Special Issue 5
2022 https://www.theghmethod.com

The GH-Method

Viscoelastic or Viscoplastic Theory (VGT #83): A Study of Influences on Consumer Price Index Resulted from Consumer Psychological Reactions and Consumption Behavior Change During the COVID-19 Pandemic 9-Quarters Period from Y2020Q1 to Y2022Q1 Based on GH-Method: Math-Physical Medicine, Especially the VGT Energy Tool (No. 673)

Gerald C. Hsu*

eclaireMD Foundation, USA

Abstract

The author is a mathematician and engineer who has conducted medical research work over the past 13 years. Thus far, he has written 670 medical research papers. Beginning with paper No. 578 dated 1/8/2022, he wrote a total of 80 medical research articles using the viscoelasticity and viscoplasticity theories (VGT) from physics and engineering disciplines on 80 different medical problems with their associated data. These papers aim to explore some hidden biophysical behaviors and provide a quantitative understanding of the inter-relationships of a selected medical output (symptom) versus singular input or multiple inputs (root causes, risk factors, or influential inputs). The hidden biophysical behaviors and possible inter-relationships exist among lifestyle details, medical conditions, chronic diseases, and certain severe medical complications, such as heart attacks, stroke, cancers, dementia, and even longevity concerns. The chosen medical subjects with their associated data, multiple symptoms, and influential factors are "time-dependent" which means that all of the biomedical variables are changing from time to time because body living cells are dynamically changing. This is what Professor Norman Jones, the author's adviser at MIT, suggested to him in December 2021 and why he utilizes the VGT tools from physics and engineering to conduct his medical research work since then. From 1980 to 1981, the author attended a college in California for his MBA degree, emphasizing finance and marketing. In addition, he spent many years managing a successful high-tech semiconductor business in Silicon Valley, where it involved many key factors of economics and finance, such as gross domestic product (GDP), inflation rate, consumer price index (CPI), NASDAQ stock performance, price-earnings ratio (P/E ratio), various investment decisions, return on investments (ROI), etc. As a result, money subjects associated with finance and economics are not unfamiliar subjects to him. In addition, during the 9 years from 2002 to 2010, he self-studied psychology and established 4 psychotherapy centers to take care of 200+ abused women and abandoned children. Therefore, he has accumulated a considerable amount of knowledge on psychological behaviors, especially from the field of clinical psychology of abused victims. During his recent medical research work using the tool of viscoelastic or viscoplastic behavior theory, he suddenly realized that there is a strong similarity between medicine and economics. The behaviors and patterns of economics variables (inputs and outputs) he observed are comparable to the behaviors and patterns of medical variables he studied and researched (causes and symptoms), in terms of their curve shape & waveforms, fluctuation patterns, and moving trends, physical behaviors, etc. For example, he has applied the candlestick chart or K-line diagram from Wall Street as an effective glucose representation tool in medicine. Most importantly, variables in both medicine and economics possessed the common "time-dependent" characteristics. The recent COVID-19 pandemic is a severe and unique experience to worldwide people that is comparable to the Spanish Flu that happened over a century ago. He wondered what type of economic impact or inter-relationship from this pandemic had on some of the current economic indices. Therefore, in this article, he selects the CPI of US cities as the output variable along with the COVID-19 death and infection cases in the USA as two input variables to conduct his combined study of both economics and medicine. The author conceived the idea of using mathematics, physics, and

Available online: 16 August 2022

*Corresponding author: Gerald C. Hsu, eclaireMD Foundation, USA

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It should be mentioned that his COVID data are rough "rounded-off" numbers that are directly extracted from the published "graphic charts (not from data tables)" from the Center for Disease Control (CDC) and Johns Hopkins University. The COVID data are simplified with rounded numbers to thousands for death and millions for infection because using the precise digits would not improve the accuracy of results much or change the observed physical characteristics of the results. Next, he searched for and reviewed a few economic articles related to GDP, inflation, CPI, etc. Over the past 2 years, due to his medical research interest, he has already been exposed to many news and articles on the media, as well as published medical research papers with clinical data regarding the COVID pandemic. This study is of particular interest to him since it links the US national economy with a severe infectious disease in modern history. This article is one of his first attempts to link COVID disease with some key economic measurements, specifically CPI. The established theory of viscoelasticity and viscoplasticity (from the physics branch of science) should not only be limited to a smaller scope of engineering applications. Its ability to link certain variables' time-dependent characteristics and their associated energy estimation via the hysteresis loop area is equally powerful for applications in both medicine and economics. The author would like to describe the essence of the VGT in 6 simple steps using the English language instead of mathematical equations for readers who do not have an extensive academic background in engineering, physics & mathematics - an excerpt from Wikipedia is still included in the Method section of the full-text article. The first step is to collect the output data (strain or ε) on a time scale, e.g. quarterly CPI. The second step is to calculate the output change rate with time (dε/dt), e.g. CPI change rate of each quarter. The third step is to collect the input data (viscosity or η) on a time scale, e.g. quarterly numbers of COVID infection and death. The fourth step is to calculate the time-dependent input (time-dependent stress or σ) by multiplying dε/dt and η together. (This "time-dependent input equation" is: Stress σ = strain change rate of dε/dt * viscosity η). The fifth step is to plot the input-output (i.e. stress-strain or cause-symptom) curve in a space domain (x-axis versus y-axis) with CPI strain (output or symptom) on the x-axis; and COVID Death/Infection stresses (time-dependent inputs, causes, or stresses) on the y-axis. The sixth step is to calculate the total enclosed area within these two input-output curves (or hysteresis loop areas) which is also the indicator of associated energies (either created energy or dissipated energy) of this dataset of input and output. These energy values can also be considered as the degrees of influence on output by inputs. After having this English description, he would like to use the following re-defined VGT equation from engineering and physics to address the unique "time-dependency characteristic" of both economics and medical variables. He can then establish a stress-strain diagram in a space domain (SD) where: Strain = ε (CPI) = individual strain value at the present quarter. Stress = σ (based on the change rate of strain multiplying with a chosen viscosity factor η, e.g. COVID death case, COVID infection case) = η * (dε/dt) = η * (d-strain/d-time) = (viscosity factor η using individual viscosity factor at present quarter) * (strain at present quarter - strain at previous quarter). These inputs (causes or viscosity factors) are further normalized by dividing them by the average viscosity factors. This normalization process can remove the dependency of the individual unit or certain characteristics associated with each viscosity factor. This process allows him to modify the variables into a set of "dimensionless variables" for easier comparison and interpretation of results. In summary, there are 5 observations listed from this combined study of CPI (one of the US economy indexes) versus the COVID pandemic outcomes: (1) From the time domain (TD) statistical analysis results, the correlations are CPI vs. COVID infection = 67% (moderately high correlation); CPI vs. COVID death = 16% (no correlation); COVID death vs. COVID infection = 61% (moderately high correlation). On the surface, these collected COVID data should behave like a set of independent numbers which have nothing to do with the economic data. But this guessed statement holds true for the COVID death case only. The COVID death dataset has no correlations with other economic indices except with COVID infection of R=61% (a pure medical research subject). Of course, this high correlation between COVID death and COVID infection is more visible within the Y2020 sub-period. During the Y2020 period, the initial shock from COVID deaths, lacking mRNA vaccine, effective urgent care treatment methods, and insufficient healthcare staff and facilities have resulted in a highly linear correlation between death and infection, i.e. in Y2020, higher death rates are indeed associated with higher infection rate without other significant perturbation factors. However, after Y21Q2, the combination of availability of mRNA vaccine, an approach to herd immunity, an improvement in urgent care treatments, and sufficient healthcare staff and facilities have reduced the death rate significantly. But, at the same time, the arrivals of different COVID variants with different contagious strengths and mortality rates have changed this picture again. For example, delta has a higher mortality rate and omicron has a higher spread rate with a lower mortality rate which has changed the relationship between death rate and infection rate in Y2021. From the angle of additional influential factors, the psychological fear of COVID, large US government relief funds, and unexpected supply-chain disruptions have also added to behavior changes in US consumer spending. Particularly, the psychological behavior change would cause CPI to shift between different economic segments. For example, consumer spending has changed from closures of many small businesses and "real" shops to increased "online" ordering and delivery services via Amazon, UPS, etc. All of the above-described facts have shown that both of infection rate and death rate of the COVID pandemic have indeed contributed to their influence levels on CPI. (2) Researching the part of strains from the VGT results, the CPI started from 258 (1982-84 as 100) in Y20Q1, dropped slightly to 257 in Y20Q2, and then continuously increased to its peak at 284 in Y22Q1. The CPI change rate (strain change rate) is also continuously rising from 0.6 in Y20Q4 to 6.3 in Y22Q1. This strain change curve, i.e. CPI change curve determines the basic waveform pattern of two stress-strain curves. (3) Researching the part of stresses from the VGT results, these 2 stress-strain waveform patterns of death and infection are highly similar to each other (these two stresses have an 85% correlation) which depends on the strain (CPI) change rate. Furthermore, the magnitude difference between these two average stresses is only 25% (infection 3.73 and death 2.98). The highest stress values of both death and infection occurred in Y22Q1 which resulted in the highest CPI in Y22Q1. (4) The combination of strain and stress components determines the actual size of the hysteresis loop area or its associated energy, i.e. the degree of influence of the stresses (COVID) on the strain (CPI). The VGT study shows a COVID infection area of 129 (53%) versus a COVID death area of 113 (47%) and an almost 1:1 ratio for this longer 9-quarter period. The sub-period of 5-quarters from Y21Q1 to Y22Q1 also reflects the same loop area ratio of 53% to 47%. Although this 5-quarters sub-period only occupies 57% of the total 9-quarters period, this observation proves the Y2021 period's domination of the stress-strain (COVID-CPI) behavior. (5) From this VGT study, the contributions to CPI from COVID death and COVID infection are almost equal. In Figure 2 of COVD death versus COVID infection (a pure medical study), it is interesting to note that the stress-strain curve during 2020 behaved like a skewed straight line. This meant a higher infection rate brought a higher death rate under the clear observation of lacking effective mRNA vaccines, unavailability of better treatments, and insufficient healthcare facilities in Y2020. This specifically weak phenomenon of Y2020 also reflects the combination of realities with the initial shock in the American community, the lack of pandemic's central command, and the US government's war plan. However, during the post-Y2020 period, i.e. after Y21Q1, with the availability of mRNA vaccines and more effective treatments in hand, the death rate started to drop except for the last 2 quarters of increased infection rate due to omicron variant (higher transmission power but with lower mortality). This explains the twisted-rope shape of the stress-strain curve after Y21Q1. This VGT energy tool adopted from engineering and physics disciplines can indeed provide some interesting clues for useful interpretation of results from this particular research work of combined economics (CPI) and medicine (COVID).

Keywords: Viscoelastic; Viscoplastic; Consumer price index; COVID-19; Gross domestic product

Abbreviations: CPI: consumer price index; GDP: gross domestic product; SD: space domain; TD: time domain; MPM: math-physical medicine

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The author conceived the idea of using mathematics, physics, and engineering in medical research while he was learning and practicing psychological care approximately 20 years ago. Due to the protection of his psychological patients' clinical data (the privacy and confidentiality requirement), he decided not to use the collected data of his patients in his research work. Besides, most published psychological papers are "subjective and language descriptive" rather than "objective and equation/number descriptive" like most science and engineering papers. As a result, in this article, he will describe the interconnection between human psychology and COVID fear in descriptive language, instead of using analytical equations and numbers for his economics analysis. However, regarding the part of connections or relationships between

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= σ (based on the change rate of strain multiplying with a chosen viscosity factor η, e.g. COVID death case, COVID infection case)
= η * (dε/dt)
= η * (d-strain/d-time)
= (viscosity factor η using individual viscosity factor at present quarter) * (strain at present quarter - strain at previous quarter)

These inputs (causes or viscosity factors) are further normalized by dividing them by the average viscosity factors. This normalization process can remove the dependency of the individual unit or certain characteristics associated with each viscosity factor. This process allows him to modify the variables into a set of "dimensionless variables" for easier comparison and interpretation of results.

2. METHODS

2.1 GDP, inflation, CPI & COVID

The author takes a few excerpts from several articles he has read recently and listed them below:

"Over time, the growth in GDP causes inflation (the author's note: There is a +84% correlation existed between GDP and inflation within these 9 quarters). However, inflation, if left unchecked, runs the risk of morphing into hyperinflation. If the overall economic output is declining, or merely holding steady, most companies will not be able to increase their profits (which is the primary driver of stock performance); however, too much GDP growth is also dangerous (From Reference 1).

Higher production leads to a lower unemployment rate, further fueling demand. Increased wages lead to higher demand as consumers spend more freely. This leads to higher GDP combined with inflation (From Reference 2).

There is a negative relationship between inflation and GDP in the UK, at least in the short run (the author's note: this may result from one of the shortcomings, time-window size, of using statistics tools), which is consistent with most of the theories that have been developed throughout the years (From Reference 3).

The US Consumer Price Index (CPI) may understate the rate of inflation during the COVID-19 crisis because it does not reflect pandemic-induced shifts in spending patterns (the author's note: the correlation between CPI and COVID infection is 67%) according to findings reported in Inflation with COVID Consumption Baskets (NBER Working Paper 27352) (From Reference 4).

"We are experiencing this sudden surge in inflation for two main reasons," says Craig Kirsner, President of Stuart Estate Planning Wealth Advisors in Coconut Creek, Florida. "First, for the past year and a half due to Covid, hardly anyone was spending money. Now that the economy is back open, people are spending and traveling and, as such, there is a bottleneck with very high demand. Our system isn't set up for this high demand level, so that causes inflation in the short term. Second, with interest rates lowered to almost zero since March of 2020, these low-interest rates have spurred demand in housing which is experiencing a large backlog as well as adding to inflation worries."

"It's largely due to a perfect storm of supply chain disruption from Covid, government spending to fill the economic void, and a synchronized global recovery driven by vaccine rollout and economies re-opening," says John P. Micklitsch, Chief Investment Officer at Ancora in Cleveland. "The pandemic is probably just the event that exposed over a decade of underinvestment in the global commodity supply chain and the vulnerability of 'just-in-time' iinventories to this sort of supply shock."

"A large portion of what we are experiencing in inflation is due to the deflation which we saw in 2020 during the Covid shutdowns," says Mike Windle, CEO at Custom Wealth Solutions in Plymouth, Michigan. "As prices work to normalize, it is causing inflationary pressure. Add to that the pent-up demand caused by the Covid lockdowns; we are seeing prices rise quickly."

If many point a finger at Covid causing inflation, many point a second finger at national leadership.

"Legislation from Washington has likely played a role in increasing demand for goods over the last year," says Saunders. "The CARES Act distributed direct cash payments to individuals and also increased unemployment benefits. These had a direct impact on increasing the incomes and savings rates of many individuals. Along with these transfer payments, the Act also allowed for those in need to defer payments on mortgages and student loans, 'freeing up' more cash for individuals to spend on goods and services."

"Injecting large amounts of cash into an economy through stimulus and other spending programs like the proposed trillion+ dollar 'infrastructure' bill will ramp up economic growth, and will certainly not decrease inflationary pressures," says Taddei. "It is a combination of issues, fiscal stimulus, the Federal Reserve's loose monetary policy and the subsequent increase in the money supply that creates more money chasing fewer goods and services." (From Reference 5).

The US Consumer Price Index (CPI) may understate the rate of inflation during the COVID-19 crisis because it does not reflect pandemic-induced shifts in spending patterns, according to findings reported in Inflation with COVID Consumption Baskets (NBER Working Paper 27352) From Reference 10".

2.2 MPM background

To learn more about his developed GH-Method: math-physical medicine or MPM methodology, readers can select the following three articles from the 400+ published medical papers.

The first paper, No. 386, describes his MPM methodology in a general conceptual format. The second paper, No. 387, outlines the history of his personalized diabetes research, various application tools, and the differences between the biochemical medicine (BCM) approach versus the MPM approach. The third paper, No. 397, depicts a general flow diagram containing ~10 key MPM research methods and different tools.

All of the listed papers in the Reference section are his written and published medical research papers.

2.3 Elasticity, plasticity, viscoelasticity, and viscoplasticity (LEGT & VGT)

The difference between elastic materials and viscoelastic materials (from "Soborthans, innovating shock and vibration solutions").

What are elastic materials?

Elasticity is the tendency of solid materials to return to their original shape after forces are applied on them. When the forces are removed, the object will return to its initial shape and size if the material is elastic.

Medical analogy: The medical application is when cause or risk factors are reduced or removed, the symptoms of certain disease would be improved or ceased.

What are viscous materials?

Viscosity is a measure of a fluid's resistance to flow. A fluid with large viscosity resists motion. A fluid with low viscosity flows. For example, water flows more easily than syrup because it has a lower viscosity. High viscosity materials might include honey, syrups, or gels – generally things that resist flow. Water is a low viscosity material, as it flows readily. Viscous materials are thick or sticky or adhesive. Since heating reduces viscosity, these materials don't flow easily. For example, warm syrup flows more easily than cold.

What is viscoelastic?

Viscoelasticity is the property of materials that exhibit both viscous and elastic characteristics when undergoing deformation. Synthetic polymers, wood, and human tissue, as well as metals at high temperature, display significant viscoelastic effects. In some applications, even a small viscoelastic response can be significant.

Medical analogy: Viscoelastic behavior means material has "time-dependent" characters. Biomedical data, i.e. biomarkers, are time-dependent due to body cells are organic which changes with time constantly.

Elastic behavior versus viscoelastic behavior

The difference between elastic materials and viscoelastic materials is that viscoelastic materials have a viscosity factor and the elastic ones don't. Because viscoelastic materials have the viscosity factor, they have a strain rate dependent on time. Purely elastic materials do not dissipate energy (heat) when a load is applied, then removed; however, a viscoelastic substance does.

Medical analogy: Most of the biomarkers display time-dependency; therefore they have both change-rate of time and viscosity factor behaviors. Viscoelastic biomarkers do dissipate energy when a cause force is applied on it.

The following brief introductions are excerpts from Wikipedia:

"Elasticity (physics):

The physical property is when materials or objects return to their original shape after deformation.

In physics and materials science, elasticity is the ability of a body to resist a distorting influence and to return to its original size and shape when that influence or force is removed. Solid objects will deform when adequate loads are applied to them; if the material is elastic, the object will return to its initial shape and size after removal. This is in contrast to plasticity, in which the object fails to do so and instead remains in its deformed state.

Hooke's law states that the force required to deform elastic objects should be directly proportional to the distance of deformation, regardless of how large that distance becomes. This is known as perfect elasticity, in which a given object will return to its original shape no matter how strongly it is deformed. This is an ideal concept only; most materials that possess elasticity in practice remain purely elastic only up to very small deformations, after which plastic (permanent) deformation occurs.

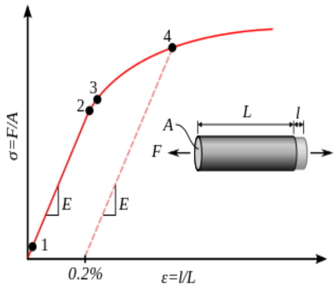
In engineering, the elasticity of a material is quantified by the elastic modulus such as the Young's modulus, bulk modulus or shear modulus which measure the amount of stress needed to achieve a unit of strain; a higher modulus indicates that the material is harder to deform. The material's elastic limit or yield strength is the maximum stress that can arise before the onset of plastic deformation.

Medical analogy: The elastic behavior analogy in medicine can be expressed by the metal rod analogy for the postprandial plasma glucose (PPG). Consuming carbohydrates and/or sugar acts like a tensile force to stretch a metal rod longer, while post-meal exercise acts like a compressive force to suppress a metal rod shorter. If lacking food consumption and exercise, the metal rod (analogy of PPG) will remain its original length, for a non-diabetes or less severe type 2 diabetes (T2D) patient.

Plasticity (physics):

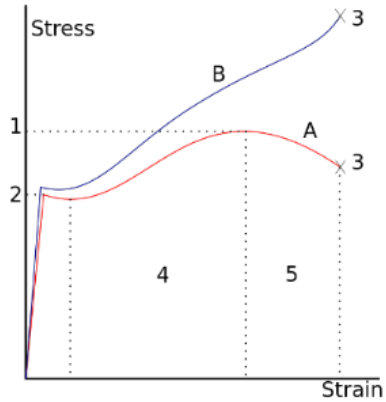
Deformation of a solid material undergoing non-reversible changes of shape in response to applied forces.

In physics and materials science, plasticity, also known as plastic deformation, is the ability of a solid material to undergo permanent deformation, a non-reversible change of shape in response to applied forces. For example, a solid piece of metal being bent or pounded into a new shape displays plasticity as permanent changes occur within the material itself. In engineering, the transition from elastic behavior to plastic behavior is known as yielding. Plastic deformation is observed in most materials, particularly metals, soils, rocks, concrete, and foams.



A stress-strain curve showing typical yield behavior for nonferrous alloys.

1. True elastic limit
2. Proportionality limit
3. Elastic limit
4. Offset yield strength



A stress-strain is typical of structural steel.

- 1: Ultimate strength
- 2: Yield strength (yield point)
- 3: Rupture
- 4: Strain hardening region
- 5: Necking region
- A: Apparent stress (F/A0)
- B: Actual stress (F/A)

For many ductile metals, tensile loading applied to a sample will cause it to behave in an elastic manner. Each increment of load is accompanied by a proportional increment in extension. When the load is removed, the piece returns to its original size. However, once the load exceeds a threshold – the yield strength – the extension increases more rapidly than in the elastic region; now when the load is removed, some degree of extension will remain.

Medical analogy: A plastic behavior analogy in medicine is the PPG level of a severe T2D patient. Even consuming a smaller amount of carbs/sugar, the patient's PPG will rise sharply which cannot be totally brought down to a healthy PPG level even with a significant amount of exercise. This means the PPG level has exceeded its "elastic limit" and entering into a "plastic range".

Viscoelasticity:

Property of materials with both viscous and elastic characteristics under deformation.

In materials science and continuum mechanics, viscoelasticity is the property of materials that exhibit both viscous and elastic characteristics when undergoing deformation. Viscous materials, like water, resist shear flow and strain linearly with time when a stress is applied. Elastic materials strain when stretched and immediately return to their original state once the stress is removed.

Viscoelastic materials have elements of both of these properties and, as such, exhibit time-dependent strain. Whereas elasticity is usually the result of bond stretching along crystallographic planes in an ordered solid, viscosity is the result of the diffusion of atoms or molecules inside an amorphous material.

In the nineteenth century, physicists such as Maxwell, Boltzmann, and Kelvin researched and experimented with creep and recovery of glasses, metals, and rubbers. Viscoelasticity was further examined in the late twentieth century when synthetic polymers were engineered and used in a variety of applications. Viscoelasticity calculations depend heavily on the viscosity variable, η. The inverse of η is also known as fluidity, φ. The value of either can be derived as a function of temperature or as a given value (i.e. for a dashpot).

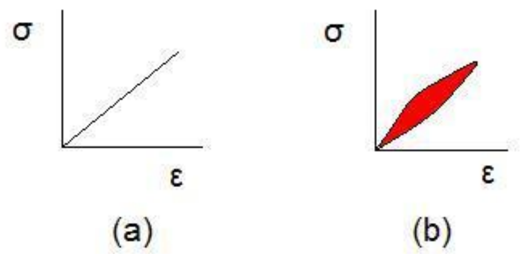
Depending on the change of strain rate versus stress inside a material, the viscosity can be categorized as having a linear, non-linear, or plastic response. In addition, when the stress is independent of this strain rate, the material exhibits plastic deformation. Many viscoelastic materials exhibit rubber-like behaviors explained by the thermodynamic theory of polymer elasticity.

Cracking occurs when the strain is applied quickly and outside of the elastic limit. Ligaments and tendons are viscoelastic, so the extent of the potential damage to them depends both on the rate of the change of their length as well as on the force applied.

A viscoelastic material has the following properties:

- hysteresis is seen in the stress-strain
- stress relaxation occurs: step constant strain causes decreasing stress
- creep occurs: step constant stress causes increasing strain
- its stiffness depends on the strain rate or the stress rate.

Elastic versus viscoelastic behavior:



Stress-strain curves for a purely elastic material (a) and a viscoelastic material (b). The red area is a hysteresis loop and shows the amount of energy lost (as heat) in a loading and unloading cycle. It is equal to $\oint \sigma d\varepsilon$ where σ is stress and ε is strain. In other words, the hysteresis loop area represents the amount of energy during the loading and unloading process.

Unlike purely elastic substances, a viscoelastic substance has an elastic component and a viscous component. The viscosity of a viscoelastic substance gives the substance a strain rate dependence on time. Purely elastic materials do not dissipate energy (heat) when a load is applied, then removed. However, a viscoelastic substance dissipates energy when a load is applied, then removed. Hysteresis is observed in the stress-strain curve, with the area of the loop being equal to the energy lost during the loading cycle. Since viscosity is the resistance to thermally activated plastic deformation, a viscous material will lose energy through a loading cycle. Plastic deformation results in lost energy, which is uncharacteristic of a purely elastic material's reaction to a loading cycle.

Viscoplasticity:

Viscoplasticity is a theory in continuum mechanics that describes the rate-dependent inelastic behavior of solids. Rate-dependence in this context means that the deformation of the material depends on the rate at which loads are applied. The inelastic behavior that is the subject of viscoplasticity is plastic deformation which means that the material undergoes unrecoverable deformations when a load level is reached. Rate-dependent plasticity is important for transient plasticity calculations. The main difference between rate-independent plastic and viscoplastic material models is that the latter exhibit not only permanent deformations after the application of loads but continue to undergo a creep flow as a function of time under the influence of the applied load.

Medical analogy: In viscoelastic or viscoplastic analysis, the stress component equals the strain change rate of time multiplying with the viscosity factor, or

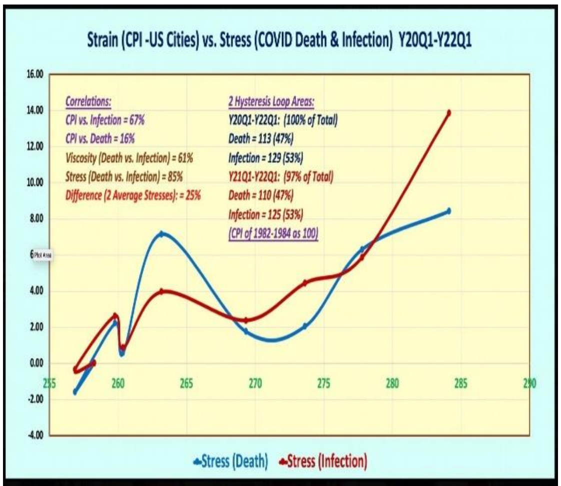
Stress (σ)
= strain (ε) change rate * viscosity factor (η)
= $d\varepsilon/dt * \eta$

The hysteresis loop area
= the integrated area of stress (σ) and strain (ε) curve
= $\oint \sigma d\varepsilon$

Note: For a more detailed description, please refer to the "consolidated method" section which is given at the beginning of the special issue.

3. RESULTS

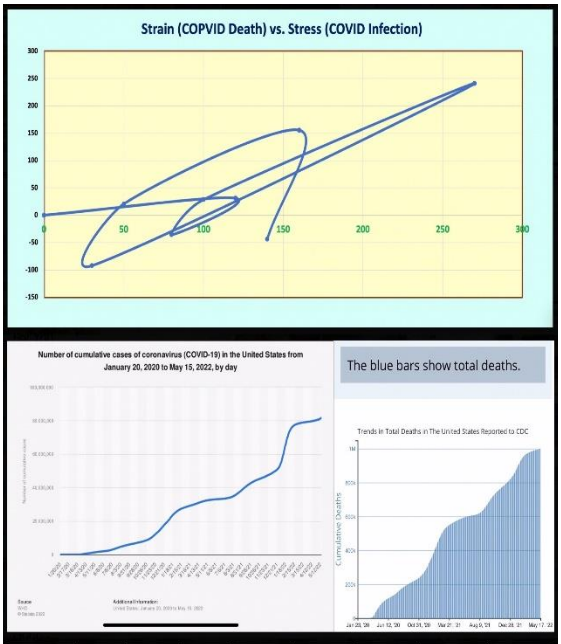
Figure 1 shows VGT stress-strain analysis results of CPI versus COVID death and COVID infection with an associated data table.



5/26/22 (1982-84 = 100)	CPI - US Cities	CPI rate	COVID Death	COVID Infection	Norm. = / Avg. Norm. Death	Norm. = / Avg. Norm. Infection	Strain CPI	Stress 1 Stress (Death)	Stress2 Stress (Infection)	Height (Death)	Height (Infection)	Area (Death)	Area (Infection)
Y20Q1	258	1.1	0	0	0.00	0.00	258	0.00	0.00	0.00	0.00	0.00	0.00
Y20Q2	257	-1.4	120	2	1.14	0.26	257	-1.59	-0.36	-0.79	-0.18	1.11	0.25
Y20Q3	260	2.9	80	7	0.76	0.90	260	2.20	2.62	0.31	1.13	0.90	3.28
Y20Q4	260	0.6	100	11	0.95	1.41	260	0.57	0.84	1.38	1.73	0.83	1.03
Y21Q1	263	2.8	270	11	2.56	1.41	263	7.15	3.95	3.86	2.40	10.77	6.70
Y21Q2	269	6.2	30	3	0.28	0.39	269	1.75	2.37	4.45	3.16	27.39	19.48
Y21Q3	274	4.3	50	8	0.47	1.03	274	2.04	4.43	1.90	3.40	8.18	14.68
Y21Q4	278	4.2	160	11	1.52	1.41	278	6.30	5.87	4.17	5.15	17.31	21.41
Y22Q1	284	6.3	140	17	1.33	2.19	284	8.41	13.86	7.35	9.87	46.65	62.60
Average / Sum	267	3.0	106	8	1.00	1.00	267	2.98	3.73	2.51	2.96	113	129
Correlation			16%	67%				25%			Y20Q1-Y22Q1	47%	53%
Correlation				61%					85%		Y21Q1-Y22Q1	110	125
											Y21Q1-Y22Q1	47%	53%
											Sub / Total	97%	96%

Figure 1: VGT analysis results and data table of CPI versus COVID infection and COVID death.

Figure 2 depicts VGT stress-strain analysis results of COVID death versus COVID infection with an associated data table.



5/21/22	Strain COVID Death	Strain Rate Death Rate	Stress Infection (M)	Norm. = / Avg. Norm. Infection	Strain COVID Death	Stress (Infection) Stress (Infection)	Strain Height (Infection)	Area (Infection)
Y20Q1	0	0	0	0.00	0	0	0	0
Y20Q2	120	120	2	0.26	120	31	15	1851
Y20Q3	80	-40	7	0.90	80	-36	-3	103
Y20Q4	100	20	11	1.41	100	28	-4	-77
Y21Q1	270	170	11	1.41	270	240	134	22841
Y21Q2	30	-240	3	0.39	30	-93	74	-17743
Y21Q3	50	20	8	1.03	50	21	-36	-720
Y21Q4	160	110	11	1.41	160	156	88	9688
Y22Q1	140	-20	17	2.19	140	-44	56	-1119
Average	106	16	8	1.00	106	34	36	14824
Y20Q1-Y22Q1	100%		61%					

Figure 2: VGT analysis results and data table of COVID death versus COVID infection.

4. CONCLUSION

In summary, there are 5 observations listed from this combined study of CPI (one of the US economy indexes) versus the COVID pandemic outcomes:

(1) From the time domain (TD) statistical analysis results, the correlations are CPI vs. COVID infection = 67% (moderately high correlation); CPI vs. COVID death = 16% (no correlation); COVID death vs. COVID infection = 61% (moderately high correlation). On the surface, these collected COVID data should behave like a set of independent numbers which have nothing to do with the economics data. But this guessed statement holds true for the COVID death case only. The COVID death dataset has no correlations with other economic indices except with COVID infection of R=61% (a pure medical research subject). Of course, this high correlation between COVID death and COVID infection is more visible within the Y2020 sub-period. During the Y2020 period, the initial shock from COVID deaths, lacking mRNA vaccine, effective urgent care treatment methods, and insufficient healthcare staff and facilities have resulted in a highly linear correlation between death and infection, i.e. in Y2020, higher death rates are indeed associated with higher infection rate without other significant perturbation factors. However, after Y21Q2, the combination of availability of mRNA vaccine, an approach to herd immunity, an improvement in urgent care treatments, and sufficient healthcare staff and facilities have reduced the death rate significantly. But, at the same time, the arrivals of different COVID variants with different contagious strengths and mortality rates have changed this picture again. For example, delta has a higher mortality rate and omicron has a higher spread rate with a lower mortality rate which has changed the relationship between death rate and infection rate in Y2021. From the angle of additional influential factors, the psychological fear of COVID, large US government relief funds, and unexpected supply-chain disruptions have also added to behavior changes in US consumer spending. Particularly, the psychological behavior change would cause CPI to shift between different economic segments. For example, consumer spending has changed from closures of many small businesses and "real" shops to increased "online" ordering and delivery services via Amazon, UPS, etc. All of the above-described facts have shown that both of infection rate and death rate of the COVID pandemic have indeed contributed to their influence levels on CPI.

(2) Researching the part of strains from the VGT results, the CPI started from 258 (1982-84 as 100) in Y20Q1, dropped slightly to 257 in Y20Q2, and then continuously increased to its peak at 284 in Y22Q1. The CPI change rate (strain change rate) is also continuously rising from 0.6 in Y20Q4 to 6.3 in Y22Q1. This strain change curve, i.e. CPI change curve determines the basic waveform pattern of two stress-strain curves.

(3) Researching the part of stresses from the VGT results, these 2 stress-strain waveform patterns of death and infection are highly similar to each other (these two stresses have an 85% correlation) which depends on the strain (CPI) change rate. Furthermore, the magnitude difference between these two average stresses is only 25% (infection 3.73 and death 2.98). The highest stress values of both death and infection occurred in Y22Q1 which resulted in the highest CPI in Y22Q1.

(4) The combination of strain and stress components determines the actual size of the hysteresis loop area or its associated energy, i.e. the degree of influence of the stresses (COVID) on the strain (CPI). The VGT study shows a COVID infection area of 129 (53%) versus a COVID death area of 113 (47%) and an almost 1:1 ratio for this longer 9-quarter period. The sub-period of 5-quarters from Y21Q1 to Y22Q1 also reflects the same loop area ratio of 53% to 47%. Although this 5-quarters sub-period only occupies 57% of the total 9-quarters period, this observation proves the Y2021 period's domination of the stress-strain (COVID-CPI) behavior.

(5) From this VGT study, the contributions to CPI from COVID death and COVID infection are almost equal. In Figure 2 of COVD death versus COVID infection (a pure medical study), it is interesting to note that the stress-strain curve during 2020 behaved like a skewed straight line. This meant a higher infection rate brought a higher death rate under the clear observation of lacking effective mRNA vaccines, unavailability of better treatments, and insufficient

healthcare facilities in Y2020. This specifically weak phenomenon of Y2020 also reflects the combination of realities with the initial shock in the American community, the lack of pandemic's central command, and the US government's war plan. However, during the post-Y2020 period, i.e. after Y21Q1, with the availability of mRNA vaccines and more effective treatments in hand, the death rate started to drop except for the last 2 quarters of increased infection rate due to omicron variant (higher transmission power but with lower mortality). This explains the twisted-rope shape of the stress-strain curve after Y21Q1.

This VGT energy tool adopted from engineering and physics disciplines can indeed provide some interesting clues for useful interpretation of results from this particular research work of combined economics (CPI) and medicine (COVID).

5. REFERENCES

For editing purposes, the majority of the references in this paper, which are self-references, have been removed. Only references from other authors' published sources remain. The bibliography of the author's original self-references can be viewed at www.eclairemd.com.

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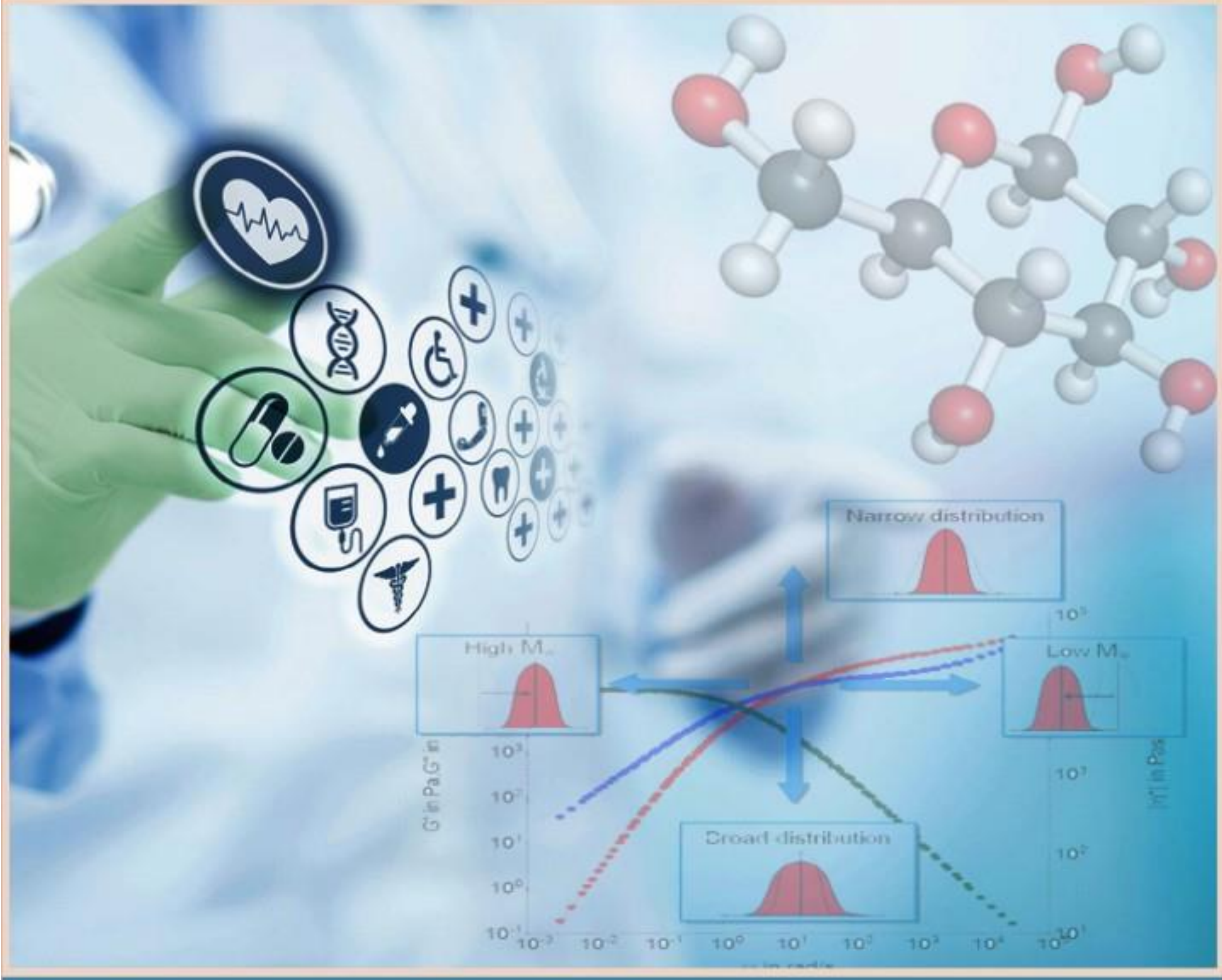
Special Issue | Issue No. 5

The GH-Method

Viscoelastic and Viscoplastic Glucose Theory Application in Medicine

Gerald C. Hsu



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