



LEICESTER GRAMMAR SCHOOL'S

YOUNG SCIENTISTS

journal

Advent 2020, Edition 10

America and Climate Change

Gargi Nisal investigates whether it's too late

Kajol Mistry writes

Could Vampires Exist Scientifically?

Quantum Computing: The Next Step?

Ali Khan explores the origins and potential future impacts and uses of the quantum computer

COVID-19

The Latest Research
Long Term Effects Discovered?



Welcome to YSJ 2021!



Edition 10, Advent 2020

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Following a break, due the COVID-19 pandemic, another YSJ edition returns with the continued sense of enthusiasm for the fields of science, technology, engineering and maths. We look forward to the array of interesting contributions over the next academic year from all year groups.

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Our journal aims to foster the passion we have towards STEM within the school community as well as providing a platform for students to showcase their interest and excitement through research in their respective fields.

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A special thanks goes out to all those who have contributed to this term's edition - we hope to see many more contributions next term! Having said that, we hope that you enjoy reading the many different articles as much as we did.

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We would like to thank everyone who has written an article for this journal as well as Mr Reeves and Dr Griffin for helping with the technical side of the journal.

The YSJ Team

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Many of the vast population have not heard of Anti-NMDA receptor encephalitis. The neurological disease was first identified by Dr. Josep Dalmau and the colleagues of the University of Pennsylvania in 2007. Anti-NMDA receptor encephalitis is an autoimmune disease where the body creates antibodies against the NMDA receptors in the brain. As a result, these antibodies disrupt normal brain signalling; causing swelling, or encephalitis. It can affect both men and women, but primarily affects the younger generation (children and young adults).

A breakdown of the key words:

Anti - Autoimmune response

NMDA receptors - Glutamate and ion channel protein receptor, activated by the binding of glycine and glutamate.

Encephalitis - Inflammation of the brain, causing swelling and disruption of brain signalling.

What are NMDA receptors and what do they do?

NMDA receptors are neurotransmitter proteins that are located in the post-synaptic membrane of a neurone. The proteins are embedded in the membrane of nerve cells (that receive signals via the synapse). They are largely involved in signal transduction and the control of opening/closing the ion channels; and additionally, are involved in memory formation and learning.

How many have been diagnosed?

Currently, the estimated number of Anti-NMDA cases is 1.5 per million people each year. However, the accuracy of

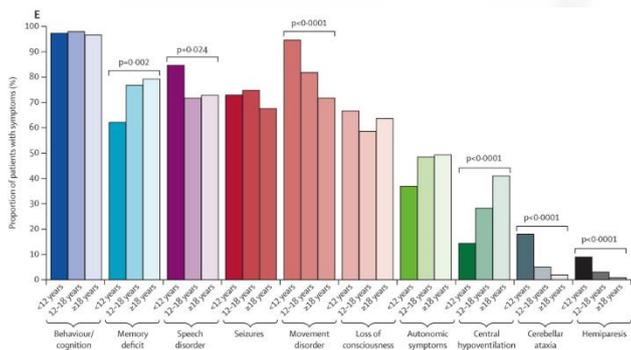
these figures is highly questionable as the disease is a fairly new discovery, so the statistic is most likely higher as some patients may not be diagnosed. 60-80% of cases with the disease are women, which is undoubtedly an astounding figure yet is unknown as to why this is the case.

What triggers this disease?

Anti-NMDA receptor encephalitis is caused by immunoreactivity against the NMDA receptor 1 (NR1) which is a subunit of the NMDA receptor. However, how this happens is unknown, and quite possibly, random. A possible cause could be herpes simplex virus encephalitis, as some of these patients have developed NMDAR-antibody encephalitis shortly after - this is not in the majority of cases but could be used to understand what exactly is triggering this inflammation and disruption of the brain.

Symptoms:

The symptoms cover a vast range of mental disorders and physical disorders. A clinical test was carried out whereby a hundred-and-eight people with Anti-NMDA Receptor Encephalitis were tested for their symptoms. Sixty-two (57%) patients had psychiatric symptoms first (including mood alteration, aggression, manic, delusion, and vision or auditory hallucinations). Forty-two patients (39%) were presented with neurological symptoms, such as seizure, movement disorder, and speech disturbances, as their initial symptom.

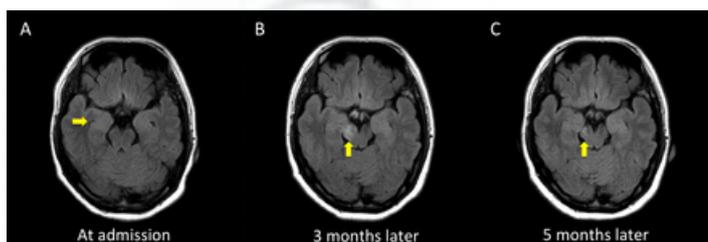


Titulaer, et. al., 2013

<https://www.frontiersin.org/articles/10.3389/fneur.2019.01330/full>

During the course, 103 patients (95%) developed one or several psychiatric symptoms. Hundred-and-two patients (94%) in this cohort had neurological symptoms: 82% had seizures, 52% memory deficits, 63% speech disturbances, 44% dyskinesias and movement disorders, 42% autonomic instability, 65% decreased consciousness and 25% had central hypoventilation (breathing at an abnormally slow rate, leads to increase of carbon dioxide in the blood stream).

MRI Scan:



<https://casereports.bmj.com/content/2018/bcr-2018-224584>

This figure shows the effect of receptor encephalitis, whereby at high signal change and swelling in the limbic system are detected on fluid-attenuated inversion recovery MRI. Three months later, the ventral side of the right middle showed high signal change and swelling

on fluid-attenuated inversion recovery MRI. Five months later, the change at the right middle brain disappeared without atrophy.

This is a very specific case, whereby the patient showed improvement with no treatment, but showed relapse involving a different lesion without symptoms.

Cure

The aim of treatment is to dampen down the immune system to stop abnormal signalling; therefore, improving the symptoms should reduce lasting damage. Most are treated with medications that reduce levels of antibodies in the blood and spinal fluid. These include treatments given into the vein: corticosteroids, intravenous immunoglobulin (antibodies collected from healthy blood donors that can bind the host antibodies) and plasmapheresis (PLEX that involves the use of machines to filter antibodies out of the host's blood). Many other medications (mainly steroids) are required to control blood pressure, seizures, anxiety, sleep hallucinations and abnormal behaviours. Additionally, Rituximab is prescribed to reduce inflammation; the drug removes some of the white blood cells in the body called B cells - removing these cells reduces the production of the antibodies playing a role in the illness.

Rituximab is a monoclonal antibody. It targets a protein called CD20 on the surface of the leukaemia and lymphoma cells. It sticks to all the CD20 proteins it finds so the cells of the immune system can locate these cells and kill them. It is mainly a treatment for chronic lymphocytic leukaemia but is also used for anti-NMDA receptor encephalitis.

Recovery:

Recovery is generally fairly slow and typically occurs in reverse of symptom onset. Surprisingly, the most severe symptoms typically resolve first while the cognitive, behavioural and memory problems take a while longer to resolve. Severe symptoms are generally movement deficiency, reduced levels of consciousness and seizures. Most patients make a full recovery within two years of disease onset.

Most patients do make a significant recovery; however, it is complex because of fears of relapse or reemerging symptoms. Children in particular may have difficulties with memory and attention but can be improved by support from therapists. Relapse includes 14-25% of patients.

The disease can be fatal, with many patients dying due to cardiac arrest or from complications with long stays in hospitals, and the use of powerful immunosuppressants.

Link with other diseases:

The most common disease which is closely linked to anti-NMDA receptor encephalitis is tumours (referred as paraneoplastic disease). If there is a tumour detected, it is normally a benign tumour of the ovary - the most common type is teratoma. Teratoma is a rare type of tumour that is also called a dermoid cyst of the ovary, containing a diversity of tissues including hair, teeth, bone, thyroid, etc.

A tumour is more likely to be found in young women who became sick during their childbearing years (therefore is less likely to affect age 10 and under, or older than 50 years). The removal of an existent tumour also can speed up recovery and reduce chances of relapse.

A tumour may be found in men, usually located in the testes, and other types of tumours that have been associated are lung cancer, thyroid tumours, breast cancer, cancer of the colon and neuroblastoma. Very few men have tumours detected (<5%), with 20-30% of women having an underlying tumour.

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The World Wide Web was invented by Tim Benners-Lee in the 1989 and it has grown by leaps and bounds since his 'Eureka moment'. It used to be confined to personal computers but gradually became available on smartphones too with the creation of 4G and 5G networks.

About 84% of adults in the UK (16+) have phones as of 2020. Today, the world is dominated by technology. People are addicted to their devices and are not prepared to let go of them. Was the internet and social media created for this purpose? Or have we morphed it into a world dominating, fake news spreading, depressing, and just annoying weapon?

Social Media is a lot more powerful than we think it is. A good example is George Floyd's death back in May. Once it reached social media, it spread violence and unrest. Although majority of the Black Lives Matter protests were peaceful, the small minority that were violent made all the difference.

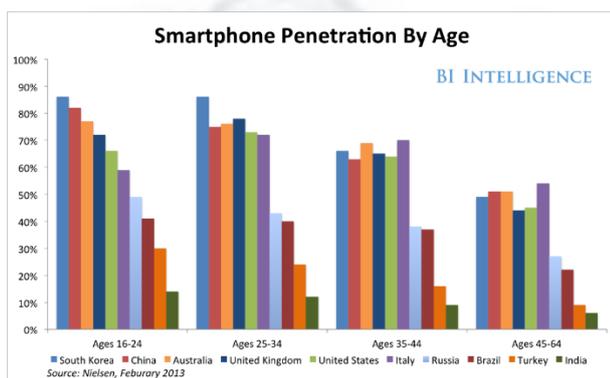


Figure 1: Age distribution (smart phones usage)

This bar chart above clearly explains that the younger age group are more attracted to their smartphones than older age groups.

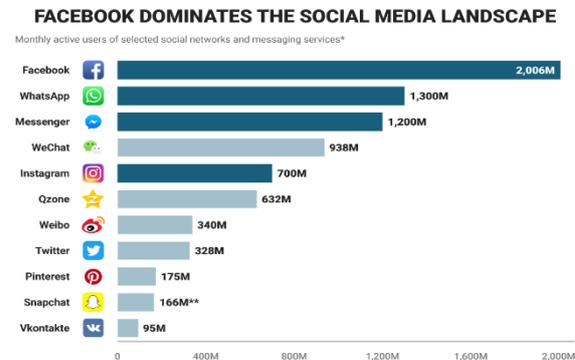


Figure 2: Most popular social media websites. In the above chart, Facebook holds a firm base as the most popular social media platform.

Social Media was invented for commercial as well as entertainment purposes. Do we use it for this reason though? I personally believe that social media could be used as a platform for conspiracy theories. Especially during the pandemic, these contentious ideas went through the roof. A particular bizarre theory was that 5G spreads coronavirus. Or even that COVID-19 is a hoax!

There are five ways of how these radical claims come to your Facebook page. A joker, a silly theory which starts as a joke, but then gets radicalized and people start believing it. A hacker, someone who spreads them to get money. A politician, who might spread it for their country's gain, for example Donald Trump saying China created the virus on purpose. A conspiracy theorist, who doesn't believe anything at all. They're the ones who linked 5G to coronavirus. Finally, an insider, a fake account of someone you think is trustworthy. An example of this would

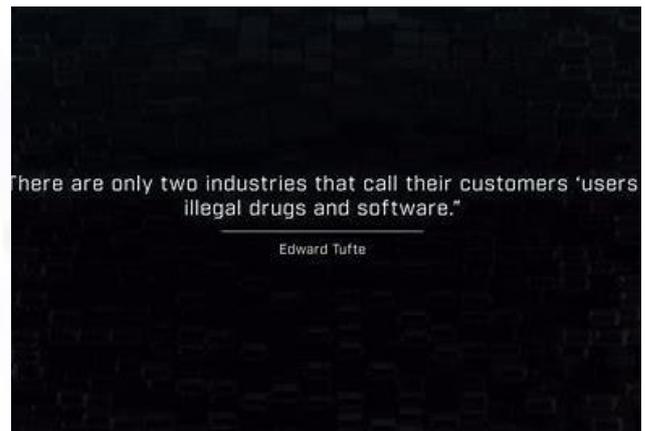
be when Trump took Hydroxychloroquine, a doctor on social media posted about the drug to say it was the only drug that could cure the coronavirus (which does not have any scientific evidence). So, next time someone on your WhatsApp group sends a funny but controversial meme, be careful what you share.

Social Media platforms are designed to addict you, and make you spend as long as possible on their own web creations. This gets them money from all the adverts they place on the website along with passing on our data for commercial purposes. In 2020, roughly **3.81 billion** people used social media. In fact, if these platforms weren't free, would we be so addicted? But it is free. So, we are not 'the customers. We are 'the product'. Our time and attention are being sold. Anything which comes free needs careful evaluation.



We're the product. Our attention is the product being sold to advertisers.

Figure 3: This shows that we are being used for financial gain.



There are only two industries that call their customers 'users' illegal drugs and software."
Edward Tufte

Figure 4: A comparison between drugs and software.

IS THE INTERNET REALLY HELPING TO SAVE THE PLANET?

During the lockdown period, lots of schools, colleges and offices have been doing online work. We presumed that this is good for the environment, as we had the opportunity to work from home. But how much energy does the internet, social media, Microsoft Teams or Zoom need so we can do our work?

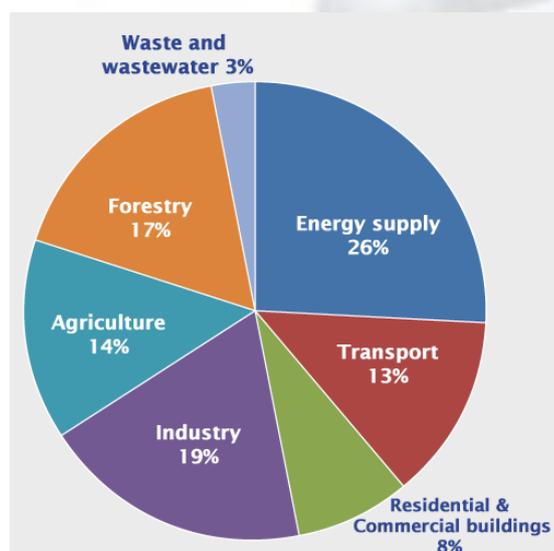
In fact, Information and Communications Technology amounts emits equal amounts of Greenhouse Gas Emissions as Aviation (2%). However, this was before COVID-19.

All the photos and videos and data we use on the internet are stored in database centres across the globe. Some people refer to this as 'the cloud'. There are supercomputers which consume lot of energy for this! As an example, just one rack of servers, hard drives and network cables take up the same amount of energy as to boil 15 kettles of water for a day! It is left for our imagination to extrapolate this to a supercomputer.

One such provider is Amazon, or AWS (Amazon Web Services). Only a third of Amazon's profits come from the shopping website. The rest is from AWS. In 2014,

AWS said they had a target for 100% renewable energy sources by 2030. From each year after their progress has been published in the public domain. In 2018, they said that they had exceeded 50%. In 2019 however, they didn't. When they finally did, they said the new figure was 42% rather than 50% but this time over the whole business.

A good way of being environmentally friendly while using the internet is, when you aren't watching the video, you can listen to a non-video-based application, like Spotify. This saves 90% of energy used on YouTube. This is one easy way you can help our planet. It requires a lot of education on a large scale to save data usage and energy consumption to make a substantial difference.



The figure on energy supply could be lowered if we didn't use our devices so much.

In conclusion, the internet was a new, weird and unreliable but amazing creation when it was first proposed to the people of the world. Now, internet and smartphone technology literally direct our life daily. These companies based in Silicon Valley, are just as powerful as governments. Just as

controversial, just as wealthy. However, more importantly, they're just as important. How would you feel if someone took away your access to Google? Or Amazon? We wouldn't last for a week. The world would be in chaos if that happened. So, you don't need to delete your social media account, but just not use it as much. I highly recommend you watching "**The Social Dilemma**" on Netflix. It explains what I have written above, but it gives you a bigger picture from the experts. The main characters are people who created things such as the like button, emoji's etc: but didn't agree with their companies on ethical issues like giving lots of notifications if the 'customer' wasn't using the respective platform. For more information about the internet and the environment, I recommend you watch '**Is Your Online Habit Killing the Planet?**' by Dispatches on Channel 4.

Thank you for reading and I hope you enjoyed doing so. Please take on board the salient points I have made, and if you like them please apply them in your daily practice to make a difference to the way we engage with social media.

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- Figure 4: The Social Dilemma Quotes - FABRIZIO TADISCO
- Figure 5: Global Emissions/Climate Change/ US EPA
- Netflix: The Social Dilemma
- Dispatches: Is Your Online Habit Killing the Planet?

I am sure you know of a great many stories that begin with the words ‘Once upon a time in a faraway kingdom...’ What if we changed those words slightly to something more like...

“Today, in this time, on a faraway planet...”

What would the story be like?

Would it be an action-packed thriller, with star troopers and light sabers?

Or a fairy tale kingdom with fairies and wizards?

Or maybe something a little closer to home, something not unlike the planet that we live on now... a sister planet, forgotten and desolate.

MARS

From the very beginning of the solar system, Mars and Earth in their embryonic stages were sisters. Around 4.5 billion years ago, our solar system was a chaotic vortex of gas and rock, which clumped together to make the early planets, Earth and Mars. Young Mars, named after the Ancient Roman god of war, was a water planet, with almost all its surface covered in seas and rivers - nothing like the desolate wastelands and deserts that we see today. Mars’ surface was rich and distinctly like the landscapes on Earth today, only with much less oxygen. While young Mars thrived, young Earth was what we would expect of Mars today - an inferno of an atmosphere, with acid seas and extreme temperatures, reaching over



200 degrees Celsius. However, a catastrophic event occurred in the history of Mars and Earth that caused the demise, and the birth of the two planets.

THE LATE HEAVY BOMBARDEMENT

The Late Heavy Bombardment, as it is called, was a particularly turbulent time in the history of the solar system. It is unclear what exactly caused it, however,

what we do know is that asteroids and meteors rained down like fire upon Mars and Earth, and Mars was hit badly during this time period. However, as we know, both planets survived, if not scarred and maimed from the experience.

Although the Late Heavy Bombardment was incredibly destructive, it had also primed both Earth and Mars with the perfect ingredients for life. While Earth had before been inhospitable and toxic, and Mars, the epitome of a perfect world, Earth had been ridden of its noxious atmosphere of carbon dioxide and was yet another water world, with oxygen and carbon dioxide balanced out in the right proportions. Earth was now the perfect place for microbes to form spontaneously as it had all the right conditions and ingredients.

HOWEVER

Mars, when it was born, had formed in a considerably less rocky area of the solar system and was therefore much, much smaller than Earth. This meant that its core cooled extremely quicker than Earth,

which caused its magnetic field to disappear. This meant that Mars' atmosphere could slowly be stripped away, leaving behind the red, barren expanses that we know today.

In 2011, the NASA Curiosity Mars rover was launched to explore Mars. It discovered that 2% of Martian soil still contained water - evidence of a long-lost water planet, akin to Earth. Could there still be potential for this lonely planet?

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The science of medicine has been around for centuries. Some of the very first documented medicine practitioners used herbal remedies, alongside animal parts to help heal patients who came to them. These practitioners were known as shamans, priests or even simply medicine men. Ancient Egypt were one of the very first document countries to begin practising medicine and a man called Imhotep was the first physician, dating back to the 3rd millennium BC. There are also some more European countries, such as Ancient Greece, who studied medicine very early on

For example, a physician from Ancient Greece named Hippocrates is called the 'father of modern medicine', and as such, had a large impact upon the future of medicine. His Hippocratic Oath was one of the first to categorise certain illnesses. Some of the oldest recorded versions of the Hippocratic Oath are kept in the Vatican. Nowadays, doctors still recite the Hippocratic Oath, which states that they will have respect for patient's confidentiality and try their best to keep their patients from harm. This is near the beginning of where ethics came into a large part of medicine and help alter how doctors, physicians acted in the future.

Today, ethics are constantly under examination and there are countless studies analysing how medicine is practised amongst doctors. There are four categories of Medical Ethics which help keep the practise of medicine safe and fair to all those it can and probably will help. The four pillars of Medical Ethics are:

- Autonomy- the patient always has the right to refuse procedures if they want to

- Beneficence- to always do good for the patient and act in the best interests of the patient
- Non-Maleficence- to never do harm towards our patients
- Justice- to treat all patients fairly and equally

The first pillar, Autonomy, is a very important aspect of medical ethics, as it helps the patient have some control over how they are treated. It also, crucially, helps stop paternalism, which is when the patient is completely overpowered by the physician, normally with good intentions. However, this can contradict patient's autonomy and does not allow the idea of informed consent to occur. Overall, it means that the patient has the right to choose what procedures they allow or disallow to happen to them. On the other hand, autonomy also concerns capacity, which is whether the patient is in the 'correct' mind to give autonomy. For example, if a patient has been struck to the head with a pole, it can be debated that the patient does not have the capacity to give autonomy, as they may have suffered a head injury, which restricts their decision making. This means that the doctor will have to look to the patient's family and see if any surgery or procedures can go ahead. Therefore, it shows how fundamental autonomy is to medical ethics and how doctors can perform procedures on patients.

The second pillar, Beneficence, is another key aspect to medicine because it shows that doctors and physicians must act in the best interests of the patient, in order to help them return to good health. This pillar of medical ethics does face some controversial views on the exact importance of it. For example, many scholars, such as Edmund Pellegrino, find beneficence to be the only aspect of medical ethics that *really*

matters. This suggests that some highly educated people find the other pillars of medical ethics to be irrelevant, in comparison with beneficence, as they find the true meaning behind being a doctor is to help heal patients and cosmetic procedures are against the code of ethics. To put the pillar of beneficence in a real-life example is difficult, as it is widely debated about what is truly the 'correct' procedure in different situations and circumstances because many doctors and scholars struggle to exactly describe which procedures help the healing process and which do not. Ultimately, the 2nd pillar of medical ethics, Beneficence, is also a crucial aspect of medicine as it helps direct which types of procedures the doctors should perform, as it must be in the best interests of the patient.

The third pillar, Non-Maleficence, is arguably the most difficult aspect to learn fully in medical ethics. The basis of non-maleficence is to not do harm to patients; however, it is best said in Latin:

'primum non nocere'

This phrase literally means *'first, do no harm'*, which has given the idea, that non-maleficence is the primary aspect of medical ethics. This is supported by the inclusion of non-maleficence in the Hippocratic Oath, the oath that states that the doctors will not do anything that may cause the patient to come to harm. For example, euthanasia is the practice of killing your patient intentionally, in order to end their suffering. Most doctors who practice euthanasia (in countries where it is legal like Canada or Belgium) find their work to do what is in the best interests of the patient, but this contradicts non-maleficence and how the doctor should do no harm to patients. However, in certain instances, when a doctor performs a procedure, he knows will impact the patient's life badly, but

continues with it due to the fact that if the treatment succeeds it will help the patient and also if left untreated the illness or condition may worsen and eventually be critical for the patient. This shows that when a risk in a treatment is taken, if it is balanced by beneficence (that the procedure will do more good than bad), then the procedure may go ahead. This is known as the Doctrine of Double Effect, or the combined effect of beneficence and non-maleficence, when a part of the treatment can have a bad effect in the patient, yet the beneficence of the treatment may be overwhelming, causing the treatment to proceed. Overall, the 3rd pillar of medical ethics, ties very much with beneficence and both help to do what is best for the patient, without harming them.

The fourth pillar, Justice, is the basic principle of equality and fairness within medicine and how doctors should treat all patients equally. However, a better word to use is 'equity' as it perfectly describes how patients should be treated fairly. Justice is a very complex ethical idea and consists of treating everyone fairly but also prioritising certain individuals based on who needs the help and assistance the most. Doctors, now, must analyse the costs and the benefits of treating one patient's needs over another's. This can be very stressful for a doctor and to assist them in this complex manner, they can turn to the GMC (General Medical Council), who can help with the problem-solving that is a part of the daily life of a doctor.

Ultimately, the four pillars are in no particular order, due to their equal importance within the world of medicine. Justice, Autonomy, Beneficence and Non-maleficence are all key to help training medics with their understanding of the ethical guidelines, which help keep doctors in check and aim to help provide

the best type of care and treatment for the wide variety of patients who enter the doors of a hospital, GP practice or any other medical building, looking for assistance for their problem.

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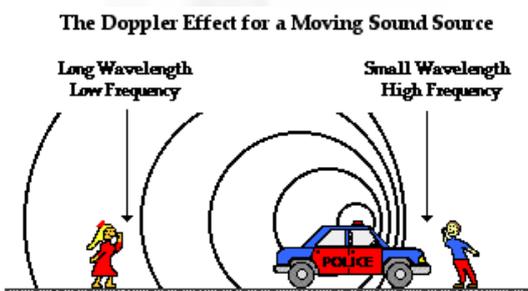
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In Physics, the concepts of relativity, proposed by Einstein, are the basis of explaining many occurrences in the universe. The Doppler Effect is a fundamental theory, applying to sound, light and other types of waves. Named after Christian Doppler, in 1842, the effect has since allowed physicists to explain other theories, such as The Big Bang Theory (a theory which explains the birth of the universe).

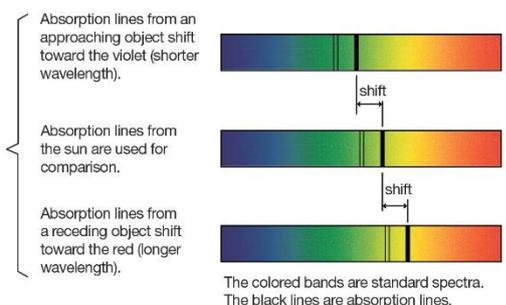
The Doppler Effect is a change in frequency (and therefore wavelength) of a wave, caused by a change in distance between the wave source and the observer. A common example of the effect is a police car, with sirens on, travelling past a person (in this instance, the observer remains stationary). As the police car travels towards the observer, the sound waves of the siren become more compressed (wavelength decreases), meaning the frequency of waves increases. This increase in frequency causes the observer to hear a higher-pitched sound (as frequency \propto pitch). Conversely, as the police car travels past and away from the observer, the sound becomes more and more lower pitched, as the sound waves become more stretched out, causing frequency to decrease. With the theory of relative motion, the same effect applies to when the observer remains stationary, and the source of sound is in motion.



Light waves and colour can also be explained by the Doppler Effect, in terms of redshift and blueshift (these principles lead us to explain The Big Bang Theory). As we know from the electromagnetic spectrum, within the visible-light waves category, white light is made up of 7 different colours: red; orange; yellow; green; blue; indigo; and violet. Red light waves have the largest wavelength (approximately 700 nanometres) and violet light waves have the shortest (approximately 400 nanometres). In relation to the Doppler Effect, when an object is moving away from us, the light waves become stretched (the wavelength increases), and therefore the light becomes redshifted (as it moves to the red end of the light spectrum). When an object is moving towards us, the wavelengths of the light decrease, and the light is therefore blueshifted (as it moves to the blue end of the spectrum).

The Doppler shift

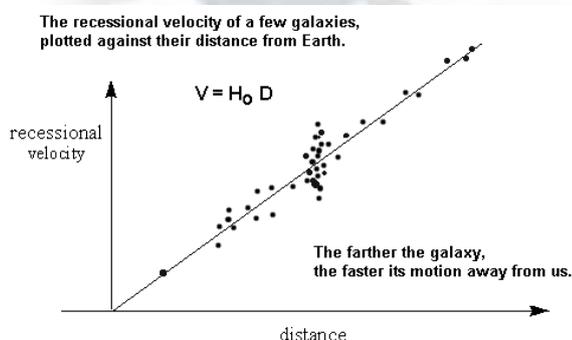
The amount of shift depends on the velocity of the object in relationship to the observer: the greater the velocity, the greater the shift.



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The redshift of any object in space can be observed and calculated using emission lines. Emission lines allow us to calculate the difference in observational wavelength compared to the rest wavelength (the wavelength of the lines if the object was not moving).

This theory of redshift enables physicists to prove the Big Bang Theory, in relation to the galaxies around us. Edwin Hubble, an American astronomer, published work in 1929, which explained redshift applicable to observations from our planet in relation to other galaxies. The work revealed that most of the galaxies observed from Earth are moving away from us, due to changes in their wavelength and redshift observations. From this, we can deduce that the universe is constantly expanding, and therefore that the Big Bang Theory is correct, as everything moves away from the original explosion which supposedly created the universe. Hubble's Law takes this further by proving that the further away the galaxy is from earth, the faster it is moving away from earth. The formula for this is $v = H_0 D$, where v is the recessional speed of the galaxy, H_0 is Hubble's constant (used for expressing the expansion of the universe), and D is the distance of the galaxy relative to earth. Hubble also proposed two fundamental concepts about the universe, as part of his 'cosmological principle'. It states that the universe is both homogenous (matter is spread across the universe in an even way, where the density of the universe does not change), and isotropic (the universe appears the same to an observer from any direction, i.e. it has no fixed limit).



On this graph, the slope of the line is equal to Hubble's Constant (H_0)

The Doppler Effect can also lead us into useful calculation, in which we can calculate the speeds of both the observer and the source, as well as the original and observed frequencies of the waves. The Doppler equation is $f' = ((v+v_0)/(v-v_s))f$, whereby f' is the observed frequency, f is the original source frequency, v is the wave speed, v_0 is the velocity of the observer and v_s is the velocity of the source. However, this equation is only applicable to sound waves; for light waves, or other wave on the electromagnetic spectrum, and to calculate redshift, the equation must be changed to become aligned with Lorentz' transformation. The new equation becomes $V_{\text{observed}} = V_{\text{source}} + \sqrt{1+B}/1-B$, where B is used to represent v/c (c =the speed of light). This equation links to Einstein's theories and equations for his velocity addition relationships.

Shock waves and sonic booms may also be described by the Doppler Effect. If an object is in motion faster than the speed of sound, the sound it creates is known as a sonic boom. This is due to the source always being ahead of the sound waves it propagates. The most common example of this is a fast aircraft flying, however the first man made object known to create a shock wave was a bullwhip. The sound has lots of energy, causing disturbance to human ears.

In conclusion, the Doppler Effect is a key theory in physics, linking to many other principles in relation to the relativity of space and time, and adds a scientific perspective to the ongoing debate about how the universe began.

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Picture 1: <https://www.physicsclassroom.com/Class/waves/u10l3d3.gif>

Picture 2: <https://cdn.britannica.com/49/97249-050-7C845926/Doppler-shift.jpg>

Picture 3: https://www.wvu.edu/planetarium/a101/101/hubbles_law.gif

Introduction

As COVID-19 still remains prominent in our lives, the question must be asked whether humanity is ready for another disease. Due to modern globalisation and our keen emphasis to return everything to normality in terms of economy, the handling of recent pandemic has not been the most successful with global cases exceeding 50 million and deaths exceeding 1.25 million. The hope of recovering by the end of year has faded away with many countries realising that a second lockdown is necessary. However, the most important thing is to learn from our mistakes since it will not be the last devastating pandemic we face and will prepare us for the forever forthcoming Disease X.

Brief History of Epidemiology

From the very first diseases known to humans to as recent as COVID-19, it is a fact that diseases live among us. However, from our frequent encounters with them, we have also learnt a lot about their strengths and weaknesses which consequently has affected everyone's day to day life. This involves the study of epidemiology - the research and analysis of diseases and their spread through a population - a backbone to our modern healthcare system.

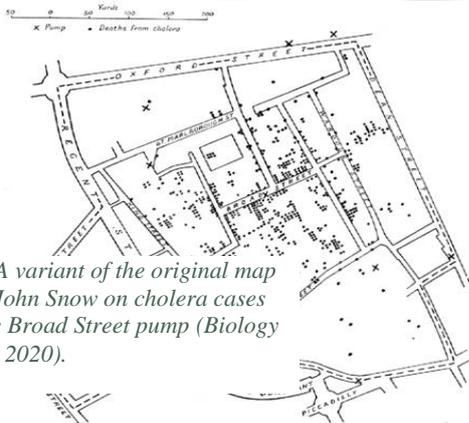


Figure 1: A variant of the original map drawn by John Snow on cholera cases around the Broad Street pump (Biology Libretexts, 2020).

It is often accepted that the start of modern epidemiology was in the 1854 with a physician called John Snow (Biology Libretexts, 2020). During that time, there was an outbreak of cholera in the Soho District of London and it was the third outbreak of cholera in 22 years. This area of London was well known for the large population paired with the poor sewage system to cause unhygienic living conditions. The outbreak of cholera was also not helped by the lack of information leading to the people often believing that it was an airborne disease and transmitted by bad smells from decomposing organic matter which Snow had argued against in 1949 (Begum, 2016). However, Snow investigated the outbreak with the help of Henry Whitehead and mapped out the locations of the deaths caused by cholera. He noticed that deaths were most common where people had access to the Broad Street Pump. This was enough evidence for the council to remove the pump handle which reduced the cases and transmission of cholera (Vandenbroucke, 2005). Further investigations of the cholera outbreak revealed that the water source of the Broad Street Pump had been contaminated by sewage from a nearby cesspit.

From the cholera outbreak, epidemiology has evolved and become an important part of the healthcare sector. Behind every disease, epidemiologists work on researching the disease from symptoms to treatments to prevent it spreading through a population. Epidemiology not only focuses on epidemics and pandemics but general public health as well such as how smoking tobacco led to lung cancer investigated by Richard Doll and Austin Bradford Hill (Biology Libretexts, 2020). With the recent COVID-19 pandemic, epidemiologists have been working

behind the scenes to help stop the virus spread and protect the health of the population.

What is Disease X?

In the future, there will be more pandemics, and some will be more deadly than the already serious COVID-19 pandemic. According to the WHO (World Health Organisation), Disease X is a placeholder name for a serious pathogen by the name of Pathogen X which is currently unknown to the human race but has the potential to cause a global pandemic. Disease X is currently on the list of priority disease along with other major diseases such as COVID-19, Ebola and MERS and the WHO believe that it is important to prepare for this disease by doing early research and development (World Health Organisation, 2018).

On the other hand, it can be argued that we will never finish discovering Disease X. Since there are over 1.67 million unknown viruses on this planet with 631,000 to 827,000 able to infect humans, it is very likely that we will never know every virus considering that scientists have only discovered 263 of these (Kessler, 2018). This means that there will always be a Disease X and the best we can do is learn from previous pandemics and improve on the way we handle them.

Possible Origins and Types of Disease X

The most likely type of pathogen which Disease X could be is a virus. Furthermore, it is also more likely that the virus will spread from an animal to a human making it a zoonotic virus and

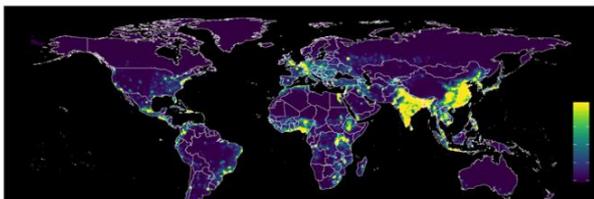


Figure 2: Map of global hotspots for diseases and where Disease X is most likely to originate (Kessler & Peterson, 2017).

examples being SARS, bird flu including H7N9 and to current knowledge COVID-19. Previous pandemics can also give an idea of where Disease X is most likely to originate from, with South East Asia, West and Central Africa and South America being the most probable places (Kessler & Peterson, 2017). These locations are all heavily forested areas with rainforests, like the Borneo Rainforest in South East Asia, the Congo Rainforest in Africa and the Amazon Rainforest in South America. This leads to a greater diversity of animals which could carry the disease and paired with the high population of some of these areas have led to urbanisation closer to the heavily forested areas. This increases the chance for zoonotic transmission through either direct transmission such as bites or stings to indirect transmission such as agriculture.

Another possible type of pathogen which Disease X could be is a bacterial infection. The world has an inevitable problem at its hands, and it involves antibiotic resistance. As the use of antibiotics increase in hospitals and prescriptions are more common, bacteria have become more resistant. This happens through the exchange of genetic material via plasmids and transposons and have rendered some common antibiotics such as penicillin useless or very ineffective in treating infections (Neu, 1992). Such example would be *Streptococcus pneumoniae* which is a serious disease that causes respiratory infections but has almost become completely drug resistant to older antibiotics. Although these types of bacteria are rare right now and only found in labs, it will become a much more prevailing issue in the future with more and more species of bacteria becoming drug resistant yet researching new drugs is still a slow process. This can

have a devastating effect on the public health of the population.

Finally, and possibly the most dangerous source of Disease X is that it could be a synthetic virus that is manmade. With labs studying diseases and epidemiology dotted around the world in multiple continents, it is not uncommon to find pathogens in there which are unknown to the general population of which includes diseases that have been developed and evolved for research purposes. One accidental mistake and they are exposed to the public can cause a pandemic which is very difficult to stop since we have almost no resistance to them. On the other hand, bioweapons could be another synthetic disease. Bioweapons are diseases which have been genetically engineered to kill humans and there would be very little we can do to cure them. In a case where a bioweapon is used accidentally, for war or as an act of terror, it would spread through the population rapidly killing millions of people. This would be the most dangerous type of Disease X and in the current situation of international relations, the use of one is not completely impossible.

Prevention, Treatments and the Future of Disease X

COVID-19 could be considered the first Disease X since many key components for the unknown disease were met by COVID-19. It also gave scientists a demonstration on how the world reacts. Globalisation was a key factor in the spread and starting from a single person in Wuhan, China, it has now become global. As the countries continue to evolve and become more interlinked with each other, globalisation is going to be the most significant cause of spread in future Disease X pandemics. The uncertainty of what Diseases X is concerning considering it can spread rapidly across the planet.

This is why the WHO has recommended for research and development of Disease X to start as soon as possible. With the backing of the Bill and Melinda Gates Foundation, key areas have been researched for prevention against a future Disease X (Simpson, et al., 2020). Such area that needs to be focused on is the clinical, preclinical and manufacturing stages of a vaccine. In the preclinical stage, accelerated research of the genome sequence is essential for a better understanding of the novel disease. This is where the Globe Virome Project visions to discover 71% of the 1.67 unknown viruses in 10 years with the expense of \$1.2 billion, a very insignificant number compared to what a pandemic could cost (Kessler, 2018). The clinical stage can also be improved by the efficient transfer and harmonisation of clinical trials across borders and the provision of more information available to all countries about the disease. Improvements to the manufacturing stage can be achieved by developing a method in which the vaccines can be manufactured and distributed quickly but also in large scales with no decrease in quality. The equality involved in sharing the vaccine around the world can also be more humanising with more focus on the hotspot of the disease and where people are at the most risk and not just by how wealthy or developed a country is.

Evidently, Disease X is a disease that we will continuously keep encountering in the future as the humans go through more pandemics. The likelihood that Disease X is a virus is high however, the chances of it being a synthetic pathogen or drug resistant bacteria cannot be disregarded. The research for Disease X must be a priority for our species to advance and become better at handling outbreaks. Though our current situation still means that COVID-19 is the main concern, countermeasures to Disease X

must be developed and accelerated to avoid a repetition of history. More investments made now in virology and diseases could save millions of lives. Once all the improvements in science are completed such as improved clinical trials and manufacturing, our success in handling Disease X will ultimately come down to politics and how we can work together as unified nations to stop a disease.

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I recently have taken an interest in researching a novel area of expertise: long COVID.

Severe Acute Respiratory Syndrome (SARS-CoV2) is a novel Coronavirus which has emerged and caused a global pandemic. SARS-CoV-2 is mainly transmitted through respiratory droplets and close personal contact (Barker-Davies et al, 2020). SARS-CoV2 belongs to the CoV β -species, alongside SARS, caused by SARS-CoV1 and Middle Eastern respiratory syndrome (MERS) in 2012, caused by MERS-CoV.

According to the Government Office for National Statistics, the number of deaths registered in England and Wales as of 30th October, was 10,887 (Office for National Statistics, 2020). The disease has had a significant impact on the population within the UK. It is anticipated that there will be immense pressure on routine medical and rehabilitation services for 12 months and beyond. This reflects the urgent need to determine the appropriate rehabilitation for SARS-CoV2 patients.

The disease predominantly affects the respiratory system; however, previous Coronavirus outbreaks have affected various other systems. This includes impaired pulmonary and physical function (Barker-Davies et al, 2020). It is therefore crucial that more extensive research be carried out, in order to determine the long-term pathophysiology of the disease.

The long-term pathophysiological effects on SARS-CoV2 survivors are becoming more apparent. It has been shown that

the exercise capacity and health status of

SARS-CoV1 survivors were significantly lower than those of a normal population (Barker-Davies et al, 2020). This is alarming, due to the genetic similarities between both coronavirus pathogens.

Recent studies have shown that there is an increased risk of post-viral or inflammatory myocarditis (Hopkins, 2020). Furthermore, another known complication is olfactory dysfunction, which results in a loss of smell (Hopkins, 2020). This emphasises the severity of complications experienced by SARS-CoV2 survivors. Furthermore, this indicates the long-term effects SARS-CoV2 has on the neurological functions of the body.

A recent study in China investigated the ocular findings of 38 patients who had tested positive for SARS-CoV2. They found 31.6% of their sample had ocular symptoms which aligned with conjunctivitis (Wu et al, 2020). This included conjunctival hyperemia, chemosis, epiphora, and increased secretions (Wu et al, 2020). It is unclear whether these signs became apparent immediately after onset or a few days after. A practitioner within the eye clinic could potentially be the first professional to see a SARS-CoV2 patient. This means ocular manifestations of SARS-CoV2 may aid a swift diagnosis and early intervention if required.

As I have a keen interest in Ophthalmology, I was fascinated to learn of SARS-CoV2 manifesting through the human eye. I am eager to continue reading further research to understand how SARS-CoV2 will impact the human body and how treatment plans in the NHS will adjust to the new findings.

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The legend of the vampire has existed for centuries, with different variations of the blood-sucking monster being represented in civilisations across the globe. There have been legends like the Ka of ancient Egypt, the Shtriga of Albania, the Tagalog Mandurugo and the Ramanga of Madagascar. Surely if such a similar monster was being represented across the globe could a vampire exist scientifically?

Certain specific characteristics of vampires vary between each legend; however certain features remain constant throughout most legends:

- The uncontrollable urge for blood, but no food nor water
- Red eyes
- Pale skin
- No need for sleep, but the vampire does remain stationary for large periods of time
- Active at night due to an aversion to sunlight
- No heartbeat
- No breathing

ARE VAMPIRES SCIENTIFICALLY POSSIBLE?

In short no, vampires could not scientifically exist. Despite this however there are definitely some logical parallels between the behaviour of the vampire and its features. For example, vampires are known to have an aversion to the sun (some burn and die in it, others simply prefer to wander around at night) and a consequence of this would be that your skin would get paler (another key feature of a vampire), as the body would no longer produce melanin to protect it

from the sun's rays. Another feature of vampires is that they do not breathe, showing that they require no oxygen and therefore no blood stream to transport it around the body, this would explain the lack of a heartbeat. It could even potentially explain the reason why some vampires do not age, as the by-products produced by oxygen in metabolism reactions age the human body. However, if there was no oxygen being used for respiration then the vampire would not be able to move.

WHERE COULD THESE IDEAS HAVE COME FROM?

There are many medical conditions that produce similar symptoms to a few of the characteristics of vampires, and as these conditions were misunderstood, people were quick to demonise them. Porphria is a blood condition that causes the skin to blister when exposed to sunlight, showing an aversion to sunlight; and the plague often left bleeding mouth lesions on the skin after a patient had recovered, this may have looked like they have drunk blood. Not to mention the noble people that thought that drinking the blood of young people would keep them youthful (famous blood-drinkers include Vlad the Impaler, Mercy Brown, Countess Elizabeth Bathory and Peter Blagojevich).

HOWEVER, IF, HYPOTHETICALLY, VAMPIRES COULD EXIST, WOULD THEY BE ABLE TO COEXIST WITH HUMANS?

Well, legend has it that a vampire needs to drink blood once every month and once it has drunk the blood of a human, that human is now a vampire. This would mean that the population of vampires would double every month. So therefore, for our planet of 7 billion people it would take a mere 33 months (just under 3 years) for the entire human population to

become vampires. In this calculation I have obviously neglected the birth rate as I believe the birth rate and the mortality rate would cancel each other out, even still the population would have to double to 14bn to last an extra month. This would then pose a problem for the vampire community as they would have no blood left to feed on.

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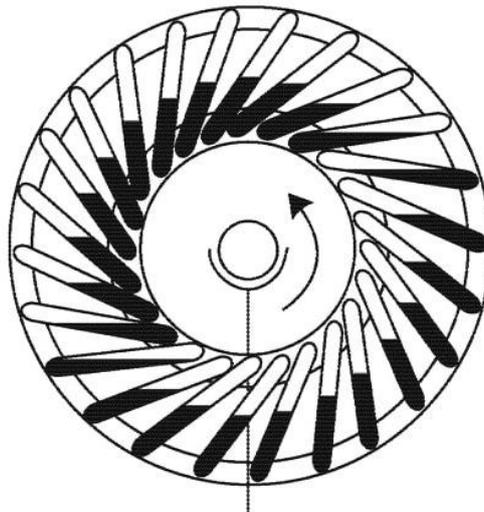
Perpetual Motion and Why it Never Works

Marek Zazulak

Firstly, perpetual motion is a motion that continues forever without any force exerted on an object which is technically possible. For example, throwing an object into space where in vacuum the object cannot be stopped by any force, so it carries on flying forever. But the perpetual motion we are looking for is the one that can be used in a machine of some sort that could possibly generate energy and be an endless source of it. One of the first attempts to create this machine was around 1159 A.D where mathematician called "Bhaskara the learned" sketched a design of a shifting-mass overbalanced wheel containing mercury which was designed to shift mass to the side causing the wheel to rotate and the angle of the curved spokes inside the wheel caused the fluid to move that side as the wheel was spinning which in theory causing endless spin. However, there is one main issue with it as if the mass is shifted to one side to make it move it will also shift the center of the mass which will cause wheel to spin back and forth and will stop at some point.

The other example of perpetual motion machine is a light bulb connected to the solar panels facing the bulb causing them to receive energy from light which is then converted into energy which powers it back and so on and so on... However, this idea is also not possible as it breaks one of fundamental laws of physics which is the first law of thermodynamics as it states that energy is always conserved, it

cannot be created or destroyed. This creates an issue as there is no 100% efficient light bulbs nor solar panels causing some of the energy losses through heat and slowly lowering amount of energy in the circuit till there is no more left and the machine stops instead of going on for ever as it was supposed to do. This also destroys the idea of endless energy source as there cannot be any



energy created so even if the circuit is 100% efficient then there will not be any leftover energy that can be used to power something else. One of the other machines worth mentioning was described in 1903 in philosophical magazine and called Strutt's radium clock. Here is how it

was described in 1920: "The core of the instrument is a particle of radium sulphate closed in a glass tube to which there are attached 2 gold plates, all of it then hangs down on an isolator inside bigger tube in which there is a vacuum. Radium constantly emits beta radiation with negative charge which leaves the particle of radium and gold plates with rising positive charge. In effect of it the gold plates start to repel each other until they get repelled so far that they touch sides of a tube which is connected to an electrical grounding. This cause electrostatic discharge and gold plates to fall back to their original place from which the whole cycle starts again". In "Scientific American" from 1905 we can find a mention of this instrument on which it says that its calculated that the radium clock can be active for 20000 years. In Polish book called "Rules of physics" from 1912 the same instrument

is described however on the neighboring page there is description of atomic decay theory which states “if any radioactive element such as uranium or radium was having perpetual source of radiation which also means energy it would violate one of the main rules of Physics as: body or circuit cannot give energy without any change or exhaust its own energy”. This statement can be used as a conclusion to the whole idea of perpetual motion machines as no energy can be created without loss of equal amount of energy somewhere else.

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Picture: A diagram of a perpetual motion machine, [Sandwheel.gif \(400×483\)](#) (wikimedia.org)

Climate Change is one of the biggest, if not the biggest, problem facing our generation and will continue to dramatically impact the lives of future generations, becoming increasingly more fatal. The term climate refers to the general weather conditions of a certain area over many years. Climate change refers to a notable change in general weather patterns- for example, areas becoming warmer, cooler, wetter. Global warming is just one aspect of this deadly phenomenon caused by human activity. Paleoclimatology data from natural sources like ice cores, tree rings, and ocean and lake sediments have allowed scientists to paint a picture of the world's climate in the past, including the drastic changes it went through in the past during the ice ages, and have used this data, in combination with data from weather stations and satellites to determine the changes our planet is going through.

The world's average temperature has already increased by a whole degree; while it may seem like an insignificant amount, small changes in temperature lead to vast changes in the climate; during the last ice age, the planet's average temperature was only a few degrees cooler than what it is today. Climate change has a huge impact on the world, including rising sea levels, extreme temperatures, and drastic weather phenomena, which could lead to the end of the human race in a few centuries if not dealt with- some of the most powerful hurricanes have destroyed hundreds and thousands of homes. Hurricane Katrina, one of the most powerful hurricanes in the history of the world, cost the US \$125 billion in damages and repair, and took the lives of no less than 1,833 innocent humans.

Hurricanes and Earthquakes have and always will be a problem on Earth, but the results of our pollution and damage prove fatal for hundreds and thousands of people each year. Land is disappearing under the rising levels of water, whilst the population continues to boom across the world, only adding to the ever-imminent danger of overpopulation. The Jurassic warming event that occurred 183 million years ago has recently been further investigated by scientists to better predict the consequences of the current phase of global warming the planet is going through. This event was caused by volcanoes releasing huge amounts of carbon dioxide into the atmosphere, leading to a rise of 4-7 degrees Celsius around the world. It has the same greenhouse effect that the world is currently going through; the excess carbon dioxide traps heat in the atmosphere which leads to the warming of the Earth. When solar radiation, some of this is reflected back into space; the rest is absorbed by land and the oceans, heating up the Earth. This heat radiates back towards space, but some is trapped by greenhouse gases like carbon dioxide, ensuring the Earth is warm enough to sustain life. However, the result of human activities like burning fossil fuels results in an increase of greenhouse gases in the air, subsequently enhancing the greenhouse effect, consequentially warming the Earth.

It is imperative that we act immediately, and although the world has seen a huge surge in climate activists like Greta Thunberg, it has also seen a concerning rise in the number of climate change deniers, mostly based in the United States; one of whom is President Trump himself. The effects of his outrageous and illogical rhetoric has had widespread effects across the US; although he has lost the election, the damage has been

done. According to a 2019 survey conducted by Yale, 31% Americans do not believe in climate change- a dangerously high statistic when combined with the fact that many who do believe in climate change don't believe it is the result of human activity when countless studies have proven otherwise. This has a huge impact on the rest of the world; the US is one of the largest contributors to global warming emissions and it emitted roughly a staggering 375 million tonnes of carbon dioxide in 2018.

The US recently pulled out of the Paris Agreement; a dangerous and destructive move regarding the future of our planet. The Paris Agreement agreed to keep the global temperature rise below 2 degrees Celsius. This, and other shocking policies regarding climate change the Trump administration

have put into place have only accelerated the warming of our planet in the last four years; more than 100 rules and regulations in the US surrounding climate change and pollutants have been rolled back or loosened. Mr Trump argues industries such as coal are vital for the American economy and keeping thousands of jobs; yet Mr Biden argues the world's richest economy can certainly afford to retrain and support these miners and affected communities whilst keeping in line with world carbon emissions goals. The effect of these have been hugely destructive, as in the last four years we have also crossed the threshold of no-return; now, many of the most devastating impacts of climate change, such as rising sea levels and temperatures, are irreversible. The

tremendous strain put onto future generations to cope with this problem is increasing day by day, and soon enough, they will not be able to cope with the impacts. At the current rate of growth in carbon dioxide, the levels will soon reach 500 parts per million, keeping the world on track to reach temperatures of more than 3 degrees- scientists say this kind of extreme rise in temperature would result in sea levels that endanger global food supplies, more extreme weather



phenomena, and could potentially destroy the Amazon rainforest, the world's largest carbon sink, through drought and fire.

Joe Biden's recent victory in the 2020 US election is a huge step forward in the fight for our planet- the US will hopefully re-enter the Paris Agreement, and many of Trump's disastrous rollbacks will be reversed. Mr Biden's policies, if not

retracted, will result in the US becoming a net zero emitter by 2050, in line with much of the rest of the world, including the UK. Many scientists argue however, that this is not enough- more needs to be done to prevent our planet spiralling into a well of disaster. Other countries like China, the world's largest carbon dioxide emitter, are also implementing progressive climate change policies and introducing a great number of solar and wind farms in an attempt to reduce its effect on world climate change, recently announcing they aim to reach net zero emissions by 2060. Despite many excellent policies put in place by world leaders, our planet and humanity itself is still under threat, and will continue to be unless change is executed.

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Photo: Picture of Earth from Space - Universe Today

It's no secret that the technological world as we know it has undergone dramatic and unprecedented alterations in the way we communicate and process information. Presently, with Google's claim of precisely conducting a chemical reaction simulation using a quantum computer in September of this year (Savage, 2020), we find ourselves in the same position which we were in at the first usage of the modern binary system in computers in the 20th Century: at the cusp of a revolution to the limits of the data and information we can use.

The evolution of quantum physics, based on quantum theory principals of matter and energy at a sub-atomic scale (Hurley, 2018), has provided the basis for a new branch of computing ('quantum computing'), which currently has the capacity to perform benchmarks which would take a modern computer over 10,000 years to perform (Arute *et al.*, 2019). While still in an early phase with both minor and major flaws, it spawns the possibility of advancements (such as potential medical applications) which have never been seen before.

The Quantum Computer's Origins

Quantum computing is a newer class of computer science which revolves around a different computational method to traditional binary systems. This new system's viability relies on its ability to simultaneously conduct multiple, complex operations and eliminate 'tunnel effect' of modern programming - where it is not limited by barriers which currently hinder binary systems.

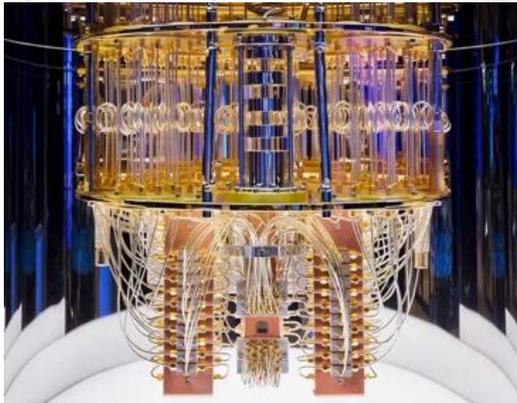
From *Cerebro* in Marvel's X-Men (1964) to Star Trek's *Duotronics*, the idea of a 'supercomputer' had long stirred the imagination of most avid sci-fi lovers, but only in the last 40 years has this dream stated to materialise. The mere

possibility of these powerful machines, millions of times faster than the technology of the time, was first floated by Paul Benioff in 1980, as he described the first 'quantum mechanical model', which explained that such a machine could theoretically be possible using quantum physics. (Lu, 2019)

Indeed, it was just science-fiction that brought itself to the forefront of the minds and mouths of the critics of Richard Feynman, a renowned physicist, in his famous 'Simulating Physics with Computers' lecture of 1981. He expressed the incredible potential that quantum science possessed, describing its ability to compute even the most intricate of quantities, saying: '*if you want to make a simulation of nature, you'd better make it quantum mechanical*' (Hidary, 2019)

In 1985, David Deutsch published the first grounded idea of a quantum machine, calling it a 'quantum Turing machine' after the British computer scientist Alan Turing. 7 years later, along with his partner Richard Jozsa, Deutsch proposed the first example of an algorithm which this theoretical machine would use, before Peter Shor's 'Shor algorithm' of 1994 perfected the algorithm to factor larger numbers much faster than the 'classical' computers of today. In 2001, a coalition team from IBM and Stanford University first implemented Shor's algorithm in the first ever quantum computer, and, along with Google, have since made major advancements in the efficiency of these machines. In October of 2019, Google announced that they had reached a point of 'quantum supremacy' - where they have solved a problem using a quantum computer which has been proven practically impossible for a standard computer to solve - in just 200 seconds. (Cossins, 2019)

A quantum computer at IBM

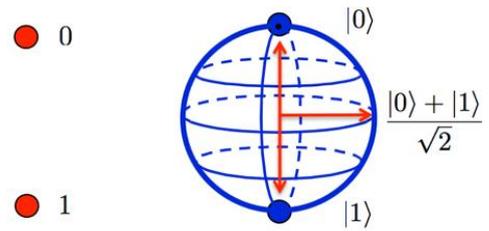


The Qubit

Quantum computers use the 'qubit' as opposed to the conventional 'bit' - which can only have a '0' or a '1' value - as the basis of each piece of information. Each qubit has the ability to hold one, both, none at all, or even multiple of different types of each input value. In different proportions, this allows a quantum computer with just 30 qubits to perform at a level which dwarfs that of modern systems.

The qubit's unique ability to take on multiple states is known as '*superposition*' - an ability which must be manually manipulated into each qubit by researchers using microwave beams. Another fascinating property of the 'qubit' is *entanglement* - two members of a pair of qubits mimicking the state of the other so that if one changes, the other changes with it. This is a property which can be achieved even at a long distance between the qubits. Incredibly, this phenomenon is known to have even completely baffled physicist Albert Einstein, who described it as a 'spooky action at a distance' yet holds the key to the quantum computer's speed. As a result of entanglement, adding more qubits to a quantum computer provides an increase of speed which is exponential (rather than the linear increase of 'classical' machines). (Giles, 2019)

Unfortunately, qubits in their current state do have limiting flaws, albeit ones



Classical Bit

Qubit

which have somewhat lessened in effect in recent years. The constant interaction of qubits with their environment causes them to eventually decay and sometimes disappear - known as *decoherence*. The most subtle vibrations or temperature changes can cause qubits to lose their state of 'superposition' - which is why they must be kept at supercooled temperatures (close to 'absolute zero' at approximately 273°C) while in vacuum chambers (Schmidt, 2019). As a result, quantum computers have only been used by large corporations (including IBM and Google) who access the machine remotely. However, this does not rule out the possibility of quantum computer remote access to the wider public as the technology gradually improves in the future.

Quantum Computer Applications

Due to the unique properties of qubits and the ability of a quantum computer to conduct calculations and searches efficiently and quickly, quantum computers can be used to determine the number of possibilities there are for a given event, regardless of the dizzying scale of some probabilities. Volkswagen's Chief Information Officer, Martin Hoffman, stated that quantum computers could at one point be used on a day-to-day basis (ICTReverse.com, 2020). This would be in the form of urban traffic prediction - up to 45 minutes in advance for drivers - which can eradicate traffic jams and thus drastically reduce motor accidents.

Similarly, the ability to calculate different probabilities can speed up the

learning process of Artificial Intelligence, which can be used in a range of industries from medicine to construction. As displayed by Google's quantum chemistry test in September 2020 (Savage, 2020), quantum computers can simulate chemical reactions which may be impossible to complete physically. This drastically improves the feasibility of more efficient pharmaceutical products produced using less chemicals. Fertiliser products are also something which can be chemically altered using the calculations of quantum computers, which would have profoundly positive impacts on the environment. Furthermore, Quantum computers can simulate actions in particle physics, which could catalyse the progress in developing a new form of renewable energy.

The ability to accurately create financial models is also on the cards using quantum computers. This could aid investors in deciding where to put their money and which stocks to keep or lose, shaping the economy of the world. Nearly 30% of the GDP of USA is in some form affected by weather, including food logistics, production etc. (Jackson, 2017) - another complication resolved by quantum computers. Quantum computers could accurately build climate models to predict the weather to an incredibly precise degree - which would also provide an earlier warning from natural disasters.

Only time will tell whether quantum computing will serve as the next step into the future - but even if it manages to achieve a fraction of the promise it currently holds, it is certain that it will provide substantial solutions to some of humankind's greatest problems.



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Picture 1: IBM
Picture 2: Zahid Hussain
Picture 3: www.zhinst.com

Marine life is one of the most important ecosystems in the world and revolves around plant and animal species that live in the sea or ocean. Nevertheless, it is also one of the most vulnerable ecosystems in the world as poor marine organisms ingest litter, are entangled by debris and choke to death. But, the Covid-19 pandemic is seeming to turn the tables as lower levels of air pollution and other greenhouse gases have been recorded. The Covid-19 outbreak as well as the lockdown measures seem to be providing our planet Earth with a chance to rest and rightly so. In fact, Sir David Attenborough, the naturalist and broadcaster, said: 'In times of crisis, the natural world is a source of both joy and solace...The natural world produces the comfort that can come from nothing else. And we are part of the natural world. If we damage the natural world, we damage ourselves.' [1]



The Eastern Pacific Leatherback turtle - an endangered species

According to a BBC article published on 4th April 2020, the Eastern Pacific leatherback turtle which is currently on the brink of extinction is expected to disappear within 60 years. [2] According to a group of conservation scientists and organisations including Fauna and Flora International (FFI), only ten years remain to save this endangered species. Alison Gunn, programme manager for the

Americas and the Caribbean at FFI commented: 'We have it within our power to protect these animals and enable them to thrive, but all those who have a hand in shaping their future need to work together to do so.' According to a report of a population model, targeting the correct conservation efforts and enforcing projects that are maintained efficiently are some of the ways in which the Eastern Pacific leatherback population can be revived and hopefully increased. Leatherback turtles are victims to many forms of threats such as habitat loss and they are also at risk of ingesting marine debris such as plastic and litter. Dr Peter Richardson, MCS Head of Ocean Recovery said: 'Pacific

leatherbacks will stand a better chance of avoiding extinction if we can reduce fishing bycatch and increase hatchling production on the beaches.' [3] The key interventions outlined in the BBC article

include 1) Ensuring that the deaths of 200-260 leatherbacks caused annually by 'bycatch' of turtles is avoided. ('Bycatch' refers to the unwanted marine creatures that are captured in fishing nets, where the fisher actually intended to trap another species); 2) Intending to produce 7,000-8,000 more hatchlings annually by improving the nest protection as well as incubation conditions. So, in short, the approach adopted by marine specialists is to initially reduce the death rate of leatherbacks and then attempt to increase the birth rate. However, rebuilding marine life is definitely a challenge for humanity as many factors such as climate change and levels of pollution need to be mitigated.

Description of the Eastern Pacific leatherback turtles

Did you know that leatherback turtles can weigh up to 2,200 pounds? Fascinating, right? In fact, the leatherback turtle is the largest turtle in the world. Before the number of leatherbacks started declining, they were widespread in every ocean except the Arctic and Antarctic. The leatherback turtles are the only species of the sea turtle that don't have a hard shell and are therefore named after their sturdy, rubbery skin. [4] Since the 1980s, the population of leatherbacks in the Eastern Pacific has plummeted by an astonishing percentage of more than 90 and therefore it is enlisted as 'Critically Endangered' on the IUCN (International Union for Conservation of Nature's) Red List of Threatened Species. [5] The IUCN Red List provides an inclusive outlook on the global conservation status of various species and therefore is an indicator for the plight of the vast biodiversity in the world. In addition, the Endangered Species Act protects many adorable animals as well as valuable marine life.



Marine life can recover by 2050 if we act now

With the world's fishing fleets restricted, marine life has been given the amazing opportunity to recuperate. Oceans, covering 70% of the Earth's surface, are indispensable to the world. In fact, they

entail innumerable benefits. For instance: the ocean produces over half of the world's oxygen and the ocean transports heat from the equator to the poles, regulating the climate as well as weather patterns. Oceans are also helpful in the field of medicine as many medical products originate from the ocean, including various ingredients that aid in tackling health problems like heart disease. The oceans have been in trouble for quite some time. With issues such as increased temperatures and acidity, widespread coral bleaching has been caused, especially in Australia's Great Barrier Reef. Therefore, the world's oceans are at risk of being deprived of the rich and incredible wildlife. Urging people to consider upon their actions, Carlos Duarte, professor of marine science, said; 'We have a narrow window of opportunity to deliver a healthy ocean to our grandchildren's generation, and we have the knowledge and tools to do so.' [6]

Human influences on the ecosystem

As we are all aware, humans all over the world constantly take resources from the biosphere. Global ecosystems supply water, food, clothing, medicines and construction materials, to name but a few, for a population of 7.8 billion people. Biological resources are progressively being depleted due to two major reasons: 1) the increase in human population and 2) humans exhausting more resources than required for survival. In addition, the Earth's climate is changing. Global temperatures are increasing. Although, the world's climate has altered regularly over time, evident from the fossil records which show how often the world has undergone ice ages and periods of desertification, never has the world experienced such fast and immediate climate changes. In fact, there is a growing body of evidence that climate change is a result of human activity and therefore this topic is of

deep concern and reflection. Nonetheless, a prompt response of the Covid-19 pandemic on the Earth, with the whirr of traffic becoming less resounding, has led to reduced levels of global carbon dioxide emissions. Particulates in the air can cause a plethora of problems, because if they are inhaled, then it is possible for them to get stuck in the lungs and cause severe damage, for instance: respiratory problems in the long-term. Furthermore, particulates are also detrimental for the environment as they help to reflect sunlight back into space which means that less light reaches the Earth resulting in global dimming. Reduction in levels of air pollution can bring a vast number of health benefits for all around the world. For instance: crops can get a better chance of growth as pollution inhibits plant growth and the spread of Covid-19 can be lessened as high levels of air pollution aggravate the viral uptake. So, with lower levels of air pollution, the air will no longer inflame and hopefully be more beneficial than before. In fact, the World Health Organisation (WHO) has started researching the impact that airborne pollution particles have on the spread of coronavirus and whether the presence of pollution makes the disease more baneful. [7] In conclusion, the harsh realities of this pandemic can be used as a glorious opportunity to revive the marine life and protect species. The reduction in air and noise pollution have already provided great silver linings in this pandemic and therefore protecting marine life will be just like the icing on the cake. I would like to end on a quote by Lauren Myracle, an American writer: 'You will love the ocean. It makes you feel small, but not in a bad way. Small because you realise you're part of something bigger.' [8] So, let's all look forward to celebrating clean beaches and fresh sea air for both humans and marine life.

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Picture 1: Leatherback turtle, Owen Humphreys
Picture 2: Reinhard Dirscherl, Ullstein Bild, Getty Images

Facial Transplants - The most innovative achievement of reconstructive surgery

Erfun Sephideh

The reconstruction of facial defects and deformities caused by trauma, burns and surgical removals of tumours have always been a great challenge for surgeons. The head and neck regions are an extremely complex anatomy while at the same time providing essential functions which decisively contribute to each patients' quality of life; therefore, an exceptional amount of care and dexterity is needed to deal with this area. Ideally, surgical intervention should result in aesthetically satisfying results as the face contributes to each patients' identity formation and as this part of the body is always exposed, the basis of social interaction.

Conventional reconstructive procedures such as free flap transfers (a procedure in which tissue and its blood supply are surgically removed from one part of the body i.e. the leg and transferred to another area of the body) do not comply with these aesthetic requirements when there is a case of extensive damage or loss of greater parts of the face, such as cases where the face has experienced sharp force laceration from heavy machinery. And so innovative therapeutic strategies had to be developed as an answer; here face transplants emerged as a viable alternative.

Facial transplantation is part of the "vascularized composite tissue allotransplantation" concept referring to all non-organ transplants and combining bone, tendons, muscles, nerves and skin. It couples the principles of microsurgical reconstruction with those of human organ transplantation and has opened new possibilities in the reconstruction of severely disfigured patients.

The first facial transplant ever was successfully performed in November 2005 on Isabelle Dinoire after being severely facially mutilated by an attack by an attack from her own dog. It was a success and since 40 have been carried out with a 90% post-transplant survival rate and no surgical failures.

The main characteristics of the first 5 face transplantations are as shown:

11/2005	Devauchelle Amiens, France	F, 38	46	Animal attack	Partial myocutaneous
04/2006	Guo Xian, China	*M, 30	25	Animal attack	Partial osteomyocutaneous
01/2007	Lantieri Paris, France	M, 29	65	NF 1	Partial myocutaneous
12/2008	Siemionow Cleveland, USA	F, 45	44	Gunshot injury	Partial osteomyocutaneous
03/2009	Lantieri Paris, France	M, 27	43	Gunshot injury	Partial osteomyocutaneous

Further causes of injury include burns, radiotherapy side effects, and crush trauma.

Recipient and Donor Selection

To date, only patients with extensive tissue damage resistant to conventional reconstruction procedures have been included. Moreover Lantieri (the lead surgeon in the first three full face

transplants) considered only defects that included the full destruction of orbicularis oris and orbicularis oculi muscles to be without a prospect

of reconstruction by other means. The team in Boston only included patients with defects comprising above 25% of the facial area and/or loss of one of the central facial parts.

In other words, facial transplants are only carried out when they are absolutely



Figure 3 - Orbicularis oris displayed in green

necessary, and no other form of surgery can be applied to the situation.

In order to find the optimal candidates for face transplants, Siemionow et al. developed a preliminary assessment tool called the FACES score. Patients were excluded in cases of significant medical comorbidities, missing guarantee for a post-transplant follow up, high risk of recurrent cancer for immunosuppression, and pregnancy. These protocols allow only psychologically and immunologically stable patients as potential recipients. Before going into the relevant transplant programs, all recipients had undergone various surgeries for reconstruction, all with poor functional and aesthetic outcome.

Most facial allografts are harvested from brain-dead heart beating donors. After it is harvested, the face of the donor is restored via construction of painted resin masks, following ethical guidelines and 'psychological burden of the donors' families.'

Risks and Benefits

Benefits

Improved functionality

Face transplant surgery can restore the physical functionality of a human face, "including the ability to breathe, speak, swallow, smile and show other emotions."

Restoration of appearance

A face transplant's ability to restore a "near-normal facial appearance" can help patients to regain the confidence to return to their former lifestyles and engage in their previous employments and social activities."

Less pain and discomfort

Face transplant surgery is one large procedure, whereas conventional face reconstruction (e.g free flap surgery as previously mentioned) involves many

surgeries and many recoveries; "face transplant surgery does not involve any other surgical sites on the body where the patient's own skin is removed for use on the face."

Risks

Rejection

Although it has not happened yet as of November 2020, there is a possibility that the immune system of a patient who has undergone the transplant will reject the new face. If this occurs, the facial transplant will have to be removed and alternatives must be discussed; either another face transplant at a later date or other forms of conventional face reconstruction must be carried out.

Effects on mental health and identity

As the face plays a substantial role in one's personal identity, there is the concern that patients will not identify with their new face and will feel distressed. However, studies by the Brigham and Women's Hospital have shown that "the donor's appearance is not transferred to the recipient and the recipient is typically recognisable immediately following the surgery," and assuring that the recognition will continue to improve as the face heals.

Drug side-effects

The immunosuppressant medications used to help prevent rejection of donated face tissue, or any type of transplanted tissue or organ, increase a patient's risk for developing infections, diabetes and certain types of cancer, including cancer of the skin and lymph glands and cervix cancer in women. Moreover, they have a negative impact on kidney function, with a small number of transplant patients requiring dialysis due to renal failure (around 10%). These medications will have to be taken for a lifetime.

Facial transplant success stories



Andy Sandness [above] suffered severe facial damage after a failed suicide attempt by gun leaving him severely deformed.

Here he underwent a 56-hour marathon surgery where his face was rebuilt from the eyes down. The donor was a man who had committed suicide.

Richard Norris was 22 when he shot



himself in the face in an accident in his family living room. The gunshot blew off his nose, cheekbones, lips, tongue, teeth, jaw and chin. Ashamed of his appearance, he became a 'hermit,' living for nearly a decade in an rural area with his parents, isolating himself from society. After a full-face transplant in March 2012 by a Baltimore team of surgeons, his face was fully transformed. Rodriguez (the lead surgeon) dissected the disfigured face down to the skull, attaching the new face midway back on Richard's scalp and stabilising it with screws, then finally 'draping the skin and sewing it down like a patch on a coat or a pair of jeans.' This transplant was a huge medical milestone as it yielded such great aesthetic results while being one of the first full-face transplants.

Overall

Overall, face transplantation demonstrates the sheer wonders and ability of modern medicine and the dexterity and skill of modern surgeons- to the point where they are able to remove a face from a skull and reattach a new one, and with it offering new possibilities in the reconstruction of severely disfigured patients.

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At the start of the pandemic in March 2020, Covid-19 was considered a binary disease; either severe enough requiring hospital admission or a mild respiratory illness from which most people would be expected to recover fully within two weeks. Increasingly, however, there is mounting evidence of hundreds of thousands of people left suffering with debilitating symptoms for months after becoming infected with Covid-19. Many people around the world have described a wide range of life changing experiences with devastating effects.

What is long Covid?

Although until recently there was no formal diagnostic medical term for these persisting symptoms, the phrase Long Covid has been used by sufferers to collectively describe their ongoing experience of Covid-19 infection beyond the World Health Organisation's definition. At the end of October 2020, the National Institute for Health and Care Excellence (NICE) along with the Scottish Intercollegiate Guidelines Network (SIGN) and the Royal College of General Practice (RCGP) jointly published an official definition and introduced the term Post Covid-19 Syndrome to include signs and symptoms which develop following an infection consistent with Covid-19 and continue for more than 12 weeks.

Symptoms of Long Covid

A vast spectrum of symptoms have been described by sufferers of long Covid, including breathlessness, severe fatigue, muscle and joint pains, chest pain, memory loss, cognitive difficulties, skin rashes, headaches, diarrhoea, insomnia, protracted loss of smell, clotting disorders, and mental health problems. NICE recognises there is growing evidence Covid-19 is a complex disease

which can affect any body system. The National Institute for Health and Research (NIHR) report also found evidence of fluctuating symptoms and pathology involving multiple organs from the brain (encephalitis, cognitive disorders), heart (myocarditis, arrhythmias, heart failure, blood clots), respiratory (pneumonia, pulmonary fibrosis), gastrointestinal system, inflammatory disorders, as well as kidney and liver dysfunction.

Symptoms often arise in one physiological system then abate, only for other symptoms to arise in a different system. The results of a survey of long Covid support group members found 70% experienced fluctuations in the type of symptoms, and 89% in the intensity of their symptoms. Many sufferers describe a rollercoaster of cyclical remitting and relapsing symptoms, often exacerbated by even small amounts of physical or mental exertion. There are many harrowing accounts and heart-breaking stories in the media of young previously healthy individuals whose lives have been devastated by long Covid over the last eight months. Marathon runners and triathlon competitors describe how they now struggle to walk a few yards or carry out simple daily tasks, whilst doctors and health care workers are unable to return to work.

How many people are suffering from Long Covid?

NIHR report suggests that one in three people have not fully recovered several weeks after initial illness whilst a substantial proportion have symptoms persisting for months. Public Health England (PHE) found that around 10% of people with Covid-19, who were not admitted to hospital, had reported symptoms lasting more than four weeks, whilst other studies estimate as many as 35% may be affected. In September, the

Covid symptom study by Kings College London reported up to 60,000 people in the UK were suffering from long Covid for more than three months. Recently another study reviewed data from the Zoe Covid Symptom Study app which now has over 4 million regular contributors and found long Covid affects 10% of 18 to 49 year olds who become infected with Covid-19. The study estimated one in seven are ill for at least 4 weeks and one in 20 for at least 8 weeks whilst one in 45 continue to be affected for at least 3 months. However social support groups including the Long Covid SOS group estimate numbers are likely to be much higher with up to 500 000 people in the UK currently suffering with long Covid.

Many people still struggling with symptoms of long Covid since March did not have access to Covid testing at the time, as tests were restricted for hospital inpatients



early in the pandemic.

A number of small surveys are reporting remarkably similar findings which highlight much larger numbers are affected by long Covid. An observational cohort study in the Lancet reported 78% of patients had abnormal findings on cardiovascular MRI ten weeks after initial infection and 36% still reported continuing symptoms.

A separate study by Coverscan reported in the BMJ, found 70 % of young low risk patients, with persisting symptoms had damage to multiple organs four months after initially becoming infected. The same pattern has been seen elsewhere in the world. The Journal of the American Medical Association,

reported that researchers from Italy found 87% of discharged patients were still experiencing at least one symptom 60 days after first becoming unwell whilst 55% had three or more symptoms. Similarly a survey conducted by the British Medical Association (BMA) found a third of doctors have treated patients with long term Covid-19 symptoms, highlighting the high prevalence of long Covid in the community.

Who is most at risk?

The NHIC reported ongoing Covid-19 symptoms can be experienced by all age groups, from the youngest children to the oldest people, and people from all backgrounds. They concluded those groups who are at low risk of life

threatening disease and death during acute infections are not at low risk of living with Covid-19 long term. Research at King's College London using the Covid symptom app data found certain characteristics including being female, excess weight and asthma raised the risk, as well as having

more than five different symptoms in the first week of infection.

People from all professions have been affected with long Covid, including many doctors and healthcare workers. The British Medical Association (BMA) is therefore now considering long Covid as an occupational health issue.

Causes

Covid19 is still a relatively new disease and it is unclear why some people's recovery is prolonged. The NIHR Report suggests that people still suffering debilitating symptoms after seven months may be experiencing a mixture of four different syndromes simultaneously including: post-viral fatigue, post-intensive care syndrome, permanent

organ damage and long-term Covid syndrome. Other theories suggested by Greenhalgh et al in a recent article published in the British Medical Journal, include possible persistent viraemia due to a weak antibody response, inflammatory relapses, reinfection, auto-immune reactions, and deconditioning, as well as mental health factors which may all contribute.

Management

Scientists are currently struggling to find a cure for long Covid as there are so many differing symptoms, and Covid-19 is still in its infancy. A growing number of health professionals are calling for long Covid to be officially recognised and supported. In early October, the UK government responded by announcing a £10m investment to fund long Covid-19 rehabilitation clinics across England to help those suffering with the long-term effects of the virus. Recently the government announced plans to establish 40 long Covid clinics across England. The government has also provided £8.4m in funding for the Phosp-Covid study, a UK-wide consortium led by researchers at the University of Leicester, to investigate the long-term health outcomes of the disease. Around 10,000 patients are expected to take part in this study, which is the largest in the world and encompasses many medical disciplines reflecting the range of symptoms seen in long Covid patients. NICE and SIGN have announced they will work with the Royal College of General Practitioners (RCGP) to develop guidelines for clinicians on how to manage the persistent effects of Long Covid. In October 2020 Greenhalgh et al published guidance for management of Post-acute covid-19 in primary care, including identifying serious sequelae and adapting a holistic approach to rehabilitation.

Meanwhile many suffering from long Covid are relying on peer support through social media channels including Facebook and Slack.

Impact of long Covid

Long Covid symptoms can occur even after an initial mild acute illness and many of those affected were previously physically fit, healthy young people. Experts now warn long Covid could become an even greater global health issue than deaths caused by the disease, with many suffering crippling symptoms since the pandemic first began and still not knowing if they will ever fully recover.

As we enter the second wave of Covid-19, and the number of infections vastly rises again, the number of people suffering with the debilitating symptoms of long Covid are also likely to increase further. Many more people are likely to suffer months of debilitating symptoms and face uncertainty about ever returning to good health. Many affected by long Covid are young people of working age who will be unable to work, which will also have a substantial impact on the economy as well as increase the need for NHS resources.

The concept of herd immunity would also be inconceivable given the risk of developing crippling, life changing symptoms of long Covid after an acute infection.

Conclusion

Covid-19 does not only cause severe acute illness in older people and those with underlying health problems, but long Covid can also have debilitating long term effects in young healthy people too, including those of our parents' age, teachers and older students in the school. The misery and life changing effects caused by long Covid starkly highlights the importance of abiding by the rules and doing everything we possibly can to prevent the spread of Covid-19 within our school and amongst

our loved ones, to avoid any further families being devastated by long Covid.

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