Special Issue 5
2022

The GH-Method

Viscoelastic or Viscoplastic Glucose Theory (VGT #81): An Economics Study During 2+ Years from Y2020Q1 to Y2022Q1 Investigating the Influences on the US National GDP from Two Input Variables of the National Inflation Rates and COVID Pandemic Death Cases Based on GH-Method: Math-Physical Medicine, Especially the VGT Energy Tool (No. 671)

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Abstract

Beginning with paper No. 578 dated 1/8/2022, the author wrote a total of 80 medical research articles. He utilized the viscoelasticity and viscoplasticity theories (VGT) from physics and engineering disciplines based on 80 different datasets from chosen medical subjects. These papers aim to explore some hidden biophysical behaviors. They provide a quantitative understanding of inter-relationships between a selected medical symptom, i.e. biomarker, and a few intermediate steps that include a variety of selected multiple influential input factors, “root causes or risk factors”. These hidden biophysical behaviors and possible inter-relationships existed among lifestyles, diseases, complications, or longevity. All of the selected datasets of multiple symptoms and risk factors are “time-dependent” which means that all variables are changing from time to time. This is why he applies VGT in physics and engineering to conduct his medical research work. From 1979 to 1982, the author attended a university for his MBA degree with an emphasis on finance and marketing. He spent many years managing a successful high-tech business in Silicon Valley, where finance and economics are not unfamiliar academic subjects to him. During his recent medical research work using VGT, he considered the similarity between the medical and the economic systems. The financial and economic variables (inputs and outputs) are similar to the medical variables he studied (causes and symptoms). All of these medical and economic variables have possessed “time-dependent” characteristics. The recent COVID-19 pandemic is a unique and severe experience in the world other than the Spanish flu that happened over 100 years ago. He wondered what kind of impact or inter-relationship existed during the pandemic outcome along with overall economic activities. Therefore, he selects the US gross domestic product (GDP) numbers as the output variable along with the US inflation rates (inflation) and the US COVID-19 death cases (COVID) as two input variables to conduct his math-physical medicine (MPM) analysis using the VGT tool. Initially, he Googled the GDP and inflation data. Next, he searched and read a few economic articles on GDP, inflation, consumer price index (CPI), etc. Over the past 2+ years, due to his medical research interest, he was exposed to the news, many articles, and published research papers and clinical data regarding the COVID pandemic. This article is his first attempt to link COVID deaths with some critical economic measurements. The established theory of viscoelasticity and viscoplasticity (from the physics branch of science) should not only be limited to engineering applications. Its ability to link variable’s time-dependent characteristics and associated energy estimation via hysteresis loop area is equally powerful for applications in both medicine and economics. He used the following re-defined VGT equation from engineering and physics to address the unique “time-dependency characteristic” of economic output, e.g. GDP, and two selected inputs, one is the economic input variable of inflation rates and the other is the biomedical input variable of COVID death cases. He can then establish a stress-strain diagram in a space domain (SD): Strain = ε (GDP) = individual GDP value at the present quarter. Stress = σ (based on the change rate of strain, GDP rate, multiplying with a chosen viscosity factor η, inflation % or COVID death case) = η * (dε/dt) = η * (d-strain/d-time) = (viscosity factor η using individual inflation %, or COVID death case at present quarter) * (GDP at present quarter - GDP

Available online: 08 August 2022

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at a previous quarter). Where the causes or viscosity factors are further normalized by dividing them by the average viscosity factors, i.e. average inflation % or average COVID death case. This normalization process can remove the unique unit or certain characteristics associated with each viscosity factor. In this way, he can change the variables into a set of "dimensionless variables" for easier comparison and interpretation of results. In summary, there are 3 key findings from this economic and COVID study: (1) From the time-domain analysis results, the correlations are GDP vs. Inflation % = 84% (high correlation); GDP vs. COVID = 3% (no correlation). This finding has matched the results from some published economics papers. However, the UK report on GDP versus inflation shows a negative correlation within a shorter period. Incidentally, the collected data of COVID death numbers are a set of independent numbers. The economic activities should not have any direct impact on the COVID death rate except for large-crowd gatherings may increase COVID spread and its death rate. However, COVID would have an impact on some economic measurements, including GDP and inflation. (2) Looking into some details of VGT data, the GDP change rate reached its peak during Y20Q2. Inflation reached its peak during Y22Q1 and COVID death peaked during Y21Q1. The highest stress of inflation occurred in Y21Q4, and the highest stress of COVID happened in Y20Q2. The combination of strain rate and stress components determines the hysteresis loop area (associated energy). The loop area ratio from Y20Q1 to Y22Q1 for inflation is 0.65 (31%) versus COVID with 1.49 (69%). The largest loop area for inflation occurred in Y20Q3 and the largest loop area for COVID was in Y20Q2. Therefore, the author takes a timeline snapshot at Y20Q4 and then calculates these sub-loop areas. The loop area ratio from Y20Q4 to Y22Q1 for inflation is 0.333 (41%) versus COVID with 0.47 (59%). (3) It appears that COVID has a stronger influence on GDP than inflation on GDP regardless of the full period of 9-quarters (69% vs. 31%) or the sub-period of 6-quarters (59% vs. 41%). The summary statement from these analysis findings is that COVID seems to have a stronger influence on GDP than the inflation rate.

Keywords: Viscoelastic; Viscoplastic; Economics; COVID-19; Gross domestic product

Abbreviations: SD: space domain; GDP: gross domestic product; MPM: math-physical medicine

1. INTRODUCTION

Beginning with paper No. 578 dated 1/8/2022, the author wrote a total of 80 medical research articles. He utilized the viscoelasticity and viscoplasticity theories (VGT) from physics and engineering disciplines based on 80 different datasets from chosen medical subjects. These papers aim to explore some hidden biophysical behaviors. They provide a quantitative understanding of inter-relationships between a selected medical symptom, i.e. biomarker, and a few intermediate steps that include a variety of selected multiple influential input factors, "root causes or risk factors". These hidden biophysical behaviors and possible inter-relationships existed among lifestyles, diseases, complications, or longevity. All of the selected datasets of multiple symptoms and risk factors are "time-dependent" which means that all variables are changing from time to time. This is why he applies VGT in physics and engineering to conduct his medical research work.

From 1979 to 1982, the author attended a university for his MBA degree with an emphasis on finance and marketing. He spent many years managing a successful high-tech business in Silicon Valley, where finance and economics are not unfamiliar academic subjects to him. During his recent medical research work using VGT, he considered the similarity between the medical and the economic systems. The financial and economic variables (inputs and outputs) are similar to the medical variables he studied (causes and symptoms). All of these medical and economic variables have possessed "time-dependent" characteristics. The recent COVID-19 pandemic is a unique and severe experience in the world other than the Spanish flu that happened over 100 years ago. He wondered what kind of impact or inter-relationship existed during the pandemic outcome along with overall economic activities. Therefore, he selects the US gross domestic product (GDP) numbers as the output variable along with the US inflation rates (inflation) and the US COVID-19 death cases (COVID) as two input variables to conduct his math-physical medicine (MPM) analysis using the VGT tool. Initially, he Googled the GDP and inflation data. Next, he searched and read a few economic articles on GDP, inflation, consumer price index (CPI), etc. Over the past 2+ years, due to his medical research interest, he was exposed to the news, many articles, and published research papers and clinical data regarding the COVID pandemic.

This article is his first attempt to link COVID deaths with some critical economic measurements. The established theory of viscoelasticity and viscoplasticity (from the physics branch of science) should not only be limited to engineering applications. Its ability to link variable's time-dependent characteristics and associated energy estimation via hysteresis loop area is equally powerful for applications in both medicine and economics.

He used the following re-defined VGT equation from engineering and physics to address the unique "time-dependency characteristic" of economic output, e.g. GDP, and two selected inputs, one is the economic input variable of inflation rates and the other is the biomedical input variable of COVID death cases. He can then establish a stress-strain diagram in a space domain (SD):

Strain
= ε (GDP)
= individual GDP value at the present quarter

Stress
= σ (based on the change rate of strain, GDP rate, multiplying with a chosen viscosity factor η, inflation % or COVID death case)
= $\eta * (d\varepsilon/dt)$
= η * (d-strain/d-time)
= (viscosity factor η using individual inflation %, or COVID death case at present quarter) * (GDP at present quarter - GDP at a previous quarter)

Where the causes or viscosity factors are further normalized by dividing them by the average viscosity factors, i.e. average inflation % or average COVID death case. This normalization process can remove the unique unit or certain characteristics associated with each viscosity factor. In this way, he can change the variables into a set of "dimensionless variables" for easier comparison and interpretation of results.

2. METHODS

2.1 GDP, inflation & COVID

Here are a few excerpts from other articles:

"Over time, the growth in GDP causes inflation. 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 (Reference 1)." Author's note: there is a +84% correlation existing between GDP and inflation within the 9 quarters.

"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 (Reference 2)."

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

"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) (Reference 4)."

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.

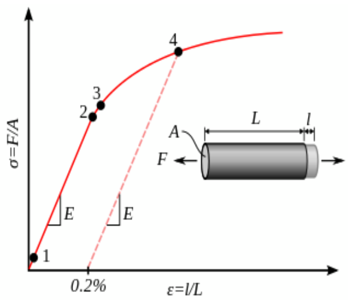
In engineering, the elasticity of a material is quantified by the elastic modulus such as the Young's modulus, bulk modulus or shear modulus which measure the amount of stress needed to achieve a unit of strain; a higher modulus indicates that the material is harder to deform. The material's elastic 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.

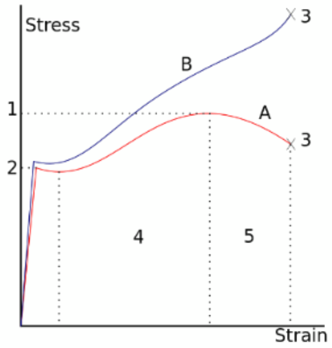
In physics and materials science, plasticity, also known as plastic deformation, is the ability of a solid material to undergo permanent deformation, a non-reversible change of shape in response to applied forces. For example, a solid piece of metal being bent or pounded into a new shape displays plasticity 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).

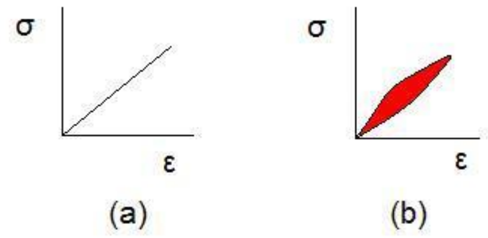
Depending on the change of strain rate versus stress inside a material, the viscosity can be categorized as having a linear, non-linear, or plastic response. In addition, when the stress is independent of this strain rate, the material exhibits plastic deformation. Many viscoelastic materials exhibit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

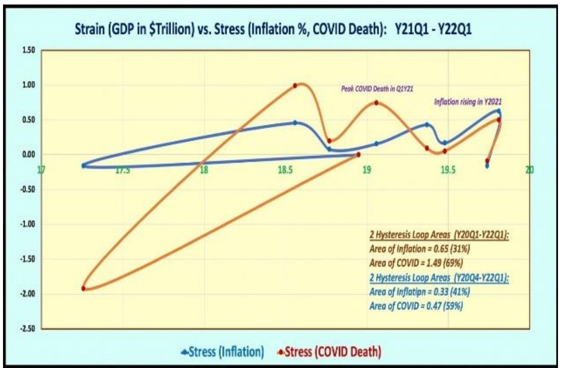
Stress (σ)
= strain (ε) change rate * viscosity factor (η)
= $d\varepsilon/dt * \eta$

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 depicts the VGT stress-strain diagram & hysteresis loop areas with a data table.



5/20/22							Norm. = / Avg.	Norm. = / Avg.	Strain	Stress 1	Stress2				
	GDP ($T)	GDP Rate	Inflation %	Cuum. Death	COVID Death	Strain Rate	Viscosity (infla)	Viscosity (COVID)	Strain (GDP)	Stress (Inflation)	Stress (COVID Death)	Height (Inf)	Height (COVID)	Area (Inflation)	Area (COVID)
Y20Q1	18.95	0	2.10	0	0	0	0.60	0.00	18.95	0.00	0.00	0.00	0.00	0.00	0.00
Y20Q2	17.26	-1.69	0.33	120	120	-1.69	0.09	1.14	17.26	-0.16	-1.92	-0.08	-0.96	0.14	1.62
Y20Q3	18.56	1.30	1.23	200	80	1.3	0.35	0.76	18.56	0.46	0.99	0.15	-0.47	0.19	-0.61
Y20Q4	18.77	0.21	1.27	300	100	0.21	0.36	0.95	18.77	0.08	0.20	0.27	0.59	0.06	0.12
Y21Q1	19.06	0.29	1.90	570	270	0.29	0.54	2.56	19.06	0.16	0.74	0.12	0.47	0.03	0.14
Y21Q2	19.37	0.31	4.87	600	30	0.31	1.38	0.28	19.37	0.43	0.09	0.29	0.41	0.09	0.13
Y21Q3	19.48	0.11	5.37	650	50	0.11	1.52	0.47	19.48	0.17	0.05	0.30	0.07	0.03	0.01
Y21Q4	19.81	0.33	6.67	810	160	0.33	1.89	1.52	19.81	0.62	0.50	0.40	0.28	0.13	0.09
Y22Q1	19.74	-0.07	7.97	950	140	-0.07	2.26	1.33	19.74	-0.16	-0.09	0.23	0.20	-0.02	-0.01
Average	19.00	0.09	3.52	467	106	0.09	1.00	1.00	19.00	0.18	0.06	0.19	0.07	0.65	1.49
Y20Q1-Y22Q1	100%		84%		3%								Y20Q1-Y22Q1	31%	69%
Y20Q4-Y22Q4													Y20Q4-Y22Q4	0.33	0.47
														41%	59%

Figure 1: VGT stress-strain diagram & hysteresis loop areas with data table.

4. CONCLUSION

In summary, there are 3 key findings from this economic and COVID study:

(1) From the time-domain analysis results, the correlations are GDP vs. Inflation % = 84% (high correlation); GDP vs. COVID = 3%

(no correlation). This finding has matched the results from some published economics papers. However, the UK report on GDP versus inflation shows a negative correlation within a shorter period. Incidentally, the collected data of COVID death numbers are a set of independent numbers. The economic activities should not have any direct impact on the COVID death rate except for large-crowd gatherings may increase COVID spread and its death rate. However, COVID would have an impact on some economic measurements, including GDP and inflation.

(2) Looking into some details of VGT data, the GDP change rate reached its peak during Y20Q2. Inflation reached its peak during Y22Q1 and COVID death peaked during Y21Q1. The highest stress of inflation occurred in Y21Q4, and the highest stress of COVID happened in Y20Q2. The combination of strain rate and stress components determines the hysteresis loop area (associated energy). The loop area ratio from Y20Q1 to Y22Q1 for inflation is 0.65 (31%) versus COVID with 1.49 (69%). The largest loop area for inflation occurred in Y20Q3 and the largest loop area for COVID was in Y20Q2. Therefore, the author takes a timeline snapshot at Y20Q4 and then calculates these sub-loop areas. The loop area ratio from Y20Q4 to Y22Q1 for inflation is 0.333 (41%) versus COVID with 0.47 (59%).

(3) It appears that COVID has a stronger influence on GDP than inflation on GDP regardless of the full period of 9-quarters (69% vs. 31%) or the sub-period of 6-quarters (59% vs. 41%).

The summary statement from these analysis findings is that COVID seems to have a stronger influence on GDP than the inflation rate.

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.

Readers may use this article as long as the work is properly cited, their use is educational and not for profit, and the author's original work is not altered

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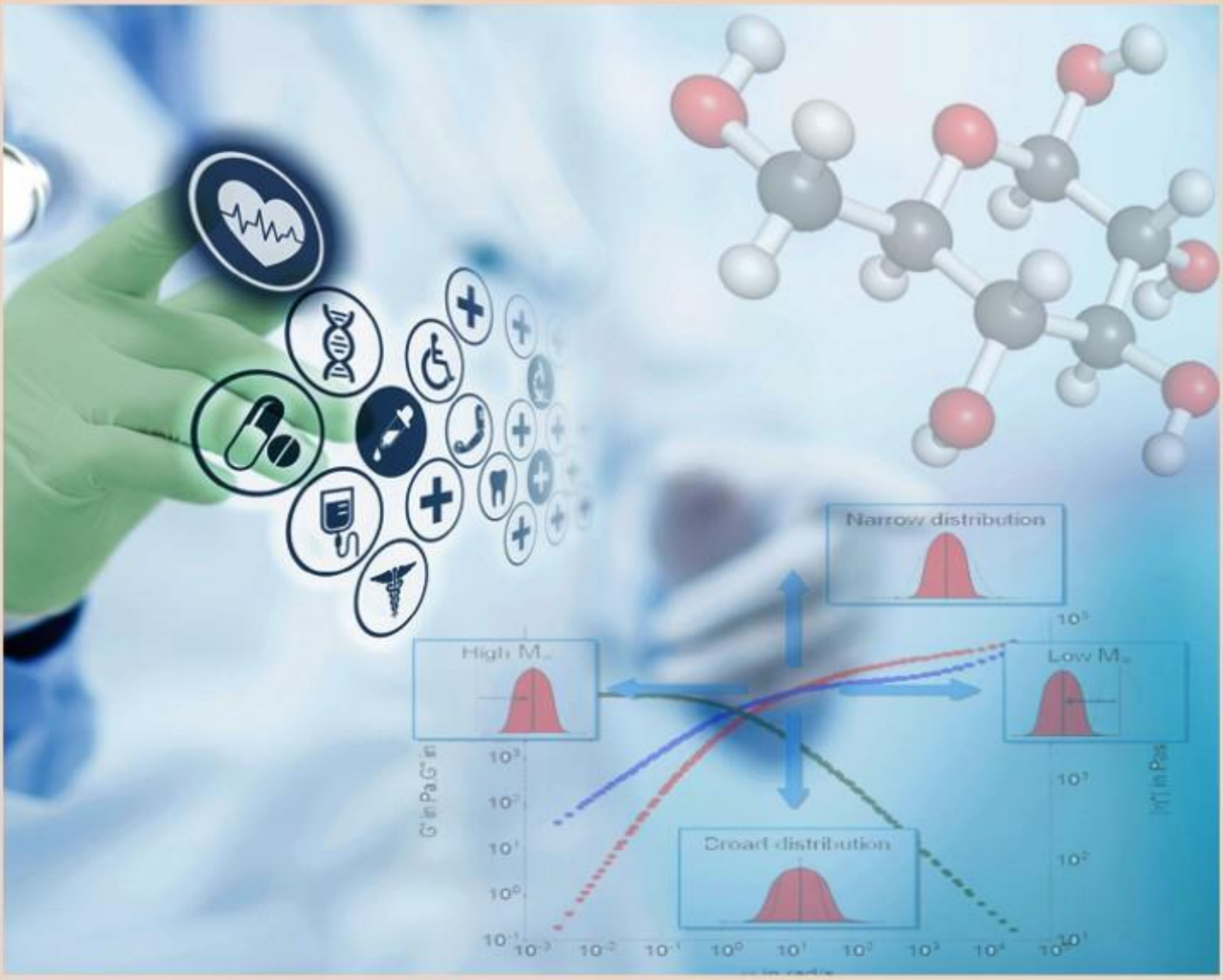

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