York City weather conditions for the first two months of New York's Covid-19 tragedy to demonstrate how air currents wash up and down the sides of buildings.

Even in 2019 the actions of these health workers around the world and in the United States were exceptional. Medical workers literally risk their lives to help patients survive a disease about which little was known. As a result, some of those health workers paid the ultimate price. The public's appreciation was well earned. Their bravery and dedication was heroic even in comparison to soldiers, fire fighters and police officers.This was especially notable because they assisted patients infected with a poorly understood deadly disease even though they witnessed its worst outcomes from the disease first hand.

Media news coverage of Covid-19 was extensive in the weeks before the first New York fatality. A primary difference between New York City and most other areas was due to actions by the residents of these apartments. To demonstrate their appreciation for these selfless medical professionals some multi-story apartment dwellers decided to show their appreciation by serenading those brave health workers from their apartment windows. Many individuals opened their windows and sang long and loud to express their deep and sincere appreciation. This paper will show that even though it was a heartfelt act of appreciation the serenades were responsible for the quick spread of Covid-19 in New York City and other areas of the country and world.

While singing heat from the apartments kept the singers relatively warm during their serenades to the cold, dry outdoors. This paper postulates that these conditions subjected singers and pedestrians to conditions that virtually guaranteed the incredibly high Covid-19 infection rate experienced during March, April and May of 2020 in New York City.

This paper proposes that even one infectious Covid-19 positive singer per city block greatly enhanced disease spread both for fellow singers and for unsuspecting victims on the streets below.

Window serenades were super-spreader events.

Most of New York City lies within a circle of 20 miles radius. About 8 1/2 million people live and work in that small area. Yet the death toll during the first two months of New York's Covid-19 siege was nearly as great as the rest of the United States and territories combined.

In New York City, the peak death toll was 824 persons dying in one day on April 7, 2020 - less than four weeks after New York City's first death. Those 824 fatalities were infected days before their ultimate demise. The time between infection and death is about 7 - 10 days.

This was a time of maximum virus viability due to atmospheric conditions and maximum virus availability due to the serenading public.

This prodigious rate of growth is amazing by any measure. There were 114 cases on March 13, 2020 and four weeks later New York State recorded more Covid-19 cases than any other COUNTRY in the world.

Until now, no one has been able to create a model to explain the number of people infected in such a short period in a locked-down city.

Respiratory disease and respiratory droplets

Scientists established that respiratory diseases such as Covid-19 are spread by airborne transmission and aerosols long before 2020. Many sources have documented the role of fluid droplets in the spread of respiratory disease. This paper challenges none of that established research and uses it as the foundation for this paper. The information used to compile this paper is primarily from NIH, NIAID and CDC research prior to the Covid-19 pandemic in the United States. No one can reasonably claim that the novelty of Covid-19 was responsible for a lack of understanding regarding the role of aerosols in spreading this new variant of the flu.

Mechanics of spread

Covid-19 transmission is by means of respiratory droplets from infected individuals even if they are asymptomatic. For purposes of evaluation respiratory disease transmission spreads in two distinct manners based on respiratory droplet sizes. Researchers categorize droplets less than 5µm (5,000nm) as aerosol transmission while larger sizes are simply droplet transmission. Breathing generates aerosol droplets at all times. Activities such as talking, coughing and sneezing generate a disproportionately larger number of droplets.[2]

Droplet characteristics

Their size allows smaller aerosol droplets to 'float' with the air somewhat like dust motes or cigarette smoke. Scientists refer to them as aerosol droplets due to the ratio of droplet mass (weight) compared to surface area. Even small air currents influence smaller droplets so they seem to be floating. Smaller droplet sizes (aerosols) are also important because their small size allows them increased penetration into the lungs resulting in greater severity of infection. Respiratory virus atmospheric spread efficacy is a function of droplet size. The most infectious aerosol diameter is around 300 nm which is about 12 millionths of an inch and invisible to the naked eye.[3]

Larger droplets are also important to consider because they can carry greater numbers of virion in each droplet. Fortunately, the larger droplets quickly fall to the ground due to gravity in a matter of seconds.

Human generated aerosol droplets can remain in the air for hours or days.

Effects of temperature and relative humidity

Viability, or ability to infect, of virion encapsulated in respiratory droplets is affected by atmospheric conditions. Influenza virion survives better at low relative humidity and low ambient temperature.[4] Figure 1 indicates data gathered from Influenza Type A research and available before the Covid-19 crisis. Subsequence research indicates SARS-Cov-2 viability is longer than Type A flu virion.

Virion remains viable and airborne for days under some conditions of low humidity and temperature.

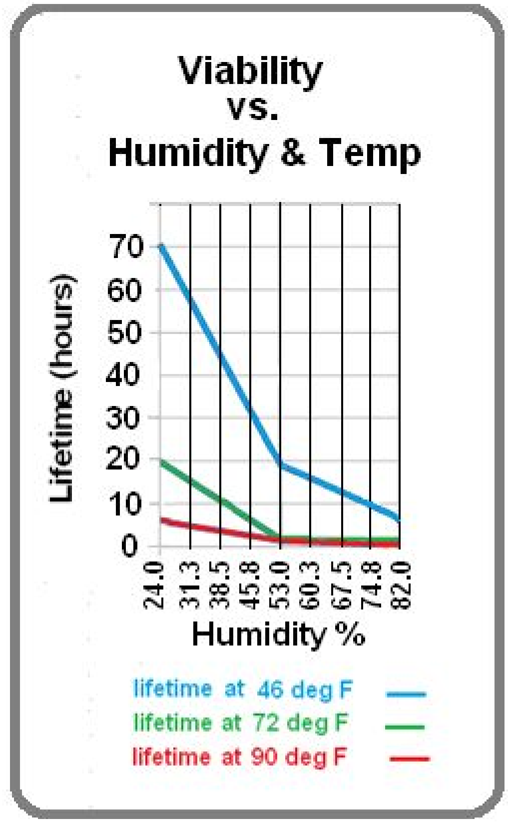

Figure 1 - Flu virion viability over temperature and humidity

Fomite

The number of virion encapsulated within a droplet varies according to approximately the square of its diameter[5] i.e. increasing the diameter of a droplet by 10 increases the potential number of embedded virion by 100 more or less.

While larger droplets contain more virion, they also settle downward quickly (seconds) and close to their source (a few feet) minimizing their disease transmission efficacy. However, after landing, larger droplets contribute to fomite (dried remnants of droplets). Unfortunately respiratory virion such as rhinovirus (common cold), influenza and SARS-CoV-1 and SARS-CoV-2 remain viable even after the droplet dries. The duration of viability depends on the surface.[6]

Droplet distribution

Smaller droplets (aerosols) have a larger surface area to mass ratio causing their extended suspension in air.[7] Influenza droplets including Covid-19 are primarily in the submicron range with about 70% of droplets having diameters in the 300 to 500 nm range, 18% in the 500 - 1000 nm range and most of the remaining droplets less than 5 um.[8]

The majority of respiratory droplets are aerosols. The most common droplet size is the most contagious.

Human breathing characteristics

For an 80 kilogram (180 lb), adult, tidal (at rest) breathing volume is about 560 ml (1 pint) per breath. Normal respiration is about 15 - 20 breaths per minute. Therefore, normal (tidal) breathing volume is about 8.4 liters (about 2 gallons or one/fourth cubic foot) of air per minute.

Influenza patients exhale from 30 to 4,300 droplets per tidal breath depending on infection severity.[9]

Total lung capacity is ten times larger than tidal air volume or 5.6 liters (5.5 quarts) of air volume.[10] This factor alone increases the number of droplets by a factor of up to 10 compared to tidal breathing volume. Speaking and especially singing tend to use much more volume than tidal breathing, even approaching the total lung volume.

To fill the lungs more quickly requires greater velocity of the air entering and exiting the lungs. This increased velocity increases the number of airborne droplets due to increased air velocity.

At a tidal breathing rate of 20 breaths per minute person at rest produces up to 86,000 droplets per minute or 5,160,000 droplets per hour. Not all those droplets contain virion even when a person is very ill.

Respiratory droplets of sizes .05µm (0.000002") to 500µm (.02")[11] [12] are present in human breath. Droplet composition is either water based or sputum. Even water based respiratory droplets are not pure water but have some salts, including NaCl (common table salt) that make the droplets hygroscopic (water adsorbing) as opposed to evaporative, as would be the case of droplets of pure water.

Salts and organics in water-based droplets allow them to survive in the atmosphere for a long time.

Water based droplets are more common in normal breathing. Sputum droplets are more prevalent during normal (vocal cord) and whispering (teeth and lips) vocalization. Morawska (2009) found that whispering breath has a droplet count three times greater than tidal (at rest) breathing, and speaking breath ejected six times greater droplet count than tidal breathing. [13]

Singing further increases the droplet count up to 10 fold or more. Droplets formed during singing are primarily long-lived mucous droplets. During normal speech and singing, there is a strong relationship between audible volume and quantity of droplets ejected.

A person at rest produces about 7,000 droplets per minute, a whispering person produces about 21,000 droplets per minute, a talking person produces about 126,000 droplets per minute and a singing person produces about 1,260,000 droplets per minute.

Virion count to infect

ID50 is the number of virion necessary to infect 50% of those exposed. In early April 2020 Seema Lakdawala speculated that as few as 10 influenza droplets would be enough to establish an infection.[14] In later works, the author states that ID50 for Covid-19 in particular is between 10 and 1,000 virion [15] [16] which could easily be present in a single respiratory droplet.

More than half the persons subjected to 1,000 virion (1 droplet) will become infected with Covid-19.

Virion count per droplet

Mild cases of Covid-19 may contain up to 0.2 X 10^5 virion per droplet, and ten times that much for severe cases of Covid-19. The authors of the Anand (2020) paper presumed that ill but asymptomatic individuals fall in the lower range of virion count per droplet.

One invisible respiratory droplet is adequate to cause Covid-19. [17]

Aerosol lifetime

To recap,

1) Aerosols, the most contagious Covid-19 droplets, may remain suspended in the air for hours or days because of their physical size and chemical composition.

2) When temperature and humidity are low Covid-19 virion in those aerosol droplets can remain viable for days

3) The droplets move with the slightest breeze.

4) These suspended respiratory Covid-19 aerosols are the primary source of infection.

The well-known Wells (1943) [18] paper shows that the lifetime of pure water aerosol droplets is fractional seconds before evaporation. The casual reader will interpreted this as implying that aerosol droplets "dry" reducing virion viability and virus transmission.

This is not true of droplets generated by humans. Because bodily fluids contain salts, and organic compounds, respiratory droplets will not evaporate quickly. In fact, they may even absorb water increasing their diameter and lifetime. In any case, a bodily fluid droplet such as sputum or mucus has a lifetime that is much longer than a water droplet because it is less likely to evaporate.

Airborne virion can remain viable for days in low humidity and temperature environments.

Background Review

- *Human breath generates aerosol droplets capable of can remaining in the air for hours or days.*
- *Airborne virion can remain viable for days in laboratory conditions of low humidity and temperature environments.*
- *The majority of respiratory droplets are aerosols.*
- *A person at rest produces about 7,000 droplets per minute, a whispering person produces about 21,000 droplets per minute, a talking person produces about 126,000 droplets per minute and a singing person produces about 1,260,000 droplets per minute.*
- *More than half the persons subjected to 1,000 virion (potentially 1 droplet) will catch Covid-19.*
- *One invisible respiratory droplet is adequate to cause Covid-19 under some conditions.*
- *Wild airborne virion can remain viable for days under conditions such as shade, low humidity and/or temperature such as rough surfaces or shady locations.*
- *Window serenades created an efficient Covid-19 distribution scenario.*
- *Window serenades were super-spreader events.*

Methods

To explain how the topology of New York City could present significantly unique circumstances to cause the high rate of Covid-19 spread in early 2020 the author will present an Einsteinian thought exercise.

The thought exercise first establishes a model that consists of an apartment-width section of a New York residential block including buildings, sidewalk and street using a random but representative block in Queens New York.

We then evaluate the model according to actual meteorological conditions including temperature, humidity, wind speed and length of day. With this data, the number of respiratory droplets per volume per unit time are calculated.

There is only one researcher on this project resulting in a very simple evaluation performed on a simple model is presented. Given time and resources the full a 24 hour, 60 day evaluation would be preferred using much more specific demographic and topological data would be preferred, but that is not available and the author believes this information is timely and the paper's voracity should be established quickly now that cold weather and low humidity are imminent.

New York City ground level air currents in New York are predominantly from the north and west at 3 to 10 mph[19] during the dates evaluated here.

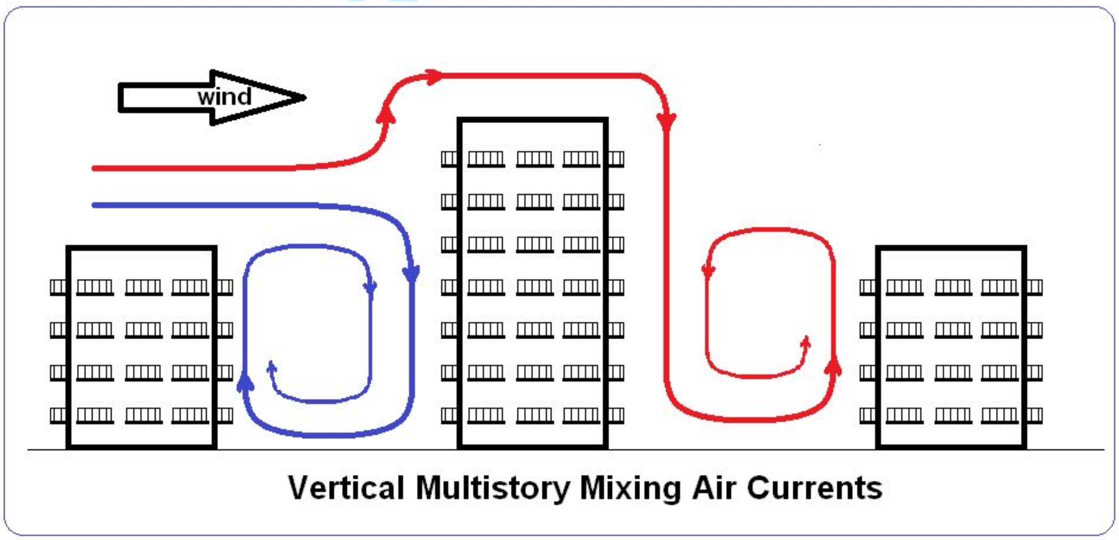

Figure 2 Vertical Multistory Structure Air Flow

The drawing "Vertical Multistory Mixing Air Currents" illustrates an example of the effects of wind between a shorter upwind building and a tall downwind building. The blue airstream illustrates interaction between a short upwind building and taller downwind building. The taller building diverts the blue airstream. The diverted breeze is down on the taller building and up on the shorter building.

The red airstream illustrates how air currents over the taller building create a vertical downward air stream near the tall building and upward for the shorter building. The swirl direction may be reversed or even go directly over the shorter building depending on effects of horizontal mixing and variations in wind direction.

In practice, these effects are so complex that architects used to resort to building physical scale models to study specific situations. However, different groups have digitized New York City topology. It would be helpful to have access to one of those data sets.

This primitive drawing hints at the very complex interactions between wind and the concrete canyons of New York City. This drawing is two dimensional, but hopefully illustrates that the exemplar model presented is reasonable. Topology between the buildings due to the wind mixes and distributes surface wind between buildings very efficiently largely because a 50' tall building, 50' wide street and 50' apartment length creates a cube, which is a geometric shape even better than a sphere for distribution and mixing of gases.

Model Assumptions

The assumptions above are for a random apartment width section of a block in Bronx, New York. There are opposing apartment buildings each with apartments occupying 50 linear feet of street front. Buildings are 10' per story. Number of apartments enclosing model volume is six in taller building and five in shorter building.

Air exchange rate

The shorter building is 50' tall.

The taller building is 60' tall.

The width of apartments is 50'.

The vertical component of the diverted blue airstream is 60' - 50' = 10' height and 50' width for a single street section.

The cross sectional area of the blue airstream before diversion is:

$$apartment\ width * building\ height\ difference$$

$$50\ ft * 10\ ft = 500\ sq.ft.$$

The average wind speed for the days included in this paper is:

$$Avg\ wind\ speed\ for\ two\ months * \frac{ft}{mi} * \frac{hr}{sec} = wind\ speed\ ft/sec$$

$$5.9\ mph * 5{,}280 \frac{ft}{mi} x \frac{1hr}{3{,}600 sec/hr} = 8.66 \frac{ft}{sec}$$

We conservatively estimated that up to 80% of the blue airstream deflects up and around the taller building reducing the vertical (blue) air volume to 20% of the total air deflected down by the taller building. The diverted air is directed down the face of the taller building.[20]

$$Airstream\ crosssection * air\ speed * deflection\ efficiency\ = deflected\ air\ volume$$

$$500\ sq.ft * 8.66\frac{ft.}{sec} * 20\%\ eff = 866\frac{cu.ft.}{sec}$$

The volume of the space between the buildings is

$$Height\ of\ shorter\ building * width\ of\ apartment * width\ of\ street$$

$$50'x\ 50'x\ 50' = 125{,}000\ cu.ft.$$

To fully mix / fill the enclosed airspace between the buildings would take

$$\frac{Total\ model\ volume}{air\ flow\ in\ cu.ft./sec} = total\ seconds\ for\ one\ air\ exchange$$

$$\frac{125{,}000\ cu.ft.}{866\frac{cu.\ ft.}{sec}} = 144\text{sec}\ = \frac{144\ sec}{60\frac{sec}{min}} = 2.41\ min$$

The volume between two buildings of five and six stories has an effective volume of 125,000 cubic feet. An average wind speed of 5.6 mph moves 866 cu. ft of air per second into the model space.

A typical (average) wind speed is adequate to exchange all the air in the model volume every 2.41 minutes.

If we assume that one song will last 2.41 minutes, one song will fully mix the volume of air contained between a set of facing apartments on block.[21]

So far, we have reasonable values for exhaled virion for an infected person, the number of virion necessary to infect an otherwise healthy person and the exchange volume of an apartment sized section of New York City Street.

Virion exhaled during one exchange of air

We will assume that three apartments of the 11 facing the enclosed volume participate in the nightly serenades. This quantity is an estimate based on multiple videos of multiple media sources. The author believe this number of participants is representative (and even conservative considering some apartments had multiple singers) of early days of the pandemic for a number of locations.

During a single exchange of air three singers exhale 3.79 million Covid-19 droplets per minute into the model space between the buildings.

$$1{,}260{,}000\frac{droplets}{min} * 2.41\frac{min}{air\ exchange} = 3{,}790{,}000\frac{droplets}{air\ exchange}$$

During the 2.41 minutes required to exchange air in the model space three singers have sprayed 3.79 million droplets into the model space.

Assuming homogeneous mixing each because there are multiple / continuous exchanges of air and this calculation is for single exchange of air, each cubic foot of air contains thirty Covid-19 droplets.

$$\frac{3{,}780{,}000\ dropets}{125{,}000\ cu.ft.} = \frac{30\ droplets}{cu.ft.}$$

We established earlier that people breathe 3.9 cubic feet of air each minute.

People breath

$$\frac{.26\ cu.ft\ breath}{4\ seconds\ per\ breath} * \frac{60\ seconds}{minute} = \frac{3.9\ cu.ft.}{min}$$

So each minute a person at street level breaths

$$\frac{3.9\ cu.ft.}{min} * \frac{30\ droplets}{cu.ft.} = 117\ droplets\ per\ minute$$

Assuming a person walks at 4 miles per hour they can travel

$$\frac{4\ miles}{hr} * \frac{5{,}280\ ft.}{mile} * \frac{hr}{3{,}600\ sec} = 5.86\ ft\ second = \frac{5.86\ ft}{sec} * \frac{60\ sec}{min} = 352\ feet$$

per a minute or just over a New York City block. Even if the person takes only one breath as they walk down the block, they will still breathe in 30 droplets (probably aerosol). Each residential block is another gauntlet.

Spread at street level

At street level walkers, runners and other heavy breathers inhale

$$30\frac{droplets}{cu.ft.} * 3.9\ \frac{cu\ ft}{minute} = 117\ \frac{droplets}{minute}$$

Three apartments with only one singer per apartment in a city block in New York city would each contribute a minimum of 117 droplets per breath of persons walking, trotting or running down the street. Each of the droplets has the ability to infect 50% of the people exposed to them. This should be a sobering revelation to city residents. But this continues for each two and one half minutes for the duration of the serenade.

Spread inside apartments

Air currents created by singing is greater than ordinary speech. These human breath generated air currents expel air out through the window in to the model volume. Virulent street air flows into the apartment replacing the singer's expelled air. Expelled air goes out with high velocity, but replacement street air is low velocity and tends to remain close to the window and the singer.

After the first exchange of street volume air, about 2 1/2 minutes, virion density is approaching homogeneity. Uninfected singers next to the open windows begin breathing air infected with respiratory droplets of other singers. If the window remains open apartment air in the window's vicinity mixes with outside air containing 30 droplets of virion per cubic foot of air. After just a few minutes of singing, air in the vicinity of the window has exchanged with outside air multiple times resulting in a high virion count. Soon the entire room has a significant viral load. If internal doors are open, Covid-19 invades the entire apartment in just minutes with or without a breeze.

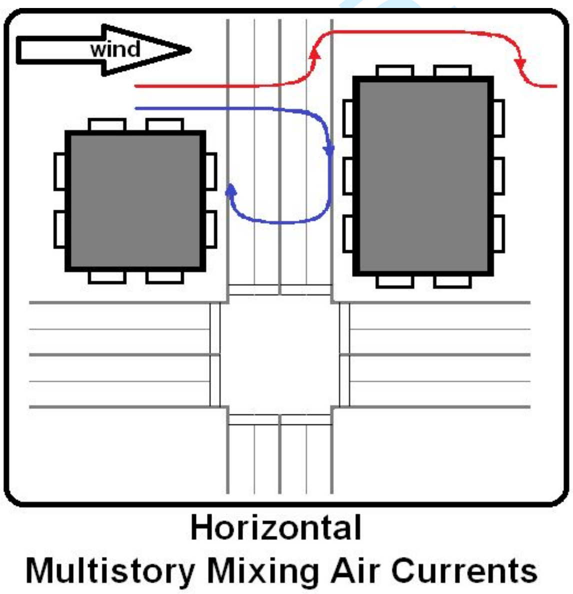

Figure 3 Horizontal Building Airflow Interaction

When singing each breath is not only maximum volume of about 1/8 cu. ft. but exposes the air deeply into the lungs maximizing infection efficacy for the virus. Every eight breaths move 30 virion-laden droplets into the deepest recesses of the lungs assuring maximum exposure to the virus. Once in the air sacks there is no significant breeze to remove the droplets from the lungs.

Irony.

Exhaled singer's aerosol droplets at lower levels in shorter building tend to rise endangering those above that level. Droplets from singers at higher levels in the taller building fall endangering those below that level. Of course, penthouse singers infect the world at large without penalty!

Mass transit

It might seem that traveling on mass transit would help alleviate the problem. Floating aerosol droplets will cling to people that walked down singer's streets to get to a bus or subway or rail station. Just as cigarette smoke from a bar clings to clothing, virion-laden aerosols cling to clothing. At first glance this claim this seems incredible. However, you can't see respiratory droplets but you can see and smell cigarette smoke. If you leave an area of moderate smoke, you will take those particles with you and they have the same aerodynamic properties of aerosol droplets, but you can smell the smoke.

There is also the problem with virion-laden fomite, the material on the streets, cars, foliage and sidewalks. Any movement, especially walking or driving, stirs up virion-laden fomite. Because of embedded salts, the fomite forms their own aerosols and hitchhike on tires, shoes, pants legs, pet fur and even postman's pushcart wheels.

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Street level spread - discussion

- The scenario discussed here is meteorological conditions that extend virion viability into days instead of minutes or hours resulting in virion having the ability to infect people many times longer than expected.
- This is especially insidious because most people are of the opinion that virion viability is minimal out of doors and protection is not necessary. The streets of New York City may be the wildest place in North America, but it is not "the great outdoors."
- The topology of multistory apartment blocks acts as traps to virion movement at or near ground level. Winds perpendicular to building faces produce a horizontal whirlpool allowing mixing and retention of any virion introduced into the perpendicular street's environment.
- Winds parallel to building faces funnel spillage from perpendicular buildings down streets parallel to the wind.
- Generation of respiratory droplets containing virion from singers is orders of magnitude greater than anticipated.
- After nights of low temperatures and humidity, an alarming amount of viable virion laden fomite droplets remained on the ground. Fomite virion were stirred up by traffic and wind providing an additional source of infection.

Serenading exposed commuters traveling under singer's apartments to high levels of Covid-19 with each trip through the neighborhood. While increased temperature, humidity and sunlight reduced the total count of viable virion during the day viable virion were present throughout the day due to fomite transportation via commuters. Commuters walking under singer's apartments literally walked through an invisible cloud of Covid-19 droplets.

In the scenario above, each minute under singer's windows exposed the lungs of a person at ground level to 117 respiratory droplets. These droplets remained in the air and on the ground long after the serenade(s) stopped.

Low level qualifiers to the above scenario.

The singing was not limited to a single song.

The number of singers was not limited to one person per apartment.

Higher level qualifiers to the above scenario.

There were potentially dozens of singers per block.

The serenades lasted for many songs.

Limits of the serenade effect

In minutes, each block was saturated and the gentle breezes at street level spread the contagion into retail, manufacturing, commerce areas and even single story dwellings.

Disqualifiers

In the beginning when only one singer on a block was infected, it would only be about 40 infected droplets per minute per singer for a small (50' in our model) portion of the block.

As the infection grew, there were multiple infected singers per block within a handful of days. Due to the nature of Covid-19 and increased level of exposure, the number of infected singers grew exponentially.

We have already established that one droplet is adequate to infect half the persons exposed. Even with a single singer per block each person that walked down the street has at best a 50/50 chance of infection (inhaling a single respiratory droplet) if walking under the apartment of a single infected singer. More importantly, everyone else that walked down that sidewalk until the sun came up the next morning was subjected to a risk that increased with each song.

Shutting down the city was little help. The walkers often had no choice. A person might walk down the street are to get medicine, get groceries, go to and from work, take out trash, move car, exercise or even go to a doctor's appointment.

The scenario above demonstrates that even the first exchange of air, which took about 2.5 minutes at typical (average) conditions, contained a significant number of virion. When the next exchange of air flows into the model space, existing infected air had to go somewhere.

After the first exchange of air, subsequent changes displace existing street level air moving virion laden air to another position. That air moves laterally (horizontally) and travels perpendicularly down the street to open lots, over shorter buildings and other breaks between the buildings such as streets perpendicular to wind direction.

The breeze exchanged air each 2 1/2 minutes resulting in exposing another fifty linear feet of street volume with Covid-19 virion. Because of lateral airflow shown in Figure 4, a sixteen-minute serenade will potentially fill an entire 320-foot long city block from street level to the height of the shortest building with a potentially lethal load of Covid-19 virion. This is with just one infected singer. In another 16 minutes, a perpendicular block is loaded with Covid-19 virion.

To recap, vertical and horizontal structure height disparities combined with seasonal breezes to created large mixing currents. Singers emitted extraordinarily large number of virion into the atmosphere. The combination results in virion-laden air in deep corners and recesses of the city due to nocturnal serenades. Once in the atmosphere the virion were viable for days and traveled with the breeze.

Window serenades created an efficient Covid-19 distribution scenario for major areas of New York City.

Excess Deaths

The author feels that the research in physical assessment of respiratory spread diseases is dreadfully underfunded. Please excuse this insensitive analysis.

The case for funding physical respiratory disease spread

To emphasize the need for funding this type research it would be helpful to estimate the number of lives lost unnecessarily. A tool of the scientific method is the double blind test, an alternative to the double blind is the reduced interaction methodology (no need to look it up) where you compare two populations that are reasonably similar but cannot be influenced by each other.

For example, you take two tanks of the same type fish and change the environment of one water tank while keeping the other tank under constant conditions. The fish in one tank cannot interact with the other tank's fish resulting in reliable results attributed to the change in one tank's environment.

During my studies of Covid-19 spread beginning in early 2020 I found two human "fish tanks" that seemed to be of similar size, demographics and circumstance with one exception. New York City attempted a complete shutdown of the city while Sweden (the country) implemented no government intervention to control the disease. Comparison of the two populations and their Covid-19 death rates seemed to show that Swedish federal government inaction was superior to New York City's massive intervention. I incorrectly assumed that the only significant difference between Sweden and New York City was the level of federal intervention.

I continued my work and made a few determinations regarding the differences in rural spread and urban spread, effects of transportation, demographic influences, geographic topology and a few other more and less significant factors while continuing to believe that the Swedish federal government's approach was superior.

Finally, I came up with the concept of an effective R_0 which would be changed according to the items mentioned above which worked rather well - until I returned to New York City. I could find no reasonable for their incredible spread rate during the time they were locked down, masked and distanced.

I won't discuss the cause of my epiphany yet, but I finally realized I was ignoring one more concept, very familiar to me as an electrical engineer. There are always been three dimensions and humans have been building, in three dimensions since Indians built their homes on cliffs in the West.

Of course, New York City is extremely three dimensional, but that is Manhattan. I lived in Sea Bright New Jersey for a year 7 miles from Manhattan and though I knew about "The City." So I used an application that won't be named while, coincidentally, I had just read a paper on the effects of humidity. I became ill (back trouble) and my medicines minimized the effectiveness of my work for a while. I came across a piece I wrote in March of 2020 about the window serenades. After the back improved, while watching an old English Soccer Game with fans the whole picture came together.

Apartment buildings could increase effective R_0 if the singers above each other as well as side by side. In other words, the spread could be in three dimensions. Without going into detail, this implied a very large change in effective R_0 that I won't attempt to explain here.

Since I had been using methods used by biologists, I took some MIT online courses on physics of respiratory spread. I decided to work from the standpoint of virion per cubic ft so that I could easily compensate for fluid flow of air if necessary. I then did an online survey of NYC communities and selected a single block at random (the scientific close the eyes and click on the screen method.) I then did some scaling after falling back on experience/knowledge from decades ago.

What people don't say about epiphanies is that they can make one look deep into their soul and question their motivations. I knew in April of 2020 that the serenades were terribly bad ideas and even wrote about them on Facebook, but I wanted to prove another theory and let the subject drop.

Now that I have this solution, I also have improved insight to my alternative theory. I received some English and research help from wonderful childhood friends. But the evaluation and theorization was up to only me. I would like to think that with a team and budget this result would have come much more quickly. I attempt to assuage my conscience with this and similar excuses.

Further results

This paper explains the quick rise and fall of Covid-19 in New York City, northern Italy, France and other localities with similar topology, weather and singers. But still I wanted to compare the New York City phenomenon with the Swedish experience. A comprehensive analysis required that I remove the effects of serenading under the conditions during the first two months of New York's Covid-19 pandemic to compare New York City and Sweden.

New York State

The first computation was for the state of New York. I compared the state's peak daily mortality during the spring 2020 surge of Covid-19 to the state's peak daily mortality rate during the winter 2020 surge of Covid-19. According to CDC data, New York's highest spring average mortality was 763 cases per day and highest fall average mortality was 220 cases per day. To normalize, or compare the spring rate to the fall rate we can multiply the spring fatalities by the ratio of fall rate per person divided by the spring rate per person. We use the total number of cases lost during the spring surge and multiply it by the ratio of peak fall cases divided by peak spring cases.

$$Total\ spring\ cases * \frac{peak\ fall\ cases}{peak\ spring\ cases} = expected\ cases$$

$$21{,}641 * \frac{220}{763} = 6{,}239$$

This gives an expected fatality number of 6,239 persons for New York during the spring surge. Subtracting this from the total number of 21,641 cases yields unnecessary fatalities of 15,402 for six weeks just in New York City. This number for unnecessary fatalities is so stunningly high so I tried other methods.

New York City

To cross check this result we compared spring 2020 rates against fall 2020 rates for New York City and then for the entire United States using CDC statistics. New York City's highest spring daily mortality was 814 and highest fall daily mortality was 55.

The ratio was:

$$\frac{maximum\ daily\ spring\ rate}{maximum\ daily\ fall\ rate} = spring\ to\ fall\ ratio = \frac{814}{55} = \ 1{,}480\%$$ [22]

This seemed a bit high so we took a simple 7-day average. The ratio was:

$$\frac{maximum\ \ average\ spring\ rate}{maximum\ average\ fall\ rate} = spring\ to\ fall\ average\ ratio = \frac{760}{44} = \ 1{,}720\%$$

This is truly an astounding number. We converted the results ratios instead of percentages out of concern for exaggeration. The spring to fall ratio of maximum and average mortalities was 14.8 and 17.20 respectively.

There were 14.8 times more **peak daily deaths** per day in New York City in the spring than the fall and 17.2 more **average daily deaths** per day in the spring than the fall.

In an effort for equity, we compared the ratios of total deaths in the first six months and the second six months.

$$\frac{first\ six\ monts\ mortality}{second\ six\ months\ mortality} = spring\ to\ fall\ ratio = \frac{22{,}954}{2{,}107} = \ 1{,}090\%$$

In New York City the total number of deaths for the first six months of 2020 were 10.9 times larger than the second six months of 2020.

We used data from the Bing Covid Tracker, [23] for the United States to determine the country wide ratio of spring cases to fall cases.

$$\frac{maximum\ spring\ average\ rate}{maximum\ fall\ average\ rate} = spring\ to\ fall\ ratio = \frac{2{,}043}{2{,}952} = .69$$

For the entire country, the ratio of spring deaths to fall deaths was 69% or a ratio of 0.69.

We cherry picked the most conservative ratios to determine that if New York City followed the national average the spring deaths would have been

$$NYC\ Fall\ deaths * \frac{U.S.spring\ deaths}{U.S.\ fall\ deaths} = expected\ NYC\ spring\ deaths$$

$$2{,}107 * \frac{2{,}043}{2{,}952} = 1{,}458$$

Instead of 22,954 deaths in New York, there would have been 1,458 deaths if New York had the same ratio of fall deaths to spring deaths compared to the rest of the country. Under these circumstances, the estimate became 21,496 unnecessary deaths in New York City.

There are many ways to estimate the number of unnecessary deaths in New York City by comparing with New York State and the United States. For each calculation the number of excess deaths in New York City is more than 10,000 persons in a two month period.

Depending on method, the number of excess deaths in New York City vary between 15,000 and 20,000 persons due to the spring serenades.

New York vs. Sweden revisited

The Swedish method appears less attractive by utilizing any of the above methods of calculating excess deaths. The normalized disparity between I was wrong about the Swedish method but now I know why. However, with this information

Conclusions

Mass media covered multi-story window serenades extensively before the pandemic reached NYC. Northern Italian cities performed the same acts of appreciation before the New York City epidemic started with similar epidemiological results. Soon other countries joined those in

Northern Italy and the United States. Each serenade location experienced comparable early 2020 Covid-19 spread.

On March 13, 2020, there were 326 official cases of Covid-19 in New York City. Testing supplies were not widely available, so there were probably many more unreported cases. There were only a few ill individuals on the first nights, and the camaraderie of song seemed to help ease the isolation. Their cold-like symptoms were not yet severe even though they would worsen later. The next night some of the singers were newly infected. They did not know they were ill because they were still asymptomatic. The asymptomatic innocently continued to sing filling the air with Covid-19 virion droplets for days before any symptoms were obvious.

Even if the singing individual is asymptomatic (infected but without visible symptoms) or in the incubation stage the viral load is very high. The incubation period (asymptomatic period) for Covid-19 is contested, but most estimates are four to six days before the onset of symptoms.[24]

The disease can last for many days after symptoms present. Each night of singing increased the viral load experienced by the singers and anyone else in the area. The continued concentrated exposure exceeded the body's capability to reject the disease even in hardy individuals. Even if they didn't catch the disease, they carried it to the far corners of the city through fabric entrapment and fomite spread.

Those singing in the serenades did nothing wrong, yet their exuberance was fatal. Why did officials familiar with the decades of work funded by their agencies ignore the U.S. government funded research indicating increased virion viability in low humidity, low temperature environments. Personal recollection is that officials blamed the New York City infection spread rate on vague generalities such as increased contact due to commuting and crowding in public venues such as restaurants and bars. There was also research indicating increased generation of respiratory pathogens due to singing.

A simple warning from the federal government regarding risks associated with public serenades during the first weeks of the pandemic would have probably reduced the death toll in New York alone by as many as tens of thousands.

Suggestion for future research

The need for increased funding of physical (non-medical) spread research

Increased physical respiratory virus transmission modeling, as opposed to biological respiratory transmission would be appropriate. As a friend once noted, drug manufacturers will always fund the chemical aspects of respiratory spread because of the possibility of profit. Only the dedicated will work on physical respiratory virus transmission modeling since there is no profit in giving advice such as closing your windows at night or using sidewalks on the same side of the road as prevailing traffic (right side in the United States). This is neither a revelation nor a surprise.

Issues such as these can only be resolved through continued INDEPENDENT research. During the Covid-19 pandemic government response has been spotty, inconsistent, thoughtless, incorrect and occasionally deadly.

The need for improved effective R_0 modeling techniques

This paper is the direct result of physical spread modeling based on developing an effective R_0 model. R_0 (R sub zero in U.S. English or reproduction factor) is a modeling construct that assumes a number of specific conditions including virus characteristics, length of exposure, number of exposures, length of typical infectious period, susceptibility of the unexposed, human interaction modes and a myriad of other factors. Early evaluation of a new pathogen bases R_0 on limited available empirical data. As scientists accumulate more data, available empirical information is evaluated and early estimates become better defined. Eventually a value for R_0 is determined based on physical modeling such as mentioned above. Mature published R_0 values give an excellent tool for evaluating effective public planning strategies and official responses to a pathogen.

However, the rigid definition of R_0 could be improved by various methods. For example, the findings of this paper are based on the proposition that effective R_0 modeling should allow for spread in multiple and fractional dimensions. i.e. When topographical features such as a river with few bridges, each side of the river are treated as different populations. Populations in mountainous areas are treated as serial strings of infected and uninfected people. People in tropical areas are different than arid areas and so forth. This paper examines the results when an urban environment modeled to accommodate three-dimensional interaction between the infected and uninfected during a low temperature and low humidity period. Multiple dimensions of interaction and modes of interaction such mobile factory workers vs. static office workers improve modeling of urban spread. In this paper multistory dwellings and multiple transportation means changed two of the original conditions regarding R_0 utilization.

Much of the original work on physical spread of droplets through the air is based on three-dimensional dispersion of particles through a homogenous medium such as infected and uninfected persons in an enclosed area.

Another example is rural spread where spread is dependent on serial avenues of spread determined by topographical features such as mountains, valleys, and/or geopolitical constraints.

Another extrememely important but seemingly overlooked factor is that spread may but does not necessarily directionality but may approach a destination from multiple directions like a city center or where only one route of ingress or egress is possible such as a beach area or a military facility.

Antidotal Information regarding funding research into disease intensity as a function of initial viral infection load

The author is not qualified to discuss this topic by any standards. At the risk of sounding foolish, the author would like to mention a secondary unscientific observation. There is no specific data to support this observation, nor would the author be competent to evaluate that data. However, Cytokine storms seem to have contributed to the large proportion of deaths in NYC and other locations. The author interprets Cytokine storms to be over stimulation of the immune system to the detriment of the patient. Some of the data evaluated for this report seems to imply that further research into the possibility that unusually high initial viral loads of SARS-CoV-2 virion might contribute to the number and severity of cytokine storm events during New York City's first two months of the pandemic.

I mention it here because the original discussion involved scenarios where a small number of singers are infected a surprisingly large number of uninfected. Later, as more participating singers were infected, the number of available virion possibly increased to well above normal human - human transmission levels and overloading any normal natural human response to Covid-19. I emphasize that this is not a conclusion but rather simple unfounded speculation on the part of the author. Any verification, validation or further consideration regarding this matter should be by Medical Doctors or researchers under controlled conditions and by means of traceable scientific methodology.

See the newly established web site www.aanoit.com for more information.

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[17] The author has encountered resistance to this statement. Since I believe it is my only biological assumption I will attempt to justify it here. Covid-19 began as a single virion if it is natural origin. That virion infected something or someone to reproduce at least once or there would be no SARS-CoV-2. The author admits that one virion may not cause an infection even if placed in the most advantageous location for its reproduction, due to many factors including innate immunity. Luck may be defined as an occurrence contrary to probability, so a person would have to be unlucky indeed to encounter a single droplet, have it delivered to exactly the most vulnerable location and have that droplet begin reproduction, which eventually expressed itself as the disease. The disease itself is proof that it happened at least once and the high infectivity of Covid-19 would indicate that luck is less of a factor than for most other respiratory diseases. Since luck is a function of inopportune probability there is a desire to quantify luck so as to minimize one's dependence on luck, which is to say reduce the odds of becoming ill. So one droplet CAN (and does) cause Covid-19 although multiple droplets are more likely to escape natural and manmade defenses. At the time examined in this paper there were no manmade defenses so one must assume that all recipients of the virion were equally vulnerable and a very small number of virion were required and a droplet depositing a

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number of virion in a small area is more likely to evade natural immunity than the same number of virion distributed over a larger area because of the relatively uniform distribution of immune response components in one's body.

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[19] Temperature, humidity, wind direction and wind strength Central Park location, (2021), (https://www.timeanddate.com/weather/usa/new-york/historic, recovered 11/2021)

[20] NOTE: It is the eddies and swirls of diverted air both by the building mass and architectural features as well as cars, stairs, surface roughness and other irregular features that justify the earlier claim of well mixed air in the model space.

[21] The approximate dimensions were suggested by 1700 Block of Bryant Avenue Bronx New York was used for this model. The block was a random selection. Building height was increased (increasing filled volume) to assure a conservative result.

[22] Bing Covid Tracker - United States Overview, 7 day average April 19, 2020 - 2,043 7 day average Dec 12, 2020 - 2844 (bing.com/covid/local/unitedstates)

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The New England Journal of Medicine
nejm.org

Cover letter for Covid In New York submission

Dear Sir or Madame;

I am a retired electrical engineer with unique knowledge regarding meteorological effects on droplet spread. I have been developing spread software since April of 2020. My background includes work for a company modeling spread of nuclear particles and/or fallout after nuclear events. I was working for Applied Physical Technology of Atlanta, Georgia when the Three Mile Island accident occurred in 1979. Yep, I'm that old! No proprietary or sensitive information is contained in the manuscript.

I also have experiencing other modeling software as both a user and designer. I have authored a book about SPICE, a modeling packaged developed by Berkeley University. *PCB Artist 2 with LTSpice Designers Guide* ISBN - 978-1489505323

Medical Doctors and researchers are uniquely qualified to evaluate and report clinical aspects of Respiratory Medicine research. However, knowledge of virus spread is enhanced by application of physical and mechanical techniques.

I realize that the paper is rather lengthy and I assure you that I have worked diligently to reduce the content. I have not been able to find similar work despite extensive research, not because it is without merit, but because it is so esoteric.

Shortening Paper

I have spent a bit of space developing my premises that justify claims of virion droplet density. Pages 4 (Mechanics of spread) thru 7 (Aerosol lifetime) are summarized on page 2 and might be generally accepted.

I also have a web site for publishing further details. https://www.aanoit.com/ . I will also keep a current copy of this manuscript and supporting information at www.aanoit.com/private for your easy access this area is not protected and is not generally available because the address is not published. I can provide password access or secure FTP access if you wish (to keep it away from web crawlers.)

Fast Track

I would like you to fast track the paper because of 1) immediate application of the findings may make a material difference in the spread of current and future strains 2) my advanced age and 3) because of subjects I would like to develop that require funding.

My research has found that social conditions affect disease spread than physical environment. However, in ultra urban situations, meteorological effects are especially significant. Specifically, certain uniquely urban activities can contribute to enhanced quantity and severity of infections.

I provide care for a relative. I live and work in a rural area of North Alabama. My remote location resulted in my research niche concentrating in respiratory spread in remote areas with emphasis on geographic and demographic modeling. This paper illustrates that including weather effects in modeling software is a major improvement, especially temperature and humidity. However, in urban areas seasonal winds have a significant impact.

I came to this conclusion because certain aspects of rural spread modeling needed verification by comparison to extreme urban spread. Surprising answers to the evaluation of urban spread vs. rural spread lead to the findings of this paper. The work took so long because the results were directly in conflict with existing narratives.

Vaccines are a wonderful development but are only effective on 90% of the population at best and may or may not be effective for future strains. Improved spread models that account for local meteorology, topology and demographics will give tools to local leaders and health professionals to more accurately anticipate future needs, even if prediction effectiveness is limited to days.

I am in my 70s. I would like to hand at least some of this work off to others. I have funded everything out of my pocket until now, but could use some help.

Author funding would normally not be a concern of a medical journal, but I assure you that the findings in this paper are the tip of the iceberg. Creation of a new generation of spread software will improve respiratory disease prediction, particularly at the community (rural) level.

Empirical methods are not the basis of this work. I do use historical data to test model efficacy. Because the models theoretically based, as opposed to empirically based, applications are not limited to repetition of historically observed phenomenon.

I have a copyright notice on the paper only to retain my access to the work and protect it from less than knowledgeable plagiarists.

Regards,

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