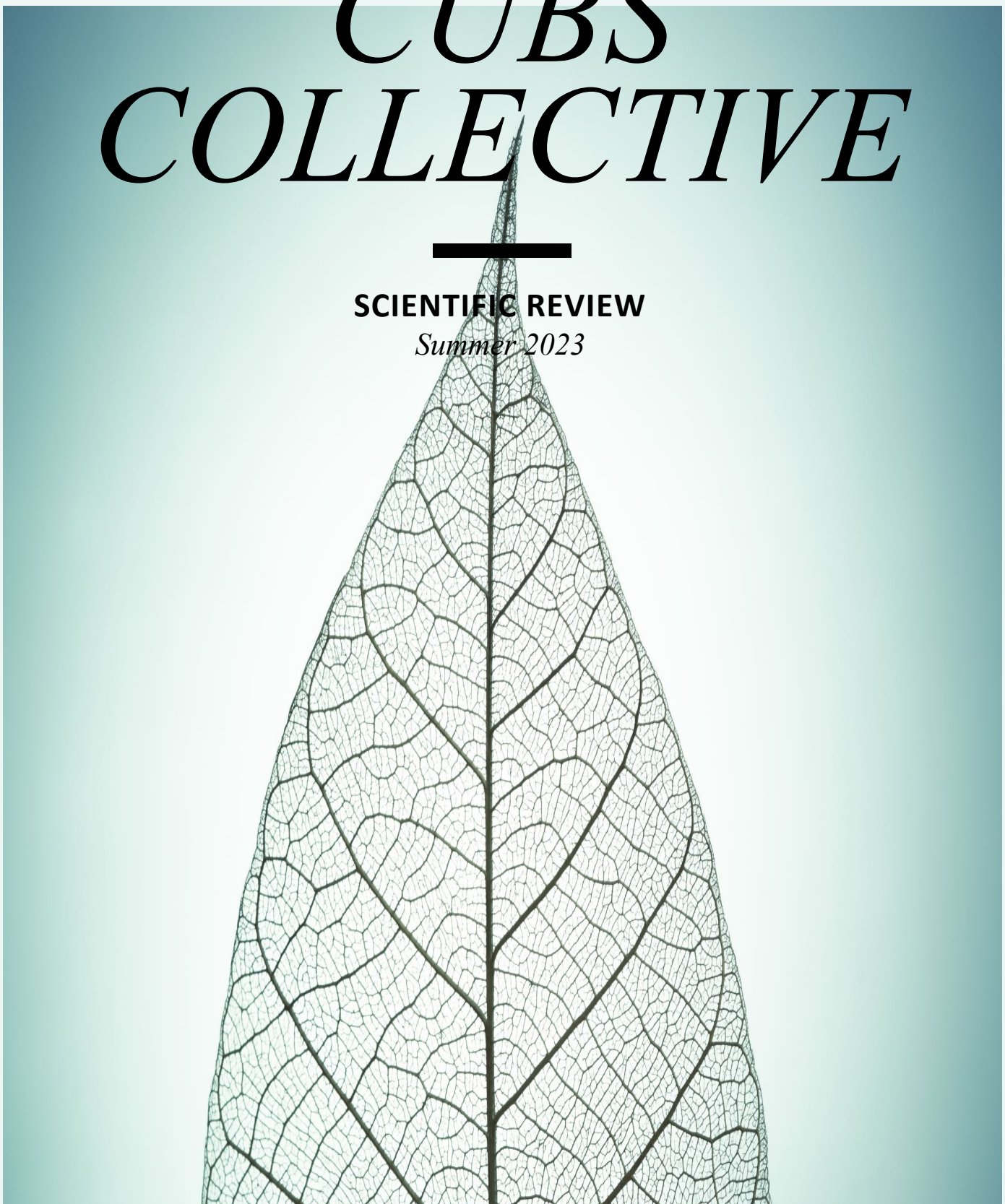
ROARING CUBS COLLECTIVE

SCIENTIFIC REVIEW

Summer 2023



LETTER FROM THE EDITOR
Pranay Talla

Dear Readers,

I am thrilled to present to you the first issue of the *Roaring Cubs Collective Scientific Review*, a product of six weeks of hard work by the bright and ambitious high school and middle school students participating in our STEM Research Scholars Program.

Over the course of the program, students engaged with a contemporary research topic of personal interest, learning how to use their personal backgrounds and experiences to motivate their research endeavors. They learned how to read primary scientific literature, write review articles, and deliver presentations on their findings, all under the personalized guidance of their mentors. It was inspiring to see their growth as student researchers over the course of their individual meetings with mentors, group seminar sessions, and finally at the symposium. Students from many different parts of the world worked with mentors and each other over our networking sessions to seek advice on how to overcome personal challenges and help each other reach the shared goal of breaking into the world of academic research.

The topics covered in this issue range from the use of robotics in rehabilitation therapy to mechanisms behind tooth pain, highlighting the diversity of research interests that have been fostered through our program. The strong recurring focus on the lingering effects of the COVID-19 pandemic, advancements in our understanding and ability to respond to environmental change, and the ethics of various applications of AI all point towards our students' passion to address the most consequential challenges facing our society. Several explorations of unique, interdisciplinary methods to study and treat chronic disease highlight students' curiosity and creativity.

I would like to extend my gratitude to our Columbia undergraduate mentors for their eagerness to support our students during this summer cohort, and I look forward to continuing to support our young scientists as they apply the skills and connections that they learned this summer to their future scientific research endeavors.

Sincerely,

Pranay Talla

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Review of CRISPR-Cas9

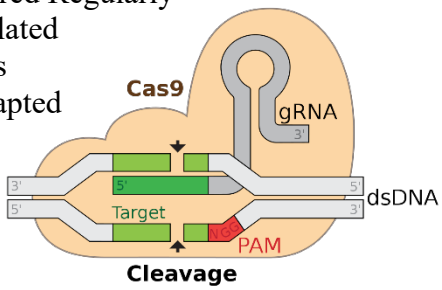
Aadi Mahajan

Section 1: Introduction

CRISPR-Cas9, a game-evolving quality altering device found in 2012, is a colossal leap forward in biomedical exploration with groundbreaking prospects in illness therapy. This study researches the presence of CRISPR-Cas9 and its possible purposes in the treatment of various diseases. From hereditary issues to infectious diseases and malignant growth medicines, CRISPR-Cas9 can change medication and improve the lives of countless individuals worldwide. Beyond its current applications, the scientific community envisions broader possibilities for this tool, as yet unexplored, in treating other diseases. As we delve into the versatility and potential of CRISPR-Cas9, it is essential to understand the underlying mechanisms that make it an extraordinary and precise gene-editing tool.

Section 2: CRISPR-Cas9: The Molecular Machinery

At the center of CRISPR-Cas9 lies the revelation of Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR) and CRISPR-related protein 9 (Cas9). Initially observed as a bacterial immune system's adaptive defense against viral infections, scientists ingeniously adapted this system for gene editing in various organisms, including humans. The CRISPR-Cas9 complex functions as "molecular scissors," guided by a single guide RNA (sgRNA) to specific locations within the genome, where it makes precise cuts in the DNA. These cuts can then lead to targeted gene removal or modification, unlocking unprecedented opportunities for therapeutic interventions in diseases with a genetic basis.



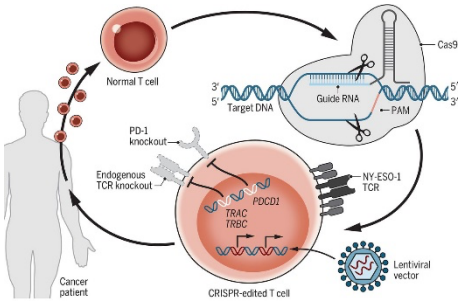
Section 3: Solving Genetic Disorders

One of the most promising applications of CRISPR-Cas9 lies in the realm of genetic disorders caused by single-gene mutations. In conditions like cystic fibrosis, sickle cell anemia, and muscular dystrophy, a specific gene mutation is responsible for disease manifestation. CRISPR-Cas9's ability to edit these faulty genes offers hope for effective treatments and potential cures. Scientists can introduce CRISPR-Cas9 into the cells carrying the defective gene, enabling precise modifications that correct the mutation and restore normal gene function. While this approach shows incredible promise, researchers continue to refine the technology to ensure its safety, accuracy, and long-term effectiveness.

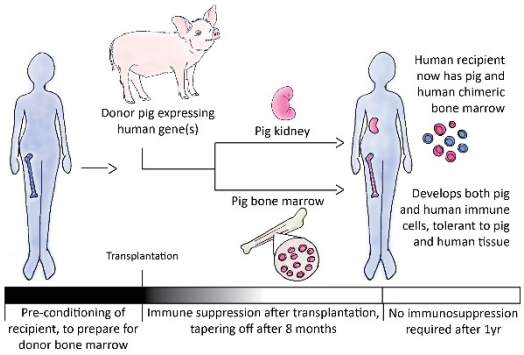
Section 4: Combating Infectious Diseases

Infectious diseases pose significant challenges to global health, and CRISPR-Cas9 offers new perspectives in the fight against viral infections. By targeting the DNA of viruses like HIV, herpes, and hepatitis B, CRISPR-Cas9 can disrupt their replication, potentially inhibiting their ability to cause harm. Furthermore, researchers explore the possibility of utilizing CRISPR-Cas9 in gene therapy for viral infections. In this approach, cells are engineered to be resistant to viral invasion by editing specific genes related to viral entry and replication, offering a new frontier in antiviral therapies.

Section 5: Precision Cancer Therapies



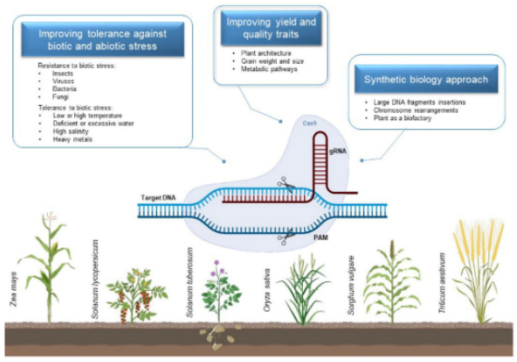
Cancer growth remains one of the most difficult illnesses to treat, however CRISPR-Cas9 offers another way to deal with addressing the intricacy of dangerous cells. By focusing on oncogenes (genes promoting cancer growth) or tumor suppressor genes (genes inhibiting cancer development), CRISPR-Cas9 can change these qualities and control disease cell conduct. The possibility to foster customized malignant growth treatments in light of a person's hereditary profile is an immense step forward in the field of oncology.



Section 6: Advancing Organ Transplantation

Organ transplantation has saved endless lives; however, the lack of viable giver organs remains a critical restriction. CRISPR-Cas9 opens additional opportunities through xenotransplantation - adjusting creature organs to be viable with human beneficiaries. By making exact hereditary changes, researchers plan to decrease the gamble of organ dismissal and further develop the endurance paces of relocate patients. While challenges continue guaranteeing the drawn-out progress and security of xenotransplantation, CRISPR-Cas9 addresses a promising road for beating organ shortage and changing transfer medication.

Section 7: Expanding to Agriculture



Past human wellbeing, CRISPR-Cas9 holds immense possibility in horticulture. The ability to engineer disease resistance in crops and livestock could bolster global food security and reduce the environmental impact of chemical pesticides. By altering explicit qualities related to illness vulnerability, specialists imagine crops that are stronger to microorganisms, guaranteeing more noteworthy harvest yields and quality. In livestock, genetic modifications could enhance immune responses, reducing disease outbreaks and improving overall animal welfare.

Segment 8: Treating Different Illnesses

The potential of CRISPR-Cas9 extends far beyond the diseases it currently addresses. Established researchers are effectively investigating its application in a more extensive range of diseases. Neurodegenerative issues like Alzheimer's and Parkinson's illnesses, which influence millions around the world, have been subjects of extreme exploration. Albeit these illnesses are

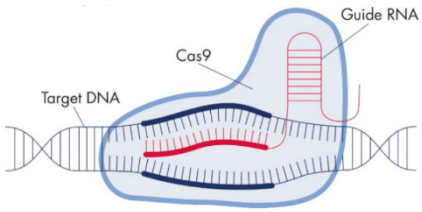
complicated and multifactorial, CRISPR-Cas9 presents a hint of something to look forward to in the battle against these overwhelming circumstances.

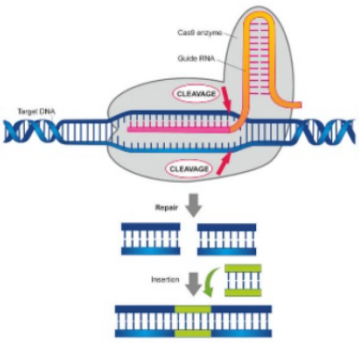
Immune system issues, where the insusceptible framework erroneously goes after the body's own tissues, are additionally possible contenders for CRISPR-based treatments. In conditions like rheumatoid joint pain, numerous scleroses, and type 1 diabetes, explicit qualities are associated with the dysregulation of the safe reaction. CRISPR-Cas9's accuracy might permit researchers to adjust the declaration of these qualities, reestablishing safe equilibrium and improving the side effects of immune system sicknesses.

Also, CRISPR-Cas9 shows a guarantee intended to metabolic issues that disturb ordinary cell processes, prompting serious wellbeing suggestions. Conditions like phenylketonuria (PKU) and Gaucher's sickness are brought about by changes in qualities answerable for metabolic pathways. Through designated quality altering, CRISPR-Cas9 could address these changes and reestablish ordinary cell capability, possibly giving viable medicines to these difficult problems.

The Science Behind CRISPR-Cas9 Treatments

CRISPR is made out of short, tedious DNA groupings scattered with extraordinary "spacer" arrangements received from past viral diseases. The Cas9 compound, directed by a manufactured single aide RNA (sgRNA), checks the genome for groupings matching the spacer, empowering it to perceive and tie to explicit DNA locales.





When the Cas9-sgRNA complex arrives at its objective, it prompts a twofold abandoned break in the DNA. The cell's regular DNA fix components then, at that point, become possibly the most important factor, endeavoring to patch the break. Analysts can impact the maintenance interaction to either present explicit hereditary changes or erase portions of DNA. This exact control of DNA considers the remedy of infection causing transformations or the guideline of quality articulation.

Section 9: Challenges and Moral Contemplations

In spite of the immense capability of CRISPR-Cas9, challenges and moral contemplations request cautious consideration. Off-target impacts, where CRISPR-Cas9 may unintentionally alter accidental qualities, present dangers to patient wellbeing and restorative viability. Thorough testing, approval, and quality control measures are important to guarantee the precision and dependability of CRISPR-Cas9 treatments. Also, the moral ramifications of germline altering and the potential for creator children require insightful conversations and clear rules to administer the dependable utilization of CRISPR-Cas9 innovation.

Section 10: Conclusion

CRISPR-Cas9 technology is a game-changer in the realm of gene editing and disease management. Its applications in solving genetic disorders, combating infectious diseases,

advancing cancer therapies, and improving organ transplantation have unveiled the tremendous potential of this revolutionary tool. Moreover, its expansion into agriculture holds promise for addressing global challenges beyond human health. CRISPR-Cas9 has the potential to transform medicine as we know it. It opens doors to a future where diseases once considered incurable may be effectively managed, and human health may be elevated to new heights. Embracing the full potential of CRISPR-Cas9 is a testament to human ingenuity and the relentless pursuit of better health and well-being for all.

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The Gut Microbiota and Epilepsy: Inspiring Bacterial and Nutritional Relations

Adalia Vargas

The gut microbiota is the microbial system in a person's gastrointestinal system. It contains many bacteria, fungi, viruses, and other creatures. The gut microbiota's characteristics such as types of bacteria and inflammation insinuate epilepsy. Epilepsy is a neurological condition characterized by recurrent sensory disturbance, loss of consciousness, or convulsions caused by aberrant electrical activity in the brain. The gut microbiota-brain axis consists of bidirectional communication between the central and enteric neural systems, connecting the brain's affective and cognitive centers with peripheral gut activities. This is not a novel idea as it dates back to the 1960s and is recognized as a great breakthrough in neuroscience since it affects the pathophysiology of different neurological and mental diseases. The gut microbiota-brain axis has been revealed to not only have an influence over epilepsy but also other neurological disorders such as Parkinson's disease, Alzheimer's disease, and multiple sclerosis. (Ding Manqiu, 2021).

To elaborate on the gut microbiota axis, immunological and inflammatory pathways in the gut-brain axis may have a role in epilepsy pathogenesis. "The immune system and inflammatory processes are influenced by the gut microbiota, which in turn governs the onset of epileptic seizures."(Mhanna Amjad, 2023) This is a significant relationship to note as inflammation has proven to be both a cause and symptom of seizures. If the gut microbiota influences these powerful processes, there may be a notable relationship between the gut and epilepsy. The microbiota in the gut plays an important function in immune system physiology. The gut microbiota influences the healthy function of microglial cells in the brain. Furthermore, short-chain fatty acids (SCFA) produced by gut bacteria have an immediate impact on the brain, altering neuronal plasticity, epigenetics, and gene expression. Serotonin, noradrenaline, dopamine, glutamate, and gamma amino butyric acid (GABA) levels can all be influenced by neurotransmitters. As a result, the gut microbiome influences brain function.

Similarly, Carmen De Caro's study hypothesizes that the gut microbiota may be involved in epilepsy and epileptogenesis, "The gut microbiota does this by mediating the pro-excitatory effect of peripheral inflammation via immune system activation (e.g. release of inflammatory cytokines and chemokines), modulating neural networks via the production of neurotransmitters (particularly serotonin, aminobutyric acid, glutamate, SCFAs, and key dietary amino acids.)" (De Caro Carmen, 2019). Cytokines influence the formation of all blood cells and other cells that aid in the immunological and inflammatory responses of the body. Inflammatory mediators promote neuronal excitability. and activate genes and contribute to molecular plasticity, both of which are implicated in epileptogenesis. Therefore, targeting small compounds that cause inflammation can be useful against seizures and epilepsy.

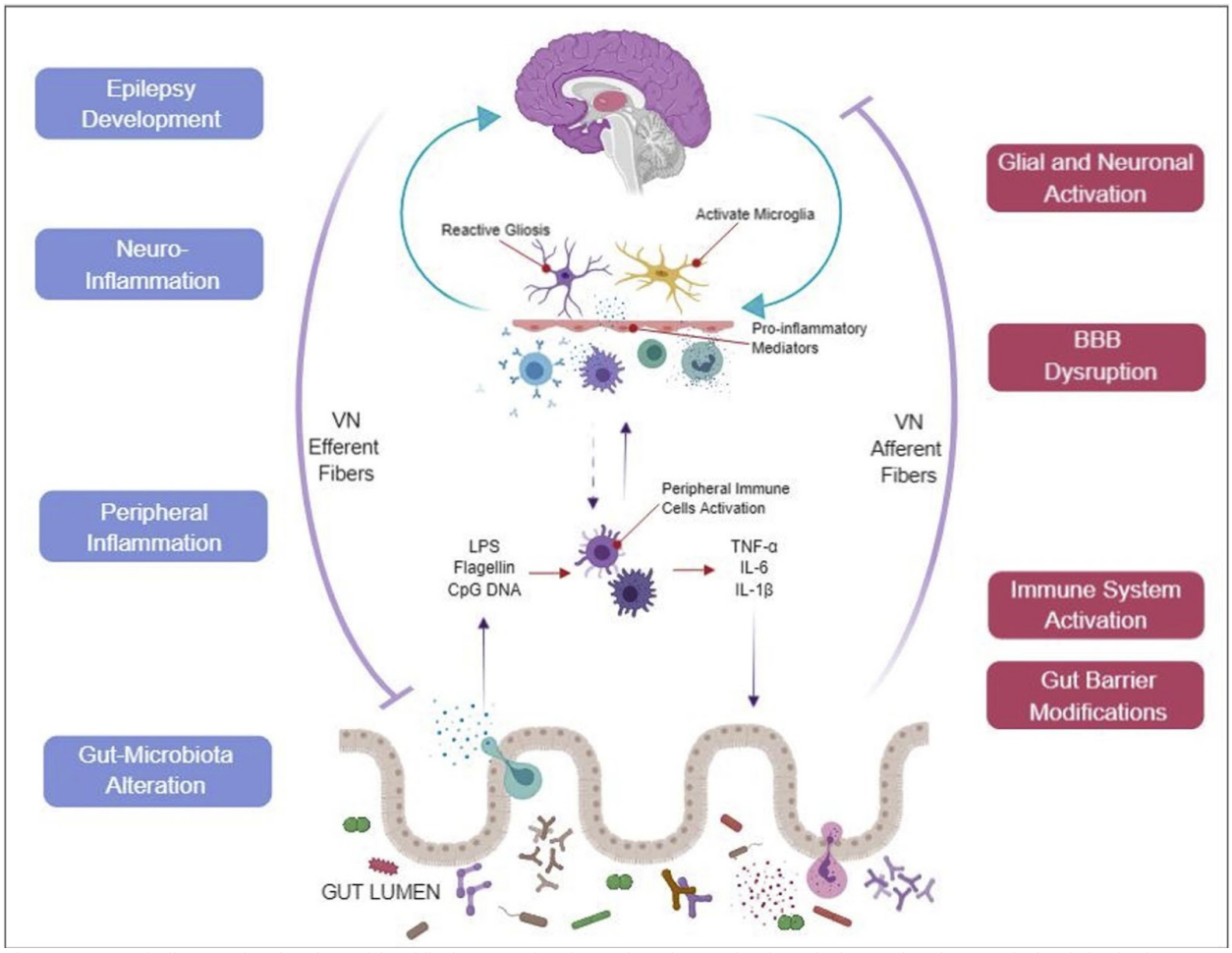

Figure 1: CNS inflammation has been identified as a major factor in seizure physiopathology (the abnormal physiological processes linked with disease or injury), inducing a vicious cycle: neuro-inflammation primes seizures, causing cell death, and epileptic seizures themselves induce an inflammatory response by activating immune cells, microglia, and producing pro-inflammatory cytokines, which sequentially activate more inflammation, contributing to the development of epilepsy. In epilepsy, a pathophysiological cascade involving gut microbiota, peripheral inflammation, and neuro-immune response is hypothesized. Source: De Caro, C., Iannone, L. F., Citraro, R., Striano, P., De Sarro, G., Constanti, A., Cryan, J. F., & Russo, E. (2019). Can we 'seize' the gut microbiota to treat epilepsy? *Neuroscience & Biobehavioral Reviews*, *107*, 750-764.

Beneficial metabolites such as SCFAs and serotonin are produced by healthy gut microbiota, which may help to prevent the development of epilepsy. SCFAs reduce inflammation and immune homeostasis and gut health. "In the gastrointestinal tract, neurotransmitters can be secreted directly by the GM or produced by gastrointestinal cells under the stimulation of GM." (Ding Manqiu, 2021). Therefore, in epileptic foci, there is a neurotransmitter imbalance, such as GABA with hypoactivity and glutamate with hyperactivity, dopamine, and norepinephrine (NE) with hyperactivity, and serotonin with hypoactivity.

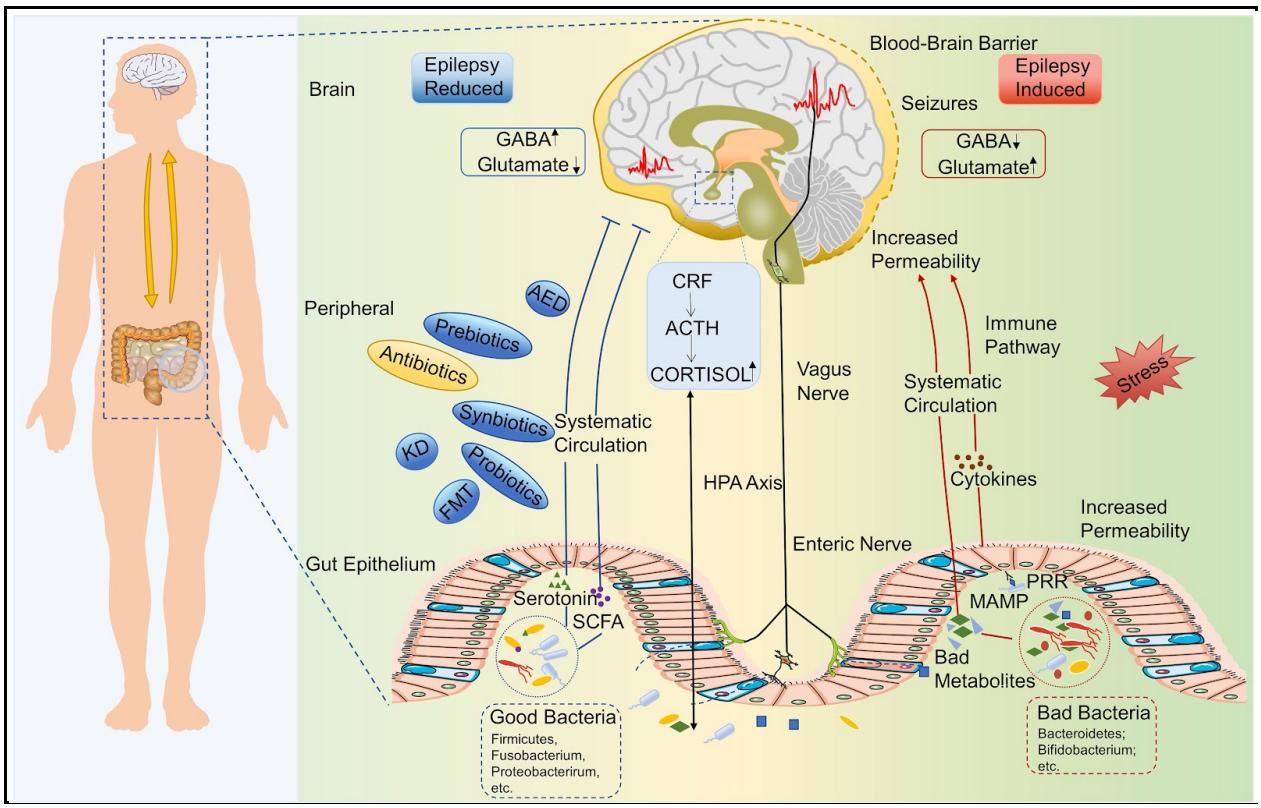

Figure 2: Bad gut microbiota can upregulate the creation of epilepsy-promoting metabolites, the secretion of inflammatory agents, and other processes, resulting in an aberrant GABA/glutamate ratio and, ultimately, epilepsy. As showcased in Figure 1, bad bacteria include Bacteriodietes and Bifidobacterium. Bacteroides have the ability to modulate the release of 6-17 interleukins (a pro-inflammatory cytokine that also functions as an anti-inflammatory myokine.) in dendritic cells, which is linked to seizures. Good bacteria include Firmicutes, Fusobacterium, and Proteobacteria, all of which are found to be in high abundance in people with epilepsy. Source: Ding M, Lang Y, Shu H, Shao J and Cui L (2021) Microbiota–Gut–Brain Axis and Epilepsy: A Review on Mechanisms and Potential Therapeutics. *Front. Immunol.* 12:742449. doi: 10.3389/fimmu.2021.742449

Birol Safak's research concluded that the bacteria, Phylum Proteobacteria was found more common in epileptic patients than in healthy volunteers. Additionally, Campylobacter, Delftia, Haemophilus, Lautropia, and Neisseria were much more prevalent in epileptic patients. In particular, campylobacter has been linked to inflammation and autoimmune disorders in numerous studies. (Birol Safak, 2019). The bacteria found to be prevailing in epileptic patients suggests that they can be used as biomarkers to diagnose epilepsy. Identifying the bacteria that could be a possible trigger for seizures or inflammation, is imperative to preventing one's high susceptibility to seizures. Proteobacteria and Fusobacteria phylum, which cause autoimmune diseases and inflammation in the intestine in epilepsy patients, were found to be significantly higher than in the healthy group, and Firmicutes, Bacteroidetes, and Actinobacteria phylum, which had a positive effect on the immune system of the intestine and central nervous system by producing short-chain fatty acids, were found to be significantly lower in the epileptic group. As a result, the alteration of gut microbiota was suggested to be a potential epilepsy treatment. This idea sparks the Ketogenic Diet, a diet that is high in fat and low in carbohydrates.

Further, Shaghayegh Omrani discovers how the process of epileptogenesis has been connected to the overproduction of pro-inflammatory cytokines such as tumor necrosis factor (TNF)-α and interleukin (IL)-6, as seen by an increased susceptibility to seizures in inflammatory illnesses. Cytokines (TNF)-α influence the formation of all blood cells and other cells that aid in the

immunological and inflammatory responses of the body, which indicates a potential cause of seizures. Interleukin (IL)-6 is a specific pro-inflammatory cytokine. For this reason, Omrani's work suggests cytokine levels as indicators for detecting brain injury in high-risk epileptic patients. Notably, in the current study, TNF-α and IL-6 levels were considerably lower in individuals who received omega-3 FA supplements versus the placebo group. Previous research has shown that omega-3 fatty acids reduce inflammation by decreasing the release of pro-inflammatory enzymes and cytokines like TNF-α. (Omrani Shaghayegh, 2019). Since omega- 3 FA has been linked to decreasing inflammation, therefore decreasing the potential of seizures, it proposes changing one's diet to incorporate more omega- 3 FA's. This can be through the consumption of foods such as fish (salmon and mackerel), soybeans, chia seeds, and flaxseeds.

Sevim Turay builds on the idea of identifying biomarkers throughout his study to discover if the Gut Microbiota can serve as a guide to the diagnosis and treatment of Childhood Epilepsy. The researchers hypothesized that the increase in bacteria (Coriobacteriaceae and Megamonas) associated with inflammation in the intestinal microbiota, as well as the decrease in nondisease bacteria or their absence from the microbiota, could be linked to diseases triggered by inflammation, such as epilepsy. (Turay, Sevim, 2023). In this way, this study replicates Birol Safak's study in which they both identified the distinct bacteria epileptic patients had. The fact that two studies achieved this in their results, shows the potential of microbiota analysis becoming more widely employed, meaning numerous microorganisms associated with epilepsy can be identified as biomarkers and used in diagnosis and patient follow-up.

In addition to epilepsy treatment methods, restoring eubiotic microbiota may improve treatment success. Regulating food habits in epileptic patients' treatment protocols may be beneficial to the restoration of the eubiotic microbiota.

Looking into the nutritional perspective, the ketogenic diet is once again, proposed by Lian Dong. The ketogenic diet (KD) is a high-fat, low-carbohydrate, high-protein diet that has been utilized in patients with intractable epilepsy since 1921. The typical fat-to-protein-to-carbohydrate ratio in KD is 4:1, which causes a metabolic pattern change from glucose metabolism to fatty acid metabolism. The conventional KD could alleviate epilepsy through a variety of mechanisms, including neurotransmitter regulation, brain energy metabolism, oxidative stress, ion channels, and gut microbiota. Both the low-sugar and high-fat components of the KD modify the 'excitability' of the brain, lessening the potential to produce seizures. Saturated fat has long been the most often used fat in KD; nevertheless, animal and human research have shown that polyunsaturated fatty acids (PUFAs), particularly omega-3(n-3) PUFAs, have anti-epileptic properties. Flaxseed, nuts, marine seafood, and marine mammals are high in n-3 PUFAs. (Dong, Lian 2022). As is evident, flaxseed and omega-3 are mentioned yet again. The application of omega-3 fatty acids to epileptic patients and their use to reduce the risk of seizures demonstrates the effective anti-epileptic qualities that dietary elements can have over epilepsy.

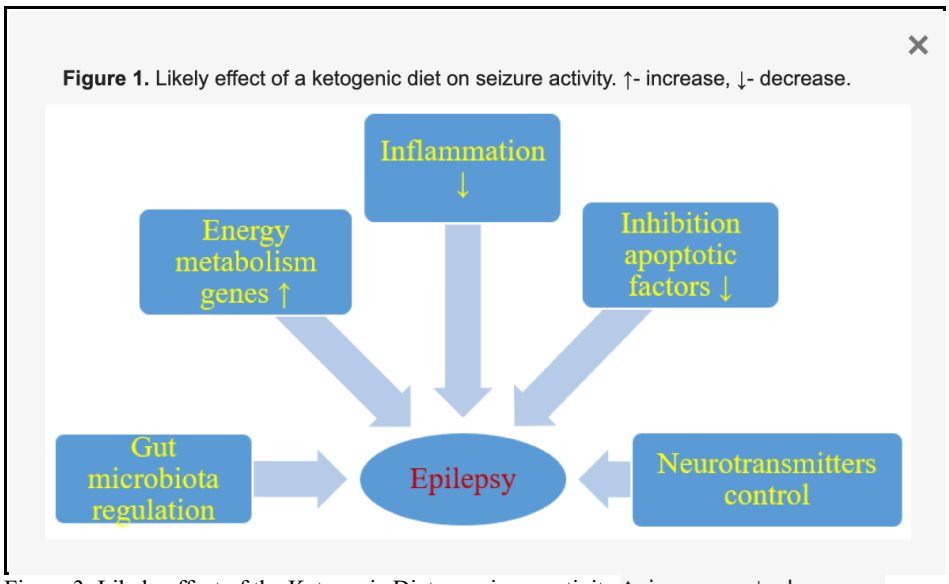

Figure 3: Likely effect of the Ketogenic Diet on seizure activity ↑- increase, ↓- decrease.
Source: Ułamek-Kozioł M, Czuczwar SJ, Januszewski S, Pluta R. Ketogenic Diet and Epilepsy. *Nutrients*. 2019; 11(10):2510. https://doi.org/10.3390/nu11102510

Bagheri's study found that treating chemically ignited rats with a probiotic bacteria mixture significantly reduced epileptic activity. The intervention also improved the cognitive performance of the experimental subjects, positively influencing both learning and memory consolidation. The biochemical measurements' data support changes in epileptic and cognitive behaviors. The current study, the first to assess the effect of probiotic supplementation on an animal model of epilepsy: rats, found that probiotic microorganisms significantly lower seizure severity. (Bagheri, Samaneh 2019)

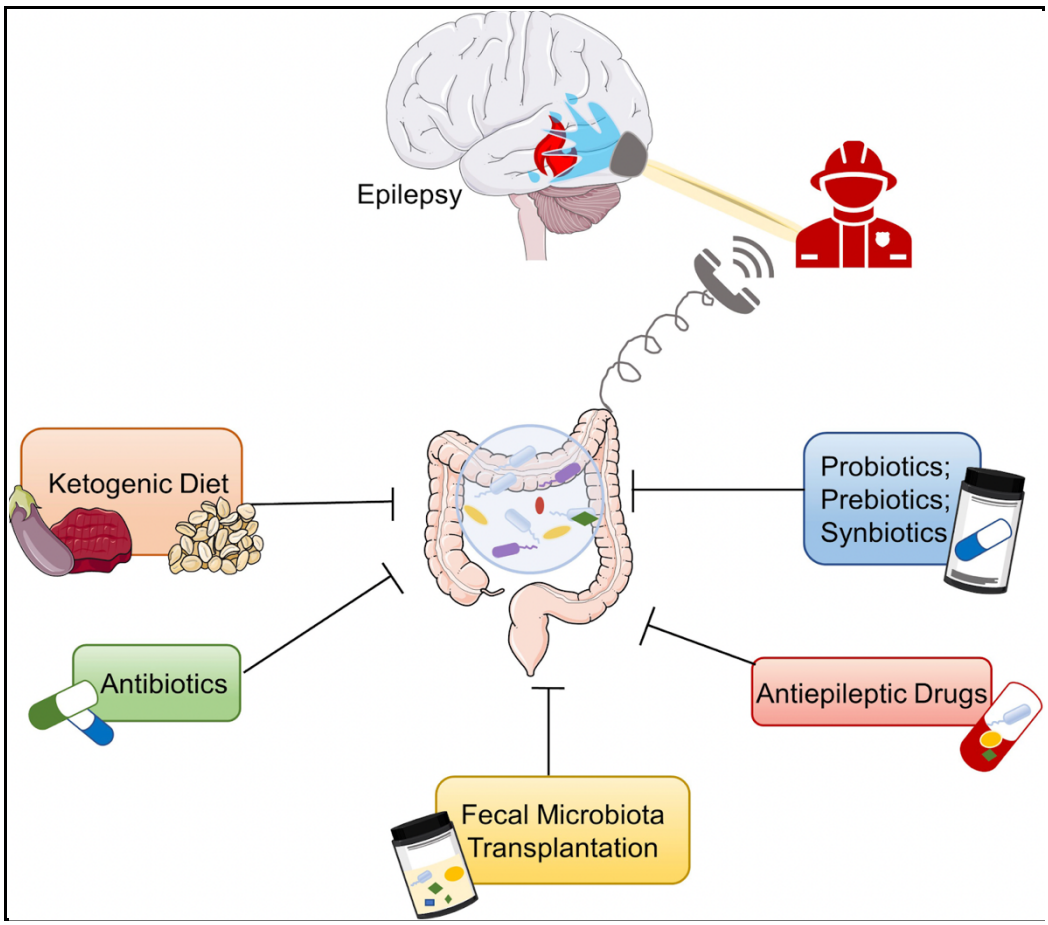

Figure 4: Potential therapy for epilepsy based on gut microbiota. Based on the microbiota-gut-brain axis, prospective treatments for epilepsy include a ketogenic diet, antiepileptic medications, probiotics, prebiotics, synbiotics, antibiotics, and fecal microbiota transplantation. Source: Ding M, Lang Y, Shu H, Shao J and Cui L (2021) Microbiota–Gut–Brain Axis and Epilepsy: A Review on Mechanisms and Potential Therapeutics. *Front. Immunol.* 12:742449. doi: 10.3389/fimmu.2021.742449

In conclusion, gut microbiota can be used to identify epilepsy and treat epileptic patients. Furthermore, given the effect of gut microbiota on epilepsy is a relatively new discovery, all sources state that more research is needed to answer problems raised by previous studies on the subject. Only a few clinical studies (usually underpowered) have been undertaken, according to the sources that discuss the gut microbiota's influence on epilepsy. Because the gut microbiota has been found to have an effect on other neurological illnesses, the discoveries established between epilepsy and the gut microbiota can stimulate more research into neurological disorders and the gut microbiota. Overall, there are potential biomarkers for epilepsy that can aid the medical field in diagnosis as well as finding a technique to eliminate certain bacteria that cause inflammation. Ketogenic diets and probiotics are one of the treatments associated with the gut-microbiota axis. The future undoubtedly contains more studies to determine why the ketogenic diet reduces inflammation, as well as the discovery of new therapeutics.

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Impact of the COVID-19 Pandemic on Individuals with OCD: Treatment and Symptoms

Aisling Kelly

Introduction

For centuries, symptoms of obsessive-compulsive disorder, otherwise known as OCD, were treated as side effects of insanity or mania. However, as psychological research evolved in the mid-nineteenth century, scientists started to understand obsessions and compulsions, contributing greatly to what is currently known about OCD ("History of OCD", 2023).

Obsessive-compulsive disorder is a chronic psychiatric illness affecting roughly two to three percent of the adult population, although it often goes undiagnosed (Grabill et al., 2007). OCD symptoms are classified in two major components: obsessions and compulsions. Obsessions are persistent thoughts and ideas that cause distress and unwanted anxiety for an individual, largely because they can create fear, disgust, and/or other troublesome emotions (Geller, 2022). There are a multitude of obsessions that have the potential to affect an OCD patient, but common ones include fear of contamination, extreme need for symmetry, hoarding, and thoughts of aggression ("Symptoms of Pediatric OCD", 2023). Many patients suffering from OCD believe they have the power to suppress these obsessive thoughts through compulsions. While obsessions are limited to thoughts and mentality, compulsions have to do with behavior. The primary purpose of compulsions for an individual with OCD is to relieve unwanted stress caused by obsessions (Starcevic et al., 2011). Some examples of compulsions include counting, cleaning, and excessively repeated acts ("What Are Compulsions?", 2022).

Despite it being a life-long illness, patients can undermine symptoms through various treatment forms such as cognitive behavioral therapy, neurosurgical treatment, and different medications. Doctors suggest a combination of cognitive behavioral therapy and medication as the strongest method of alleviating OCD in patients. However, in recent years, with the COVID-19 pandemic, patients have had limited treatment options, have dealt with worse symptoms, and the pandemic as a whole has served as a

major trigger for many individuals suffering from OCD, demonstrating the overall negative impact of COVID-19 on OCD patients.

Literature Review

Initially emerging in 2019, the COVID-19 virus spread rapidly across the globe, with the World Health Organization (WHO) declaring it a worldwide pandemic early in 2020. Essentially, the disease consists of fever, fatigue, cough, and other various respiratory symptoms and side effects (Wang et al., 2020). COVID-19, also known as coronavirus, can spread through the mouth or nostrils of an infected person, often via breathing, sneezing, or coughing. The virus infects and kills people across all age groups, although the elderly and those with underlying medical conditions are more at risk for serious infection and will be more likely in need of hospitalized medical attention ("Coronavirus Disease: Overview", 2023). Because the disease is transmitted through the mouth and nostrils, the Center for Disease Control (CDC) recommended wearing masks to prevent acquiring and spreading COVID-19. In early 2021, president Joe Biden issued a mask and social distancing mandate in public spaces, which was later lifted at different time periods throughout 2022 and 2023, depending on the state. The public health emergency was officially declared over on May 11, 2023, meaning restrictions are not as strict and in some places, non-existent. However, to this day, many local stores and community spaces still recommend individuals wear masks and distance themselves (McFarlane, 2023). Despite the end of the global pandemic, COVID-19 restrictions and fears created a lasting impact on individuals suffering from mental illness, particularly OCD. Fear of contracting the illness, coupled with limited access to treatment options, made surviving the pandemic and OCD simultaneously a significant struggle.

Throughout the COVID-19 pandemic, non-essential medical services were suspended, making it difficult for those with mental disorders to address their needs. Although some non-essential medical practices remained open and available, many did not want to access these sites for fear of contracting the disease (Hardin, 2021). Individuals suffering from OCD in particular during the pandemic struggled to obtain valuable treatment options, primarily in regards to cognitive behavioral therapy (CBT). Not only

was access limited as a result of quarantine and restrictions, but the actual components of CBT for OCD treatment often opposed social distancing regulations. In order for CBT to assist in relieving and treating OCD, patients must undergo Exposure and Response Prevention (ERP) in which they are exposed to feared objects as a means of overcoming obsessive thoughts and subsequent compulsions (Linde et al., 2022). Examples of such exposure could be eating food on a table that was not immediately cleaned prior to the meal or shaking hands with another person, both of which would not align with COVID-19 restrictions, making much of ERP treatment unsuitable for the pandemic (Hardin, 2021). Unfortunately, public-health recommendations during the height of the pandemic limited the ability to participate in this method of therapy, so clinicians looked toward ways to adjust ERP for the situation at hand. Some suggested opting for an online format, but the effectiveness of such methods were yet to be examined, making the shift between in-person, hands-on CBT to a new, restricted version, quite troublesome and not particularly smooth (Linde et al., 2022). Limited access to this form of treatment made it incredibly difficult for those suffering from OCD to live through the pandemic. A recent study even revealed that 59.1 percent of OCD patients reported that the pandemic had interfered with their treatment plan in some way, shape, or form, revealing that COVID-19 certainly had a negative impact on OCD patients (Wheaton et al., 2021).

Figure #1: Clinical Guidelines for the treatment of OCD during the COVID-19 pandemic – Explains the proper way to handle treatment of OCD during the pandemic when proper and traditional forms of treatment such as CBT were limited (Fineberg et al., 2020).

Clinical guidelines according to Fineberg, N. A. *et al., Comprehensive Psychiatry (2020)*

1. Use a compassionate, calming approach. Use telemedicine in areas where it is possible.
2. Careful history taking. Confirm diagnosis. Clarify the extent to which symptoms represent rational or exaggerated relations. Establish level of insight from patient. The concerns are often idiosyncratic. Assess comorbidities.
3. Assess suicidal risk.
4. Provide psychoeducation with balanced information about know risks and impact of COVID-19 on physical and mental health.
5. Enquire about media consumption. Offer a balanced approach and suggest trusted sources.
6. If OCD symptoms are the main problem: Review medication status, review and risk assess the CBT plan, help with social and occupational care, provide career support. Have regular follow-ups by the therapists. Establish a daily routine.

Not only did COVID-19 restrictions limit the accessibility of proper treatment therapies for individuals with OCD, but the pandemic itself served as a major trigger for people suffering from mental illnesses, and OCD patients proved to be of the most susceptible group. Many patients demonstrated worsening symptoms throughout the pandemic, particularly due to a variety of key factors: increased demand for hand-washing, recommended hand-washing steps, strict hygiene measures, stocking up on disinfecting products, and media reports on new sources of contamination (Linde et al., 2022).

Figure #2: Emergence of COVID-19 Related OCD Symptoms – Qualitative responses from OCD patients describing COVID-19 in relation to OCD symptoms. Most patients described how the pandemic worsened their existing symptoms or created new ones (Wheaton et al., 2021).

Subtheme 1a: Emergence of COVID-19 related OCD symptoms, *n*=34

Example comments:

“My main OCD is scrupulosity. The virus added contamination OCD to my illness.”

“I obsessively focus on my lung function, an obsession I never had before.”

“I have developed OCD symptoms that I have never had before, and made others worse.”

“And the only obsession I had is that I could spread the virus to other people.”

“I already suffer from intrusive thoughts about harm coming to my loved ones, since coronavirus, these have gotten markedly worse and are mostly now on the subject of the virus”

Studies also reveal that there was a significant increase in cleaning/washing compulsions during the pandemic, likely to relieve the stress or anxiety caused by the spread of disease (Cunning & Hodes, 2022). Increased hand washing/sanitizing proved to be an issue in the dermatology department, as excessive hand cleansing resulted in eczema and severe skin damage in many patients, demonstrating both the physical and mental toll of OCD during the pandemic (Linde et al., 2022). Some research suggests that individuals with OCD worry more about COVID-19 than those without, specifically in regards to the spread of the disease, which explains the increased cleaning/washing compulsions. This was especially true during quarantine and strict social distancing (Wheaton et al., 2021). The various restrictions and regulations that came along with the COVID-19 pandemic, as well as increased fear of contracting the virus itself, exacerbated symptoms of OCD in many patients, which is revealed through increased hygienic compulsions and obsessions.

Figure #3: Generalized linear model of OCD symptom change during the quarantine – Demonstrates impact of quarantine on worsening of OCD symptoms during the pandemic. Factors like living with a relative, prior contamination symptoms, and remission status on OCD all influence the elevation of symptoms throughout COVID-19 (Davide et al., 2020).

		Wald's 95% confidence interval			
Predictors	***β***	**Lower**	**Upper**	**Wald's $\chi^2_{(1)}$**	***p*-value**
Intercept	−8.17	−13.52	−2.83	8.99	.003
Remission status on OCD symptoms before the quarantine					
Remission	5.17	2.73	7.61	17.25	<0.001
Still reporting symptoms	0[a]	.	.	.	.
Living with a relative in the same house during the quarantine					
Yes	4.26	1.21	7.31	7.50	.006
No	0[a]	.	.	.	.
Contamination symptoms before the quarantine					
Yes	7.40	5.00	9.80	36.55	<0.001
No	0[a]	.	.	.	.
Age	.09	.01	.18	5.29	.021

Conclusion

Ultimately, the COVID-19 pandemic had a negative impact on individuals suffering from obsessive-compulsive disorder. Social distancing restrictions and quarantines limited both the accessibility and possibility for hands-on cognitive behavioral therapy, which is a highly recommended and effective treatment for OCD patients. The pandemic caused anxiety and stress in patients who feared they would contract the disease, resulting in extreme and excessive hygienic obsessions and compulsions, harming both the mind and body. Various outside factors influenced the increase in symptoms amongst individuals, but the pandemic clearly exacerbated symptoms in many OCD patients. Because the pandemic has officially ended and research during the pandemic was limited, it is difficult to address the overall impact of the pandemic on OCD. However, from what little research exists, COVID-19 proved to be mentally harmful for OCD patients, as it interfered with their treatment options and increased their symptoms.

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Road Damage Detection Using Artificial Intelligence

Akshay Padmanabhan

Introduction

Transportation is the lifeblood of India, connecting vast states, districts and territories to each other and the world beyond, making up an economic web or network. This network is crucial in the economic development of a region, as it connects supply hubs to demand hubs, facilitating the flow of capital and investment. However, due to the sorry state of roads in the backward regions of India, it makes the upliftment of these areas an arduous endeavor.

In the 21st century, AI has made giant leaps forward, from ChatGPT and other LLMs to neural networks, AI has taken the world by storm, spearheading various advancements in all sorts of fields. Specifically, transportation and AI work hand in hand, autonomous vehicles, pedestrian detection and more, can help make the experience of getting from point A to point B a much smoother and safer one.

This paper, seeks to summarize work done previously related to road damage detection and explore its real world applications.

The models analyzed employ the dataset from the Crowdsensing-based Road Damage Detection Challenge 2022, CRDDC2022, containing 47000 images of roads from various developing and developed countries across the world, alongside with their annotated cases of damage.

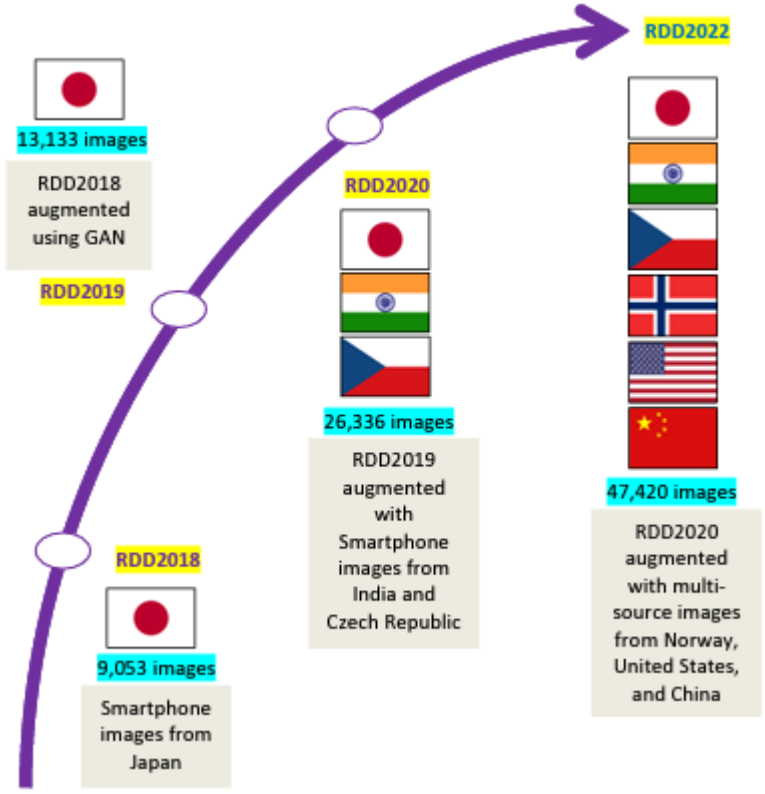
Alongside research papers and articles, news articles played a vital role in the formation of the question. Various articles from reputed publishers across India such as The Hindu and The Times of India stipulated the numerous problems that arise in the country due to poor road construction.

All the sources agree that road damage is a pressing issue, however, each approaches the problem differently. Some correlating it to crime rates, other employing various AI models to predict it , while others finding issues in distracted drivers as well.

This field, despite being a nuanced one, has deep links with booming industries such as automated vehicles, leading to it having burgeoning potential for future research.

RDD2022 Dataset: An Explanation and Shortcomings

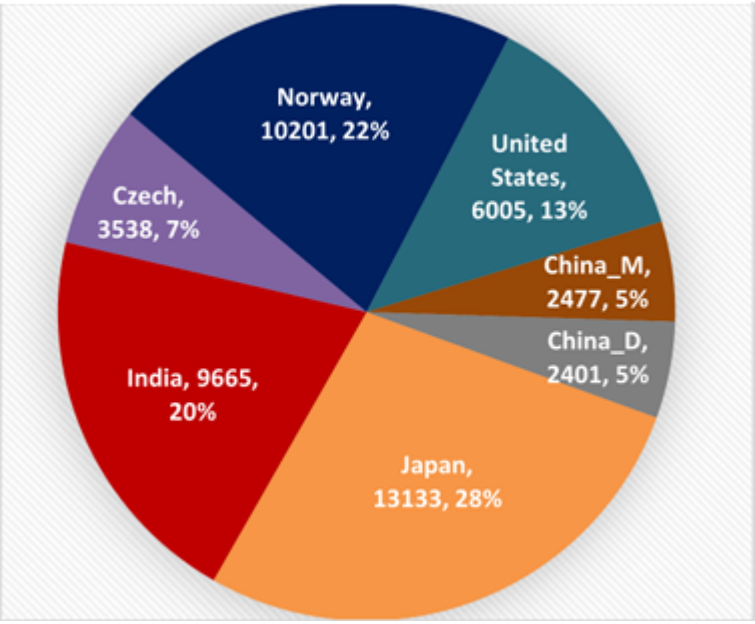
This dataset was the foundation of the CRDDC2022, which put people's deep learning skills to the test. The RDD2022 Dataset covers 6 countries, those being Japan, India, the Czech Republic, Norway, the United States and China, giving it a broad scope of damage in roads, from heavily damaged to ones with virtually no damage at all. This has helped create a well-balanced dataset, as a model can be trained for general purpose uses when it is exposed to various kinds, types and locations in which roads are present.



Most of the images have damage in the form of cracks, whereas potholes are severely lacking, this could case certain issues when a model needs to predict multiple different kinds of damage on a single road. However, there has been great progress in the dataset from 2018 to 2022, slowly closing this gap, despite it still being an issue of concern.

The number of images from different countries too is of concern, as India, Japan and Norway form the vast majority of images taken, whereas China and the Czech Republic have relatively less representation.

Also, there seems to be an imbalance in the kinds of damage across different countries, with India representing the bulk of pothole-related damage, while Norway and the USA have a huge amount of longitudinal cracks. This could also further skew the model.



Another common issue could the location of the photographs. As per the data provided for the USA images, a vast majority of them were taken in 4 areas in California. If this trend is present in other sets, it could pose further challenges to model's accuracy.

But it also has it a vast list of pros that outweigh the above cons. The images have captured a large view of each road, and have been collected via a variety of methods that provides the model with various views of a road, enhancing its ability to identify damage from different angles.

The images are annotated with state-of-the-art open-source software, thus enabling more people to use the dataset effectively. Also, since these images have been taken from moving vehicles, it enables any model trained on it to be able to pick up on road damage even while moving.

All in all, these factors contribute to the dataset being well-balanced and very useful when it comes to road damage detection, as it has a great variety of quality images.

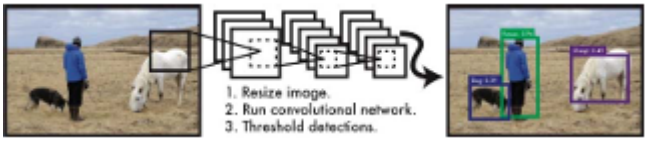
Deep Learning Damage Detection

For such large quantities of data, it is impractical to use traditional machine learning models based off of regression. Thus, most if not all models employing the dataset use Deep Learning as a way to detect damage accurately and quickly. Deep Learning is an unsupervised form of machine learning, where a model is provided with a large amount of data. This model then extracts patterns and identifies trends on its own.

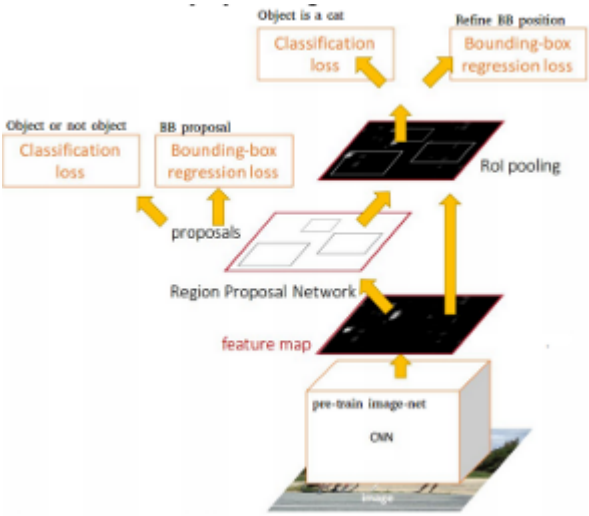
This usually takes the form of neural networks, models loosely based off of the way the human mind works, with various layers used to extract progressively higher features of the data. An advantage of this type of learning is that as the amount of data increases, the accuracy of the model continues to increase, whereas most traditional models would plateau after a certain point.

Looking at general trends in the models of the top 11 teams for CRDDC2022, all of the teams leverage the YOLO model alongside their own unique ideas, and 9 of them incorporate ensemble learning to increase the accuracy of their prediction.

YOLO stands for You Only Look Once, a very popular object detection model introduced in 2015, with its latest iteration being YOLO v8. However, teams in the challenge applied YOLO v7 and v5 more due to them being more stable than YOLO v6 and due to the fact that at the time of the challenge, YOLO v8 was not yet released.



This model in particular is a one-stage or proposal-free detector, which uses only one pass of the image to predict its location, class, etc. This makes YOLO much more efficient and quicker with respect to other popular models such as RCNN. However, it usually lags behind in accuracy when compared with its two-stage counterparts.



YOLO v8 is a relatively recent advancement, which expanded the model to support a wider range of CV tasks, including detection, segmentation, pose estimation, tracking and classification. It built upon previous versions by introducing new convolutional layers and anchor-free detection to tackle the model's aforementioned problem with accuracy.

Ensemble learning is a simple, yet very powerful concept in the world of AI. It involves combining the results of multiple different models together to get a more accurate result. It can be of various forms, including; "majority vote", "bagging", "random forest", among many others. This allows for one to weave together different models, obtaining their advantages will minimizing their disadvantages. As an example, YOLO could be used to provide a basic skeleton prediction to work

off of, and RCNN could be used to further improve the accuracy of the model. This helps to provide both speed and accuracy to our prediction.

Real World Applications

In the real world, road damage detection has a wide variety of applications. Firstly, in the world of automated cars, it plays an essential role in ensuring that the vehicle is able to traverse long distances without any hiccups along the way. This could also help in calibrating routes through areas based upon the condition of roads.

Secondly, it can be used to figure out exactly which roads are in a horrible condition, and which ones need immediate repair. This can ensure the longevity of not only interconnected transport networks, but also reduce mortality rate among regular riders. Automated detection can also reduce the cost of such endeavours, ensuring that a government or country can implement this on a large scale without worry for overly exorbitant costs.

Finally, it can also have uses in detecting the most effective road construction material over a long period of time. This could help in deciding the best compounds to use to lay roads to ensure that they do minimal damage to cars and people's health while also being as durable as possible.

Conclusion

To summarize, in this review article, we've covered what the RDD2022 dataset consists of, its drawbacks and merits, what deep learning is, its advantages over traditional models, YOLO and its basic principles, ensemble learning and the uses of road damage detection

In the writing of this article, only a handful of models were referred to and researched thoroughly. This leaves room for error, as some models may be more effective in this task specifically , or some may no longer be as useful as they were prior.

This field has immense potential for growth in the future. Linking LLMs such as BLIP-2 to ensemble learning models could produce an understandable output for humans and could possibly be applied in mobile applications for detecting road damage on the go.

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The Impact of Screen Time on Cognitive Development in Children: A Review

Alishah Fatima

1. Introduction

Due to recent advances in technology, there has been an increase in the amount of time people spend in front of screens. In particular, young children spend an alarming amount of time on technological devices (Liebherr et al., 2022). In fact, researchers have found that children are being exposed to television screens as early as six months old (Anderson et al., 2017). However, children's screen exposure increased even further since the beginning of Coronavirus disease-2019 (COVID-19); COVID-19 brought childrens' screen time to an all time high with school moving online and quarantine policies. Data collected in a study found that students who used smartphones and tablets for leisure went up from 49% pre-pandemic to 67% during (Savaş & Büyük, 2023).

Figure 1

Children's device usage outside of educational purposes before and during the pandemic

Variables		Before COVID-19		During COVID-19		Test statistic p
		n	%	n	%	
Child's tablet/ computer usage status	Yes	242	49.59	327	67.01	175.719 **0.000**
	No	246	50.41	161	32,99	
Child's cell phone usage status	Yes	281	57.60	341	69.90	187.817 **0.000**
	No	207	42.40	147	30.10	
Child's daily technological device usage time	0-2 hours	317	65.00	154	31.60	163.897 **0.000**
	3-4 hours	92	18.90	83	17.00	
	More than 4 hours	79	16.20	251	51.40	

Source: Savaş & Büyük, 2023

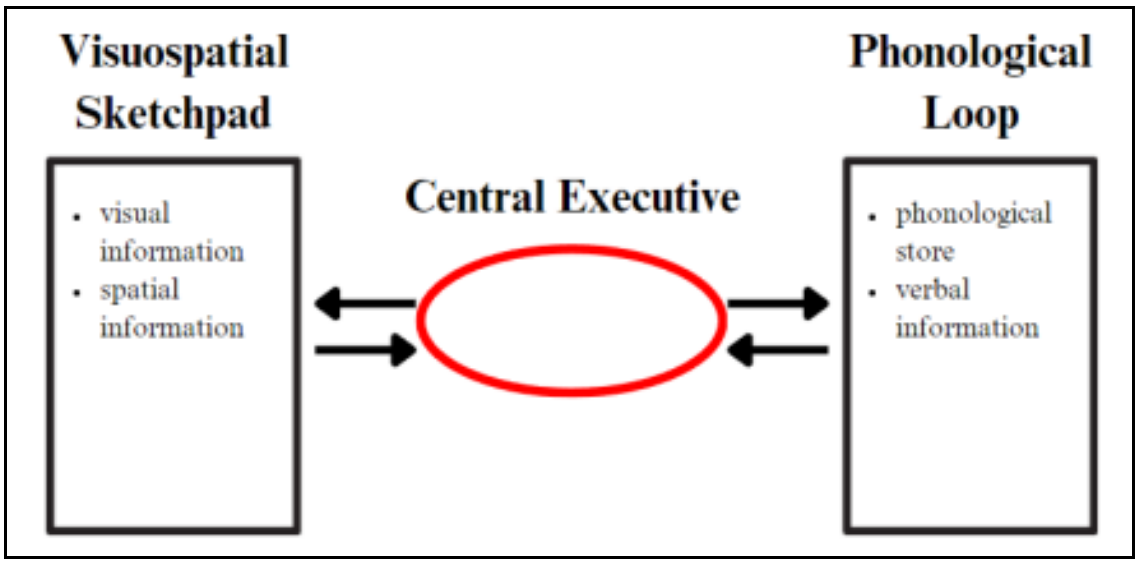
Data also shows over 50% of children using devices for over four hours, which is above the American Academy of Pediatrics (AAP) recommendation of 1-2 hours daily (Christensen, 2021). Researchers found that screen usage above the AAP guideline damages children's language and literacy skills (Hutton et al., 2020). A causational relationship can be observed between excessive screen time and cognitive ability, which this review will explore. Cognitive ability involves "reasoning, problem solving, abstract thinking…and learning from experience" (Ispas & Borman, 2015). As cognitive ability includes a variety of mental processes, individual cognitive skills need to be assessed to gain a deeper understanding on the effects of digital media (Liebherr et al., 2022). This review will focus on the various effects of screen time on working memory, language and phonological memory, and attention span.

2. Working Memory

Working memory (WM) is memory that "is used to plan and carry out behavior" (Cowan, 2008). The concept of WM was further developed with the Baddeley and Hitch Working Memory Model (BH Model). These researchers stated that WM comprises a phonological loop that stores verbal and phonological memories and a visuospatial sketchpad that does the same for visual-spatial memories. Both of these sections are managed by the central executive (Cowan, 2008, Baddeley & Hitch, 1994). WM is a vital cognitive skill because it gives people the ability to "acquire and retain information…while executing a specific task" (Liu, 2022). The BH Model is shown in the figure below.

Figure 2

Baddley and Hitch, the three component working memory model



Source: Own Work

2.1. Screen Time

Screen time is defined as the many "activities done in front of a screen, such as watching TV, working on a computer, or playing video games" (*Screen Time and Children*, 2023). Screen time can be categorized into active screen time (eg. using phones, tablets, etc.) and passive screen time (eg. television) (Liu, 2022).

2.2. Effects of Screen Time on Working Memory

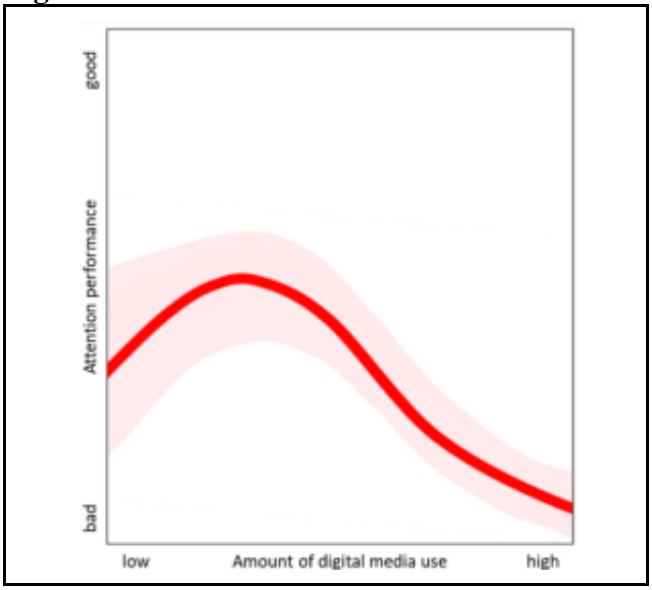
Neophytou, Manwell, and Eikelboom conducted a review of multiple articles to find correlations between screen time and memory. The review found that excessive screen time (above two hours) had a negative effect on children's memory. Evidence was found that screen time also has a negative effect on language skills. Also, negatively affected memory and language skills are directly responsible for children's declining academic performance (Neophytou et al., 2021). A study conducted by Magidan et al. found that preschoolers who had excessive screen time could not meet vital developmental milestones in memory and language skills.

However, research has shown that not all types of screen time have a negative effect on WM. A study revealed that the time preschoolers spent with interactive, active screen time did not pose a threat to their phonological memory, which is a key component of WM (Veraksa et al., 2021). In fact, educational television has a positive effect on young children's cognitive development by increasing vocabulary (Anderson et al., 2017).

3. Screen Time and Attention

Attention is defined as "the ability to sort and focus on relevant stimuli." This is an important cognitive skill that allows for processing of stimuli and problem-solving. A study conducted by Liebherr et al. examined the relationship between screen time and attention subdomains in children aged 6-10. A common pattern that was found in the study was that if screen usage stays at a low to medium intensity, it could have no or even some positive effects on attention. On the other hand, extensive use of screens, especially passive screen time, has a negative effect on attention (Liebherr et al., 2022). However, a variety of factors like types of content and socioeconomic factors also influence results. Taking these into account, the study suggests a non-linear relationship between screen time and cognitive ability in children, as shown in Figure 3 below.

Figure 3



Source: Liebherr et al., 2022

Another study was conducted with 34 preschoolers being observed in a classroom setting on five different cognitive processes. Teachers filled out questionnaires asking about student's cognitive performances based on groups separated by screen time (Sapsağlam & Birak, 2023). The results can be seen in Figure 4.

Figure 4

Table 2. ***Preschool Teachers' Answers to Research Questions***

Research Pattern	Screen Usage Time 0-1 hours		Screen Usage Tim 2-4 hours	
Do children remain unresponsive to the guidelines you give during or outside of the event?	Yes	4	Yes	11
	No	13	No	6
Do children have a pensive eye when they listen to what you're saying?	Yes	3	Yes	10
	No	14	No	7
Does he often forget where he puts his personal belongings and event supplies?	Yes	4	Yes	11
	No	13	No	6
Is he/she easily affected by external stimuli during events?	Yes	3	Yes	12
	No	14	No	5
Is he/she avoiding concentration activities?	Yes	2	Yes	13
	No	15	No	4

Source: Sapsağlam & Birak, 2023

This data shows that children who spend 2-4 hours using screens are generally unresponsive to directions, more forgetful, and avoid concentration activities compared to children with 0-1 hours. This demonstrates how excessive screen time shortens the attention span of children in educational settings, which can decline academic performance. However, more conclusive research on cognitive effects is needed as these studies are observational and are limited in their scope.

4. Conclusion

Increasing screen time in children, furthered by COVID-19, has raised many concerns about its impact on cognitive development. Excessive screen time is known to have negative effects on vital cognitive skills like working memory, language development, and attention span. Though, studies have also shown that educational screen time can have positive effects on children. However, the relationship between screen time and cognitive development is much more complex. Many hidden factors like types of media, age, and socioeconomic conditions of children affect results, so more detailed research needs to be done to address the limitations of these studies and establish clearer future steps. Ultimately, it would be best for parents and officials to promote a healthy balance of screen time in children.

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The Effect of Cannabinoids on Neurodegenerative Diseases

Christine Anyanwu

I: Introduction

Neurodegenerative diseases are one of the most prevalent diseases in the industrialized world, especially among the older generations. For a long time, there have been many isolated treatments, like medications, therapies, etc, that have sought to treat the symptoms of these diseases and mitigate their effects on the patients, but most have turned out to be unsuccessful. But with the recent discovery of cannabis in the last few decades, many researchers believe that cannabidiol is a very promising drug to treat these diseases based on its anti-inflammatory and antioxidative properties. This literature review will go over these benefits of cannabis and why cannabis is an important drug in the treatment of patients, especially those with Alzheimer's and Parkinson's disease. Each of these sources describes the importance of cannabidiol, especially CBD and delta-9 THC, and the molecular properties that make it up that is so vital to treating these diseases. This literature review will also describe the molecular buildup of cannabidiol and what makes it so useful to patients with these neurodegenerative diseases. The review will also highlight some of the specific studies done on cannabidiol, and the usage of it in a clinical setting, and the results from those usages. These sources also highlight specific studies that have been done, either pre-clinical or clinical, that show the effect of CBD on patients with different neurodegenerative diseases, and some of the symptoms that are associated with them, and the outcomes that arose from each population. These sources all agree that cannabinoids are beneficial to the treatment of the diseases, but that there may also be some setbacks or disadvantages of using cannabinoids, including many ethical concerns surrounding legalization of medical marijuana in some states and countries and the prescribing of cannabis for these patients to use. These sources also mention the potential side effects that the delta-9 THC may

cause, because of the dosage amount in some of the clinical studies. By studying CBD and other variants, either man-made, mutations, or otherwise, researchers and doctors may be able to find a cure from CBD or one that lessens the impact of the symptoms caused by these diseases. It will then pressure many pharmaceutical companies to pursue the creation of cannabidiol-related drugs and popularize the use of it.

II: What are Cannabinoids?

As mentioned in the introduction, cannabis, specifically cannabidiol, is rich in antioxidative and anti-inflammatory properties which make it so beneficial to these patients who use it. CBD was thought of as a unique substance, different from marijuana, but was eventually found to be a chemical found in marijuana, along with THC, according to a study done in the 1960s by Mechoulam et al. [4] CBD is the chemical that is found in medical marijuana, which is used in a variety of medications, mostly therapeutic, to treat different types of epileptic or other symptoms caused by other diseases, like cancer. THC, on the other hand, is the main ingredient found in recreational marijuana, and is responsible for the psychosis effect that is achieved when you get a high. Many cannabidiols still have THC present and still use in their prescriptions when doing experiments with patients, so the smaller the dosage, the less psychosis-like symptoms the patients will experience CDB is the main non-psychotropic molecule that is found in CBD, although researchers have not yet identified its main function with endocannabinoids (CB1 and CB2 receptors), as it is not clear whether they bind to one, both or none of the receptors [12]. In total, there are over 550 chemical compounds that make *C. sativa* and there are over phytocannabinoids, which include both CBD and THC, that attach to the CB1 and CB2 receptors [12]. As seen in Figure 1, there are specific functions in the CB1 and CB2 receptors

that are impacted by the appearance of cannabidiol and are responsible for pain levels in patients with these neurodegenerative diseases.

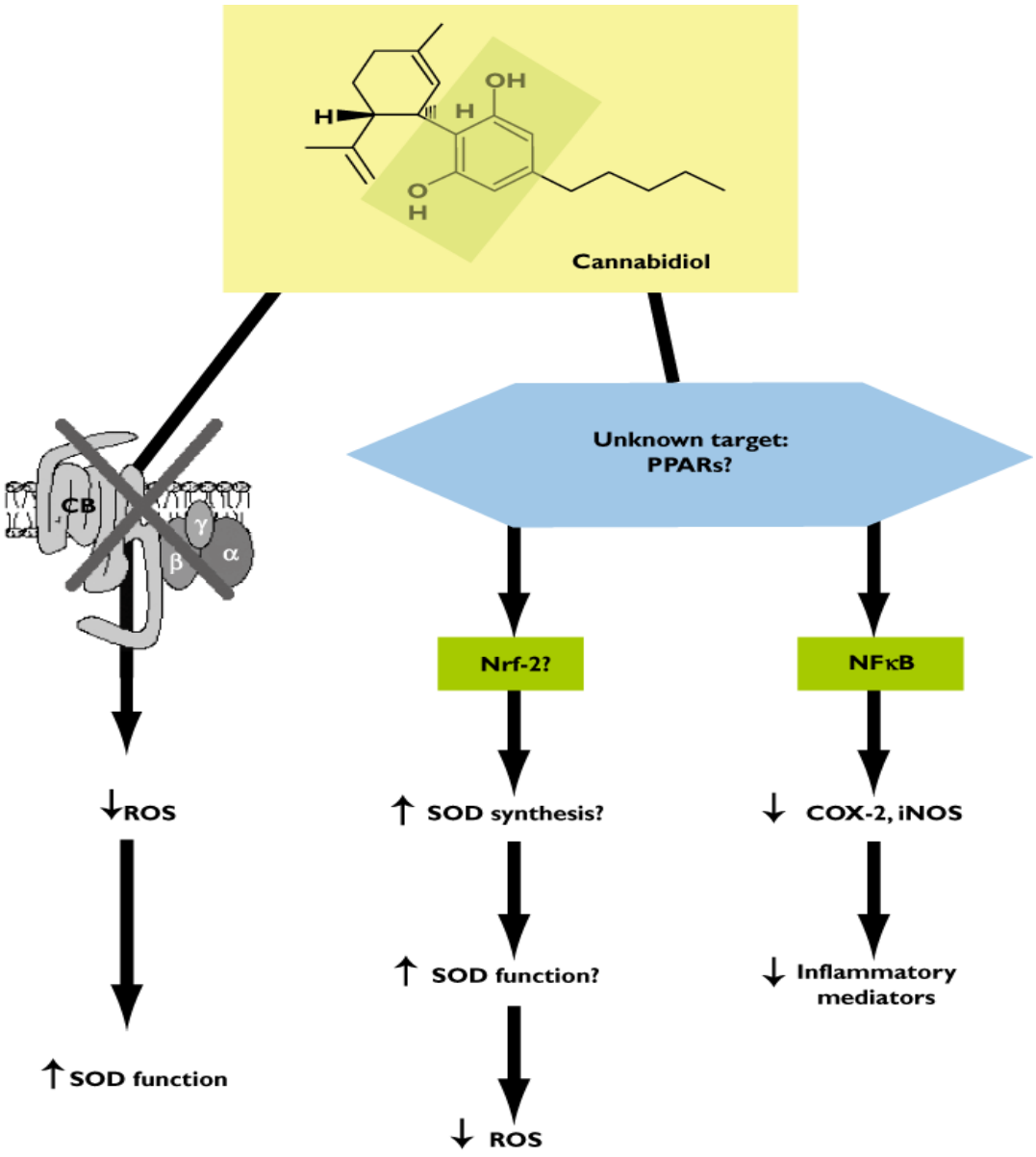

Figure 1: The chemical makeup of cannabidiol, (CBD) and some of the different functions that it promotes and doesn't promote.

III: Cannabinoids Effect on Patients With Alzheimer's

One of the diseases that CBD may be able to treat is Alzheimer's, which is one of the main diseases that researchers are focusing on, due to the positive results received from the various clinical and pre-clinical studies done in the past. In the study discussed in this literature review, these researchers focused on various symptoms that are very prevalent in Alzheimer patients. According to Herrmann et al, agitation, which is what the study focuses on, affects 20%-50% of all Alzheimer patients, which makes it an important symptom to research. Agitation is also linked to higher mortality rates, and increased caregiver burden. This study was a random controlled trial, (RCT), and is also classified as Class 1. They used nabilone, which is a man-made form of cannabidiol, to test thirty-nine patients, whose mean age is plus or minus 87. This study was done over the course of fourteen weeks, as for six weeks, these patients were given 1-2 mg of nabilone or a placebo, and followed up with a single-blind placebo for a week after each treatment phase.

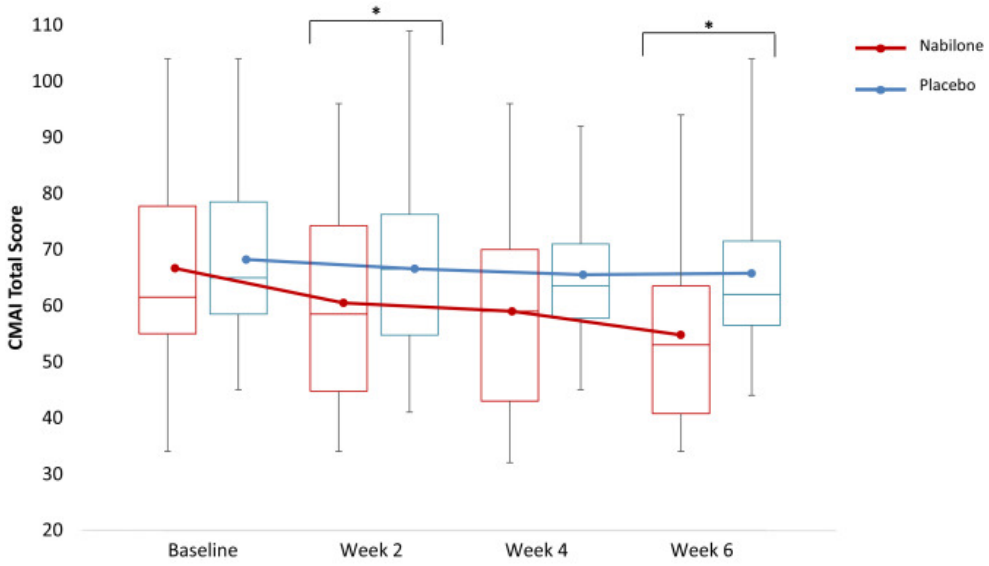

Figure 2: The results of the treatment over the course of the six week trial. (The line in the boxes represents the median and the dots on the line represent the mean of the results.)

The results of the study show that nabilone was clearly favored, as Figure 2 shows the clear decrease in the CMAI total score over the six-week period, compared to those that received the placebo. The researchers also note that while patients received the dosages for the treatment of AD, some experienced sedation, which was remedied by adjusting the dose or by adding in other drugs to help with the side effect. As seen in Figure 3, there are specific benefits of CBD, such as the reduction of inflammation in the endocannabinoid system.

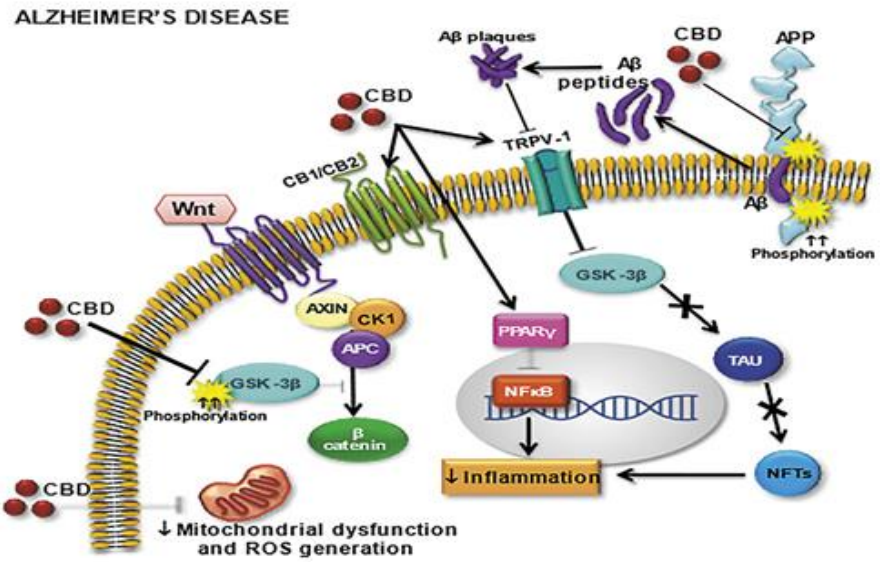

Figure 3: The main molecular targets of cannabinoids within the brain on Alzheimer's, including the endocannabinoid system.

IV: Cannabinoids Effect on Patients with Parkinson's

Another prevalent neurodegenerative disease in the industrialized world is Parkinson's disease, which affects nearly 1 million people in the U.S. and about 8.5 million people worldwide. It is specifically known for the symptoms that the patients experience, including dyskinesia (which is the involuntary tremors and jerks that patients exhibit in various parts of their body, like their arms, legs, face, or neck), and the amount of people that it affects, as

approximately 500,000 people in the United States are diagnosed with Parkinson's (PD). These particular studies covered in this literature review were examined by Lim et al. There were 3 studies, all RCTs, and all had 49 patients each. These studies all used nabilone to test the degree to which levodopa-induced dyskinesia was lessened in these patients by giving them the nabilone. The authors note that there was no clear sign of any bias. The author also discussed another study that gave 21 patients either a placebo or cannabidiol (75 mg/day or 300 mg/day) for 6 weeks. The results show no clear difference in their UPDRS score, but patients reported a significant bettering of daily lives and functions if they were in the 300 mg/day group.

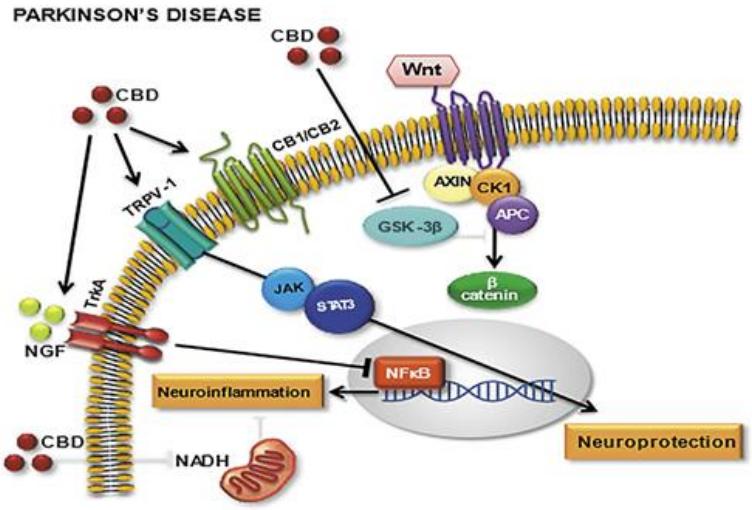

Figure 4: The molecular effect of cannabinoids of the CB1 and CB2 receptors and the specific molecular targets on Parkinson's.

V: Conclusion

This literature review went over the effects of cannabidiol, and some of the other variants, on different neurodegenerative diseases. The various studies that were mentioned in the literature review showed that cannabidiol was beneficial in general in the treatment of these diseases, although they had varying degrees of effectiveness based on what specific symptom

they were trying to address. Furthermore, many of these researchers believe that more research must be done on cannabinoids, and CBD in general, in order to create medication that is suitable for the patients and their needs. Also, with the increase in research, cannabinoids will become a more popularized method of treatment for patients with certain neurodegenerative diseases, as more information will become obtainable. So, in summary, more research should be done on the topic and the effects on the different endocannabinoids (CB1 and CB2). Legalization of medical marijuana as a therapeutic medication is also necessary, so that those who need it will be able to have access to it more readily, especially with the new research being published on the topic.

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Data Psych: Exploring the Cross-Relationship of Data Analytics and Consumers' Psychology

Esra Avşar

Introduction

The area that has been is everybody's mouths these days - data science - has been rapidly growing and evolving. Especially, with the wide-spread usage of media, the need for big data, big data, and data science have become increasingly visible. In addition, with the rapidly growing amount of accessible data sets all across the globe, psychologists have commenced to utilize these resources as well. Most specifically, experts who work in the business field.

A company must be aware of their target audience. It is not as easy as it seems to collect raw data and process it to a level where experts can make decisions based off of it. With the help of clustering data, business owners can project their customer base.

This review article will cover the usage k-means algorithm ,an unsupervised learning algorithm, in business models to determine future applications. To further discuss these applications, it is crucial to understand the fundamental differences between data science, data analytics, and big data, which we will do in the following section.

What is "Data Science"?

Data science is the area that help people find answers to unknown questions by asking questions, writing algorithms to extract data and building statistical models. Data scientists build their own automation systems and frameworks.

For example if a data scientist who wants to know how many cars are sold via a website called "Sahibinden" in Türkiye on a daily basis, they need to use frameworks and coding languages as well as the necessary data sets to build the tool to access the number of sold cars.

What is "Data Analytics"?

On the other hand data analysts, use the extracted data to obtain meaningful insights. So, data analytics include interpreting data that we have in hand to most likely develop a company, a business or an establishment.

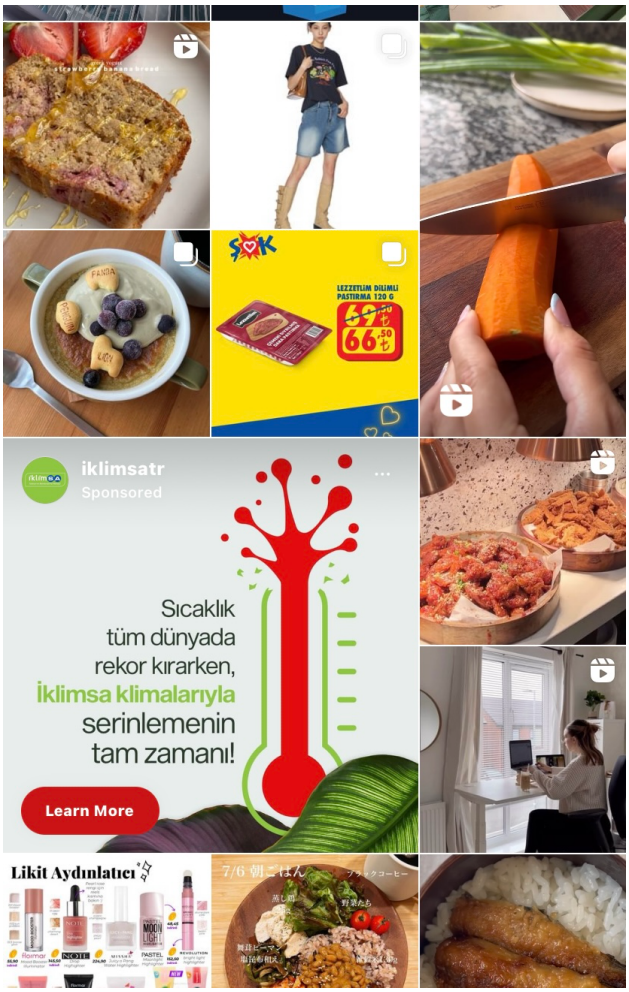
Continuing with the example mentioned before, a data analyst is the person who will utilize the data to gain perspective on the effectiveness of the website and determine what marketing principles can be followed to improve.

What is "Big Data"?

Data sets that contain large chunks of data can be defined as big data. Unlike conventional data sets, it requires special processing to examine. Nowadays , big data can be found in every branch of life including: governments, sciences, healthcare, and the most importantly business.(1)

K-means clustering algorithm and its applications for consumer behavior:

Have you ever come across with a shoe advertisement right at the time you are planning to buy one? Well, that is most likely because every click people make is being recorded. Most people, at some point have thought that someone was spying on them because the minute they start thinking about buying something or they get interested in something, it pops up in their feeds.



Above we can see Esra's Instagram feed. By looking at this example, it is obvious that Esra likes consuming food content on her social media, also she likes following fashion. So, she is more likely to see advertisements related to food, clothes, etc. Instagram clearly indicates that they collect data of one's usage of their products; they collect information regarding how someone uses their product such as the types of content that one views or engages with, the features one uses, the actions one takes, the people or accounts one interacts with and the time, frequency and duration of one's activities. They claim that they use this information to provide, personalize ,and improve their products which is necessary for business growth. (2)

The large pool of media users makes it possible to gather information regarding their preferences as mentioned above in the example. Traditional ways of compiling data such as interviews, study groups, having conversations about the purchase, etc. are very much confined, also it is difficult

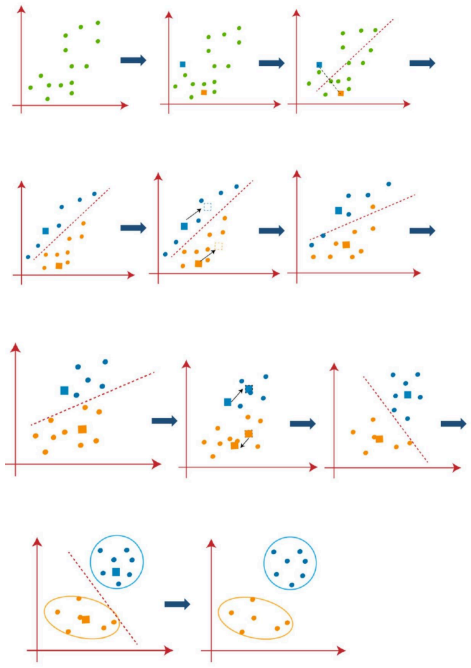
to scale customers' records, feelings, their lifestyles through observations and conversations held in the stores.(3)

Therefore Web Usage Mining (WUB) is a hot topic for many business establishments. WUB helps businesses understand the collected data and gain benefits from it. Some of the web mining techniques include statistical analysis, association rules, sequential patterns, classification, and clustering.

One of the most popular ways of clustering which divides the components in unsupervised learning is called " k-means algorithm (MacQueen, 1967)". The goal here is to turn the raw data ,especially related to Web browsing patterns, we obtained through media platforms into a structured one, and later on make decisions for our business model. (5) Unsupervised learning algorithms learn patterns in unlabeled data sets, and group similar ones. When grouping the algorithm uses distance, density and various statistical distributions. The k indicates the number of non-overlapping clusters (also the number of centroids) we are planning to get at the end of the whole process. (6)

The algorithm selects centroids based on the number of cluster we determine (k). And the data points get assigned by the algorithm to the nearest cluster center (the means in k-means points out the averaging the data). (7)

In order to start processing the data we need a technical problem to set an example. Every data scientist start with a simple question to gather data and build the algorithm as an answer. Therefore, the first step of k-means clustering would be determining the criteria and the fundamental problem they will be tackling with.



The image above was taken from https://www.javatpoint.com/k-means-clustering-algorithm-in-machine-learning (8)

As we can see from the image above, k-means cluster analysis is composed of many steps including revisions. The bigger the data set is the more revision needs to be done to relocate the centers accurately. The following steps are:

1. Assume that we have two different variables M1 and M2.

2. The number of clusters as clarified before as k, will be defined as two.

3. Later on, the determined centers should be placed randomly on the scatter plot.

4. In the next phase, we should identify which data points are close to which one of the centers by dividing the dataset into two clusters. (In the image above it is demonstrated by coloring the data points differently.)

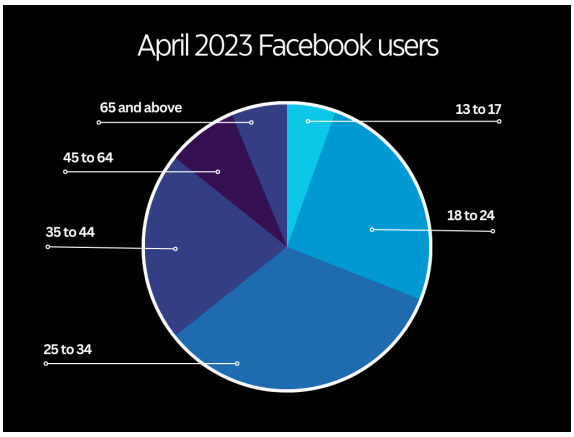
5. After all of these steps, the whole process should be repeated by choosing a new centroid location to find the closest cluster. This repetition takes place up until there are no dissimilar data points on either side of the line.

6. In the end, after the clusters are formed, the imaginary centroids can be removed.

After using k-means algorithm to cluster, data scientists have data analysts and psychologists to handle the data and interpret. Customer segmentation is the process of using clustering the customer base to investigate a certain feature in groups. The segmentation differs accordingly such as firmographic, geographic ,behavioral, psychographic, and demographic.

Psychology deals with specifically psychographic segmentation. Understanding a group of customer's usage pattern is essential when a company tries to understand the connection between their product and the mindset of their customers. This type of segmentation (Arnold Mitchell, 1980) can be traced back to the VALS (Values, Attitudes and Lifestyles) model which leverages data for market and business model research. We are more likely to make the right decision for our business if we have the right idea of how the target audience thinks.

There are many aspects of personality that can be examined under the topic of consumer behavior / psychology. It would be rudimentary to say we can completely predict a person's vision on a product. For instance, some people are habitual buyers who typically make purchases without questioning the quality or the price on a regular basis. And some people look for variety when it comes to buying; they prefer to have choices in regards to make comparisons. However, it helps to see how people interact with a certain a concept to make a prediction.



- The represented data above was taken from Meta's advertising resources, using the latest available data in April 2023. (9)

The pie chart demonstration above gives us is the simplified version of the data provided by Meta advertisement. To understand the data more efficiently, I preferred to have the clusters in a pie chart form. As an example we can base someone's age. Age is a big indicator of a person's lifestyle, social status, life views etc. According to the research (10) personality changes as a person gets older. Apart from lifestyle changes, age also effects the perception of different resources. Some researchers suggest that print media is more effective for older people since they can self-pace the information presented within this media (11). So it does have a big impact on how much a customer is willing to make a purchase, what type of products they buy and what kind of media platforms they get advertised from the most. Above, it can be seen that Facebook is predominantly used by young people and young adults. That means if a company's target audience is people within 18-25 age range, they can consider advertising on Facebook.

K-means clustering is an advanced algorithm even used in the present implications which shows how far we have come with artificial intelligence and data science applications. Merging these implications with consumer psychology and behavior analysis, businesses can come up with powerful tools. K-means algorithm is an unsupervised learning therefore training the algorithm will be sufficient to achieve find patterns and groupings in unlabeled data sets. Trend forecasting is basically the execution of predictive analysis by artificial intelligence with the help of consumer psychology. In order to practice this as accurate as possible, we should scan many platforms to identify the top-selling products.

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The Future of Privacy Within Artificial Intelligence

Fenet Diriba

Artificial intelligence has been a recent phenomenon within social media and news. Though, not many are quite informed on its history and future within society. In fact, despite the recent popularity in the media. Artificial intelligence has actually been around for quite a while, longer than most expect. Whether that be in Greek mythology or Frankenstein himself, AI has been prominent in societal cultures for a while now. Though, despite its long history, one common theme that has seemed to never leave is the ethical question of Artificial intelligence. Regardless of the time period there always seems to be implications of privacy and human rights. It begs the question of " How has AI compromised the privacy of all technology users ?". Although there isn't one sentence to answer these questions, there are research findings that may guide and inform on this concept. AI has caused privacy concerns that has sparked responses of tech world solutions and deep dives into the relation between data and AI. Research findings have unveiled the many tech world CEOs who have come up with their own solutions or ideas on tackling the fight with privacy concerns and AI. In one source, all the efforts and attempts by the U.S. government to regulate AI are highlighted. In another , it addresses the CEO of Google's take on AI and all the privacy risks within its development. Then lastly, it is unveiled that not all pieces of AI involve data and there are companies that don't risk privacy concerns. Though when it comes to research on deep diving into Artificial Intelligence and how it interacts with data there are research findings that highlights the history of AI, one's that dissect the process, and ones that acknowledge all points and aspects. Artificial Intelligence has caused a huge risk of privacy for all those who are users of the internet and/or any social media platform. There have been many debates and concerns with how to tackle this problem as it may cause a huge security risk within the future. Those who most want to hear from are the ones who are directly working on artificial intelligence, those in the tech world. In this article, it addresses all the government has and intends to do to circumvent the concerns regarding user privacy in relation to AI.

As AI has been on rapid advancement this past year, the Biden administration made a new effort to tackle all the ethics concerns that may come with this sudden increase in AI within daily lives. Many administrative officials from the White House, including the vice president met up with CEOs of companies such as Google, Microsoft, openAI, and Chatgbt. This meetup involved a conversation about the fundamental responsibilities these large corporations have. The fact that, as the evolution of AI goes on, the privacy of users is guaranteed. As AI advances, it will become more powerful and independent, which could compromise the safety and protection of US citizens. In a statement, the White House said "AI is one of the most powerful technologies of our time, but in order to seize the opportunities it presents, we must first mitigate its risks," . In this statement, the White House is vocalizing that they recognize the many achievements and potential of AI but before they open up to its contributions. The ethical concerns within AI need to be addressed first. The president vocalized that in the conversation about AI, the people are the priority in supporting AI inventions that serve the greater good by protecting security and the economy. Although the Biden administration has made many efforts to promote an ethical evolution of AI, congress has not passed any laws that would rein in AI.Despite the lack of laws, the administration has uncovered an AI Bill of Rights, an AI risk management framework, and a roadmap for a national AI research resource. Though some say that these don't have any legal teeth and are more of just a guide. Despite their attempts at creating a solution to this rapid concern about the ethics of AI, their resources aren't that helpful in tackling the problem. An analyst at Gartner Research, Avivah Litan, vocalizes that although the attempt by the government is appreciated, they need to step up both in their game and pace. As the popularity of AI went on a huge surge, Chuck Shmuer announced efforts to establish a set of rules around AI so all things involved in AI technology would be held accountable. A plan for the national science foundation to spend $140 million on seven research centers specifically dedicated to AI, is a part of the White House initiative. The administration also said that an independent commitment form including a public evaluation of AI systems with disclosure prices was agreed by many leading AI developers such as Google, Microsoft, openAI, and Anthropic. Many technologists have found it alarming how rapidly AI has come from improving tasks to generating photos and videos

indiscernible from actual images. Hinton, better known as the “godfather of AI”, stated that with AIs, a self-learning nature, there is a chance that, as it advances intellectually, it may lose the need for human prompting. Author Thomas Siebel describes the near future of AI and its ability to mimic any news report , photo, or video made by humans. Blurring the lines between what's real or fake can cause a big disturbance in society (Mearian, 2023). Similarly, the CEO of google has also had his own perspective on this issue. Google's CEO warns the public to adapt as AI begins to advance rapidly. Although programs such as ChatGBT and Bard can produce confident responses, the results aren’t quite 100% accurate. An example, ChatGBT has a sexual harassment scandal involving a real-existing law professor as the perpetrator with citation of non-existent articles about the “case”(Pappas, 2023). Many experts are very concerned with the overall development of AI as it can enhance human bias and interfere with employment. AI chatbots produce their responses by writing something they deem as “human-like” through statistical references of the next likely word of a sentence. This ability comes from their extensive training on pre-existing pieces of text. This tends to result in a confident answer from the AI, but it’s not necessarily understanding its response. The responses someone may receive from a chatbot isn’t the correct answer but the answer it believes the person wants to receive. Although ChatGBT was programmed in a way that ignores any racist or sexist responses, in reality, as AI consists of human values, there is no way to avoid these prejudicial values. Google CEO, Pichai warns the public about the future of disinformation as AI evolves. Already, “deep fakes” have become a lot more advanced in the past year. Pichai believes that regulations and pen treaties are a necessity in tackling the ongoing advancements within AI. He believes the development of these machines should also consist of social scientists, ethics, and philosophers as a start and not just up to the company(Pappas, 2023).

Lastly, With information on one's individual mobile and contact interactions, a machine can accurately choose the person out of 40,000 phone service subscribers(Ogasa, 2022). This means that using the socialization habits of humans, AI can detect humans from datasets that are supposedly anonymized. Since people tend to stay within their established social circles, a pattern is detected over time. Any company that gathers data on people's daily interaction is capable of selling and/or sharing

without the consent of the user. In an experiment, researchers at Imperial College London used an artificial neural network to recognize the patterns within users' weekly social interactions. They represented a mobile phone service that had about 43,606 subscribers' interactions over fourteen weeks(Ogasa, 2022). The data consisted of the date, time, duration, and type(call or text) of all interactions. It even included the involved and parties and which of those was the initiator. Each user's data was organized into data structures that stored nodes representing the user and its contacts. There were strings that connected the nodes with the data. Ai was then shown the web of interaction and set loose to search for the supposedly anonymized data on the web for the closest similarity. This led to the neural network linking about 14.7 percent of individuals to their anonymized selves. When given contact names as well as the target interactions, the percent of people identified rose up to 52.4%. These findings probably don't apply to the contact tracing protocols of Google and Apple exposure notification systems(Ogasa, 2022). They protect the privacy of users through encrypting all Bluetooth metadata and banning the collection of location data. Despite how challenging an obstacle can be there will always be something to facilitate the process, in this case there are many ways to control and regulate this new risk of AI.

Although, there are many conversations regarding how Ai risks the privacy of internet users, not many actually know the process and how it even leads to that point. Though in these sources, the data process of Ai is analyzed to a distinct point.

A digital footprint, a trace of all interactions and actions on the internet. We all have one, specifically dedicated to ourselves. An individual can be identified through the data points that become more detailed with every other act on the internet. Each purchase on Amazon, tweet on Twitter, or post on instagram consists of multiple data points of IP addresses, geographic location, credit card information, language and grammar, gender, race, etc. Many social media platforms, such as Facebook, Twitter, and Tik Tok. All use mobile applications to gather locations, photos/videos, likes, browsers, and even how long it may take someone to look at a post or advertisement. Biometrics or anything copied onto one's clipboard is also copied by Tik Tok, including usernames and passwords. Every email

sent and received by a Gmail user is also copied by Google. In a study by students from the University of Cambridge and Stanford, they found that 10 likes and facebook knew someone more than their coworkers, and by 70, their friends, and all the way up to 300 to surpass a spouse(McLaughlin). Admittedly, a good amount of the data collected is being used to personalize the user experience. A good portion is also going to data-driven technologies that will become a vital addition to the future. To simulate human inferences within the machine, developers need large quantities of data to train the AI. For example, in the near future, with enough quality data, Ai will be able to diagnose the onset of an illness in a way that modern medicine is incapable of(McLaughlin). For incredible advancements such as this, high-quality data and gatherers and shared data from multiple sources is needed. Though data such as this is not acquired freely nor centralized within western democracies and is usually used for commercial reasons. Other regulations for this type of data are the Health Insurance Portability and Accountability Act. The U.S. 's competitor, China, is also going through a neck-breaking pace of AI development. However, one distinction is the lack of restrictions for Chinese developers on data collection. Whenever a video is uploaded onto tiktok, ByteDance(the parent company of tik tok) uploads the data for training its voice/face technologies and deepfake technologies. When China's “safe city” products receive an installation from HikVision or Huawei servers, the data is input to train China's AI. Genetic sequences of women and children worldwide are harvested when a female gives her blood sample to China’s BGI group(McLaughlin). In another article the privacy calculus theory is applied to a real life experiment on privacy concerns within AI. AI-driven applications lead ro undisclosed and undesired data usage. Privacy within data has become a critical issue within this informational age. It represents an individual's control over the release of other personal information.

The theory suggests that someone's decision to disclose versus keep information is a decision chosen through weighing the benefits and costs of information disclosure. Privacy *concerns* refer to individuals’ general beliefs about the risks and potential negative consequences of sharing information (Zhou and Li 2014). A vital part of making an effective AI public service is to access user data. Though, users might avoid sharing their information when using. Even if it states they might not trust their

information is limited to the described reasons. Findings say that customers tend to prefer businesses that communicate their data privacy policy and offer more information on online privacy. Despite its long standing existence one thing about AI that seems to be a recurring theme within history is its compromise of privacy and human rights. AI systems are capable of singling out and identifying individuals who are supposedly not identifiable from an inputs dataset perspective. So even in circumstances where someone wasn't supposed to be identified, an AI system can accidentally identify them and expose the individual to unpredictable circumstances(Casella, 2022). Despite popular belief, not all AI uses users' personal information. For example, 5G networks target things that don't relate with privacy data like improving infrastructure quality. The three key interfaces within an AI system are Input data, the black box stage, and output data. Input data is any dta given to the AI model. At this step there needs to be established regulations as the outcome of the data can't be determined. During the Output data stage, there can still be surprise outcomes despite the efforts within the input data stage or black box data stage(Casella, 2022). In summary, AI has many components that result in its gathering of data and it all correlates to the advancement of the machine itself.

To sum it all up, A prominent feature of artificial intelligence is gathering a bunch of data and using it to advance its technology. So, the use of data is inevitable, though the ethics in which the data is used can be regulated. As stated and described above there are already many approaches taken to tackle this problem. Though, there is so much more that needs to be done to catch up with the pace of its development. Despite all of its negative components there are many positive and beneficial things AI offers and it wouldn't be smart to completely shut it down over dislikes of certain aspects. AI in today's society has resulted in the planning for future solutions and analyses of the development of the machine.

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An Ethical Perspective of AI for Healthcare Systems in Developing Countries

Keshav Chinnakotla

The transformative power of artificial intelligence has changed the way people, cities, and even countries operate. Especially in the global healthcare sector, where the market has had a compound annual growth rate of 42% (Bohr), AI has changed and will continue to change the way the world is structured. However, with this growth in healthcare there is one facet of AI that hasn't been addressed to a substantial extent--ethics. Questions of ethics within AI in healthcare stem from safety concerns, such as data transparency, racial discrimination, malicious preferences (Jain). The threat of unethical AI is increasingly relevant today, especially considering that such systems have disproportionate impacts on minority communities, or even create vulnerabilities and risks for entire healthcare systems. Additionally, in developing countries where healthcare systems are particularly vulnerable to weaknesses, unethical AI has a more significant ability to harm individuals. Considering the threats that unethical AI may pose, some form of understanding and future direction is needed to create a framework for ethical artificial intelligence in healthcare. This literature review will 1] cover the development of AI within healthcare systems of developing countries, 2] view the negative and positive consequences of AI in these regions through an ethical perspective, and 3] discuss possible solutions to the ethical dilemmas of AI, while suggesting common consensus on the issue. It does this by analyzing various population studies, participant observation studies, and mixed method analysis done by different researchers in the field.

Figure 1: Disparity of access to medical technology in low-income countries. (Mollura)

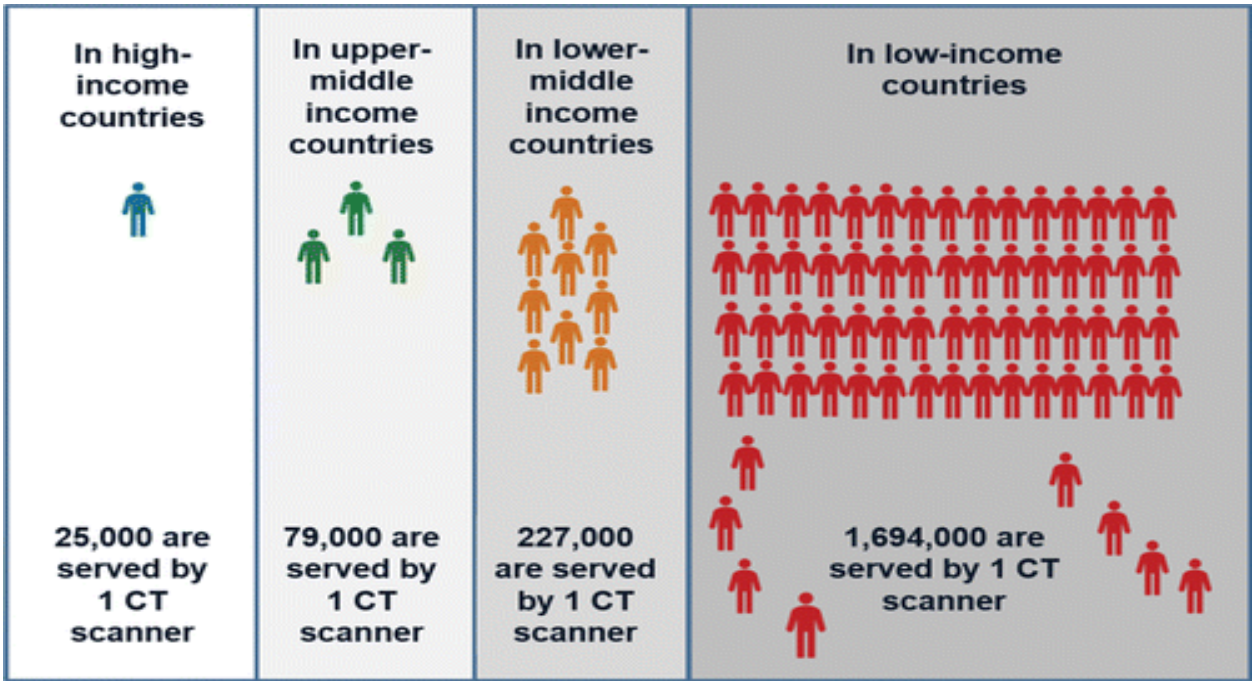
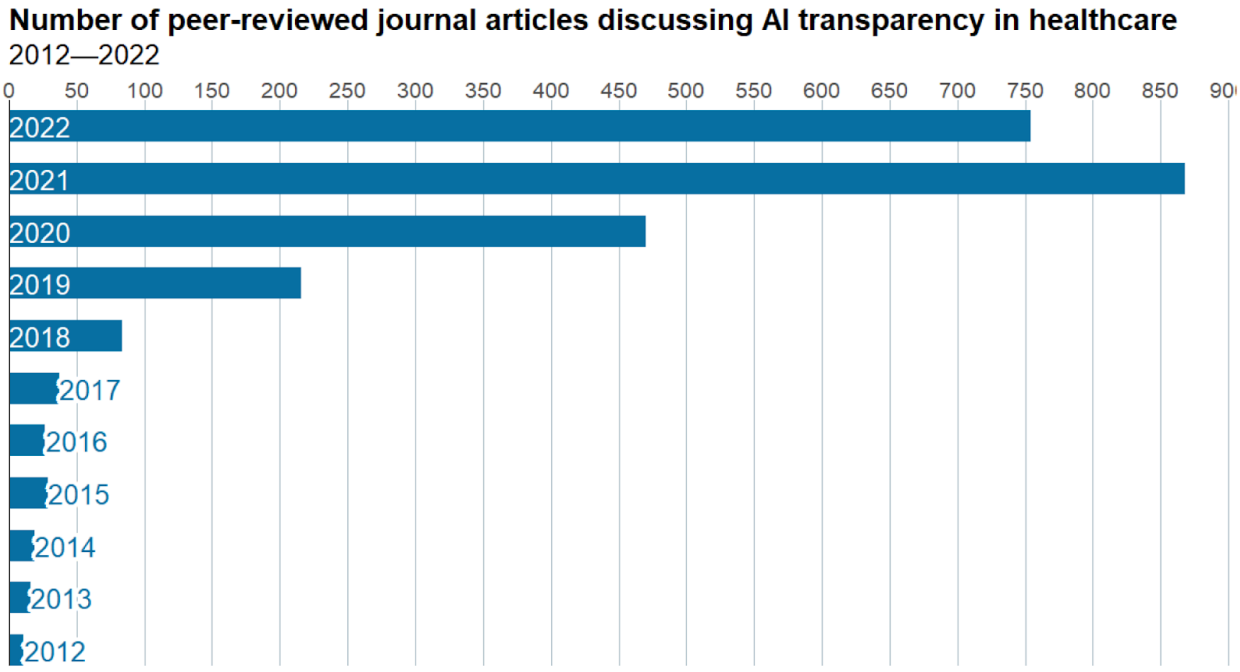


Figure 2: Relevancy of the ethics of AI in healthcare over time. (Bernal)



Artificial intelligence in healthcare systems of developing countries around the world has immense capability, and the material benefits of such technology have proven beneficial.

Medical expert systems can act in place of a human professional if one is not available, as is mostly the case in developing, resource-poor countries (Wahl). Predictability can also be achieved to a much greater extent. For instance, researchers from Brazil recently developed an AI model to predict birth asphyxia for use in developing countries, and the model has proven effective with a 95% success rate for identifying the need for birth asphyxia in medical centers (Wahl). Artificial intelligence has also been used as a detection system for disease in certain resource-poor countries. A machine learning model named MAI has been deployed in Kenya, Egypt, and Gambia for identifying life-threatening sickness in outpatient clinics, with an 88% success rate in the process (Owoyemi). Additionally, nurses in South Africa utilized the Computerized Aid To Treat (CATT) system to assist in drug prescriptions, relying on a cost-and-effectiveness algorithm (Owoyemi). Not only has artificial intelligence created new developments in the medical sector, but also it has built upon existing technology to enhance certain processes. For instance, companies in India have been using AI to aid in radiology, specifically through a deep learning system called ICON (Mahajan). Ultimately, AI has great opportunities in developing countries. However, despite such benefits, there does exist risk in regards to developing an ethical implementation of such AI systems.

Although there are material benefits of artificial intelligence in these countries, ethical privacy concerns are a major issue that create adverse consequences in the sector. The major facets of privacy issues comes from the fact that 1] AI can collect data without the consent of patients and 2] the data collected by AI can be used for a plethora of intents without the knowledge of patients. Facial recognition technology is largely responsible for collecting data without consent (Kooli). Specifically, it constitutes a threat to informed consent, as in a majority of cases the patient is unbeknownst to what specific features of the face are recorded by machine

learning algorithms, meaning companies can get access to a larger range of data without a patient's consent (Kooli). Such privacy breaches are even more dangerous in developing countries, as most have weak legal frameworks that are not very comprehensive in regards to the issue of privacy (Weissglass). This can create a regulatory gap, making it easier for personal health information to be mishandled or exploited without sufficient consequence. Considering these unprepared legal systems, it's important to evaluate the extent to which AI should be allowed in healthcare, or at the very least assess the legal system in a reformative way. Additionally, even if the patient consents to certain data collection, there still exists ethical concerns as to what the data is actually used for. In fact, especially in predictive analysis algorithms, third parties can leverage artificial intelligence to perform tasks that patients are not aware of (Cohen). Essentially, if predictions of a patient's healthcare status fall into the wrong hands, it could lead to discrimination, stigmatization, or an outright denial of insurance coverage based on perceived health risks. This adverse consequence is especially applicable to those in developing countries, as many already have very low access to healthcare systems, entailing that artificial intelligence could possibly enable a further barrier to entry toward obtaining healthcare for these individuals. Ultimately, data privacy concerns regarding artificial intelligence in developing countries could create further difficulties for an equitable system of healthcare. By weighing the possible opportunities that AI could provide to these people against the chance of barriers, decision makers should come to a consensus on the matter.

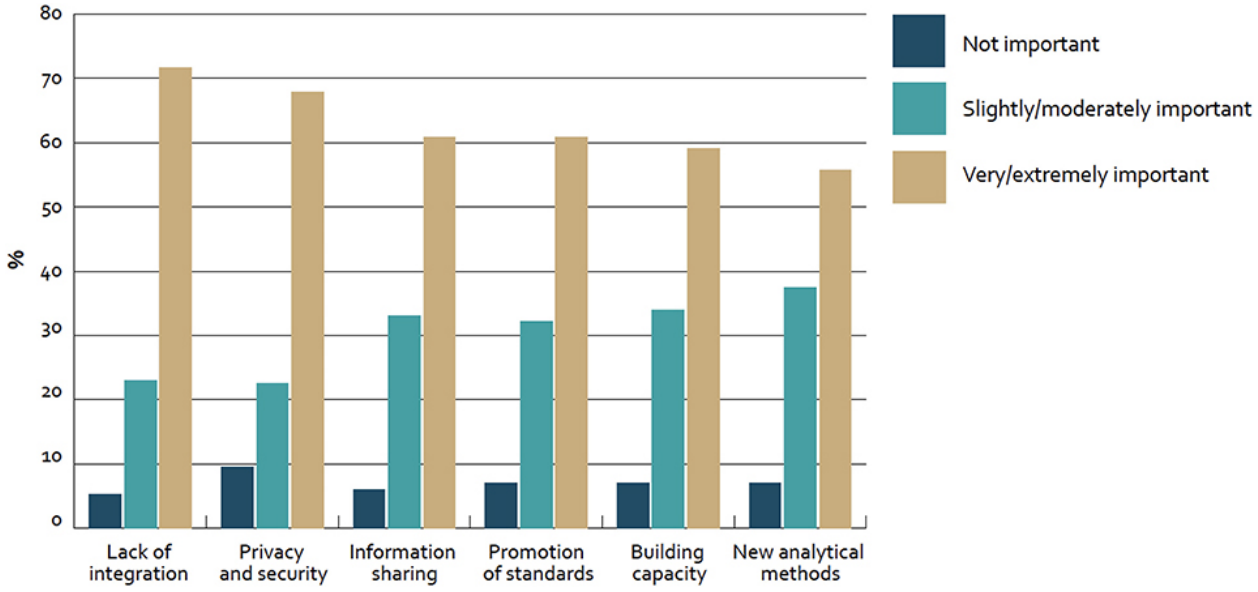
Figure 3: Comparative magnitude/severity of ethical privacy risks associated with AI. (Kooli)

TECHS

Benefits	Risks	Risk priority number (RPN) Occurrence (O)	Severity (S)	Detactability (D)	RPN
Improving efficiencies for the operational management of healthcare businesses	The fast pace of technology and impact on decision-making processes	10	10	6	600
Accuracy of diagnosis and treatment in personal medicine	Moral hazard and human intervention	5	10	5	250
Increased insights to enhance cohort treatment	Lack of regulation and algorithm bias	10	10	9	900
	Privacy pressures	10	10	10	1,000
	Safety	10	10	10	
	Human errors	5	10	10	500

Table 1.
RPN, benefits and risks associated with the application of AI in the healthcare sector

Figure 4: Relative importance of the privacy concerns of AI in healthcare -- survey of 125 countries by the WHO (Wolff)



Not only are privacy concerns an issue with AI in healthcare, but also the risk of bias within these machine learning systems can have major repercussions. One such bias area is racial bias. For instance, in Egypt, recent implementations of AI in healthcare detection systems have "mislabeled" black individuals as low risk of disease contraction even if they were actually high

risk (Aquino). Such findings are not coincidental either, but rather more systematic. Comparing such black individuals to those of a majority race in Egypt, the AI algorithm was shown to be significantly more biased against the black individuals (Aquino). Such findings demonstrate how widespread the issue of systemic bias against such individuals is, and how AI only keeps such unjust institutions in place.

Not only does racial bias exist for AI institutions in developing countries' healthcare systems, but also gender bias is a major issue in the field. AI algorithms might unintentionally reflect societal biases, which can be especially significant in developing countries where stereotypes and traditional gender roles exist (Cirillo). Essentially, engineers who develop the AI in these countries have predisposed stigmas of gender traditions, and consequently they include such predispositions in the algorithm. Such biases against women in healthcare can affect a variety of important decisions, such as resource allocation, research priorities, and health policy (Cirillo). The inclusion of gender evaluation within the algorithm, and subsequent risks of such an inclusion, reveals the major systemic bias that exists within AI in healthcare. In order for AI to be an objective system for the betterment of all groups and people, decision makers must come to a consensus.

Although these ethical concerns do exist, there are solutions being explored which developing countries can take to prevent such issues. One major stride being taken is creating accountability systems. Accountability systems for AI in healthcare stem predominantly from two regulations: 1] Creating clear forms of patient-doctor-company consent relationships in regards to the data collected by machine learning models, how that data is used, and what the implications of using the data are 2] Developing clear ethical guidelines for standards of development and legal liabilities for any problems caused (Floridi). This solution addresses the

issue of data consent and legal framework concerns, which would handle many of the root cause issues regarding AI in healthcare. Another approach centers around funding more comprehensive artificial intelligence models (Karimian). A predominant reason that many of the ethical concerns of AI in healthcare for these countries exist is because of the lack of funding for proper models (Karimian). Thus, the solution involves funding private entities to engage in more rigorous testing and validation, which would create representative datasets that are free from bias. Such funding endeavors have been recently South American in countries like Chile and Venezuela (Karimian), revealing their widespread and practical use. Decision makers should leverage possible solutions to determine the most efficient manner which would maximize the benefits garnered from AI.

The integration of AI in healthcare systems of developing countries holds immense potential to revolutionize medical care and improve patient outcomes. Future research in this field should focus on identifying additional areas of ethical concerns in AI, along with finding more specifically tailored solutions to the issues within particular countries as opposed to finding a one-size-fits-all solution. With proactive efforts, a robust ethical framework that safeguards the interests and rights of patients can be built while embracing the transformative power of AI in advancing healthcare in developing countries, but it’s up to future researchers to evaluate the most effective manner to do this.

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Uncovering the Pathway and Mechanism Behind Tooth Pain

Michelle Zheng

I.Abstract

The presence of a toothache can be signified by either a dull lingering pain or an immediate sharp piercing sensation. While it's known that inflammation of the dental pulp results in oral pain, the dental nerves' pathways that transmit the pain signals are a more complex concept. The painful sensation experienced isn't inflicted by the cavities themselves but rather by the infected pulp. This article examines two different pathways and mechanisms of oral pain. With a deeper understanding of the different pathways that transmit pain signals to the brain, dental professionals could develop better treatments for people affected by oral pain.

II. Introduction

According to the WHO Global Oral Health Status Report conducted in 2022, roughly 3.5 billion people worldwide are affected by oral diseases. Out of the 3.5 billion people, nearly 2 billion suffer from permanent teeth cavities, while around 514 million children suffer from primary teeth cavities [11]. The prevalence of these oral diseases continues to escalate globally in line with increasing urbanization and changing living conditions. This rise can primarily be attributed to insufficient exposure to fluoride, easy access and affordability of high-sugar content foods, and inadequate oral health care services within communities [11].

In this review, I will examine the different pathways that nerves travel through to transmit oral pain. A better understanding of these pathways can help researchers in the dental field develop better preventative measures and treatments when aiding oral pain. To examine these pathways, we need to first understand how dental pain begins.

III. Cause of Cavities

Bacteria such as Streptococcus mutans often proliferate above the gum line, producing lactic acid. As shown in Figure 1, the bacteria lives above the gumline which makes it prone to sucrose from food. The sucrose aids in the production of lactic acid; the presence of lactic acid can penetrate the tooth enamel, which can lead to the formation of caries (cavities) [6]. Caries then destroy the enamel, causing inflammation of the pulp [10]. When the pulp is inflamed, the nociceptors in the pulp are activated. Depending on the simulations, either A-delta or C fibers will be alerted [3].

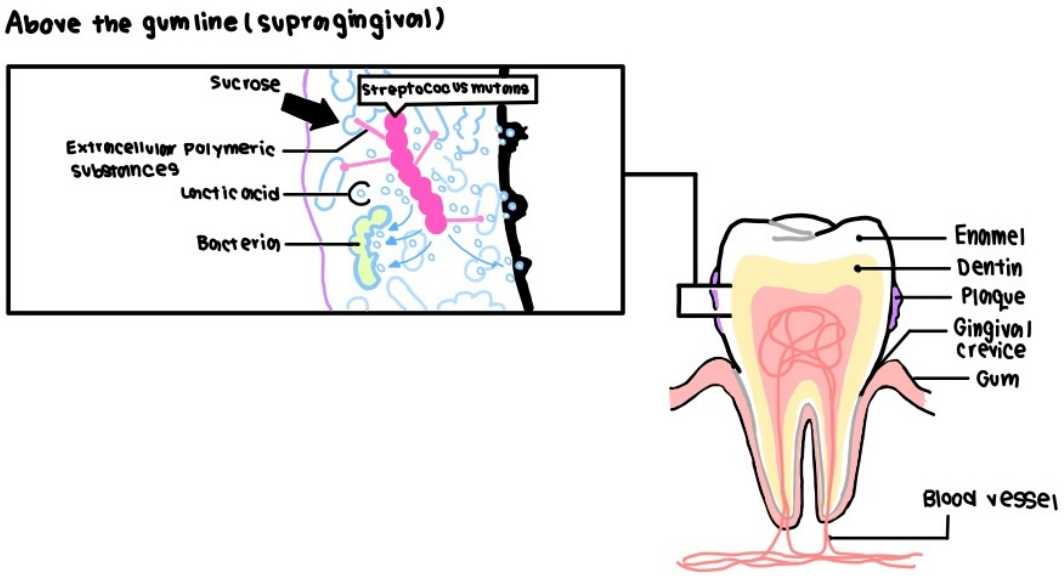

Figure 1 - Sucrose comes from food such as candy. When sucrose lingers on the dental plaque, it can feed bacteria such as Streptococcus mutans. Sucrose speeds the production of lactic acid which could result in holes in the teeth and damage to the enamel and dentin.

IV. Role of A- delta and C Fibers

A-delta fibers respond to mechanical or thermal stimuli while C fibers respond to chemical, thermal, or mechanical stimuli [9]. A-delta fibers are characterized by their sharp and short-lasting pain while C fibers are known for their dull, lingering pain. Similar to A-delta

fibers, C fibers are responsible for transmitting burning and itching sensation but the signal doesn't reach the brain at the same speed, as C fibers are slow conductors [5]. The fibers are located at different regions of the tooth as demonstrated in Figure 2.

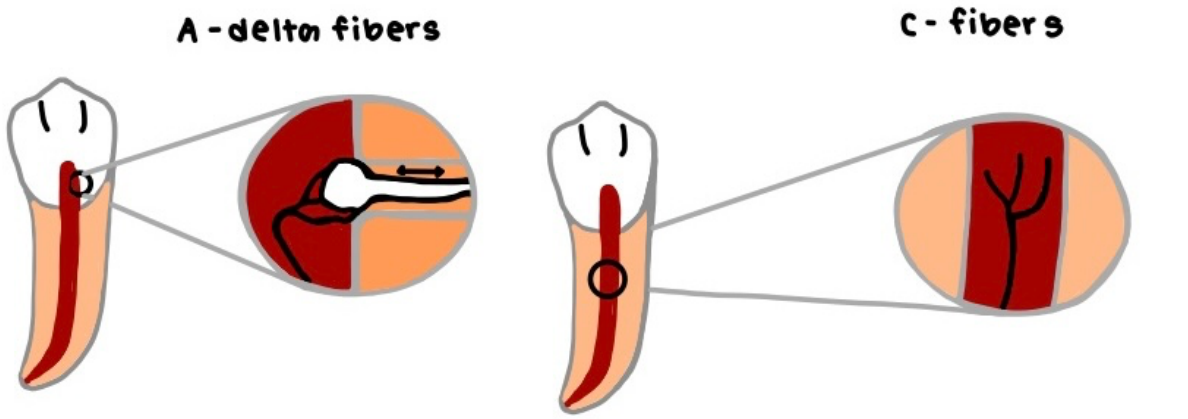

Figure 2 - A-delta fibers are located near the dental pulp meanwhile the c-fibers are located further down the root of the tooth.

V. Pathway of Oral Pain

Pain stimulation from tooth pain travels through the A-delta and C fibers and the dorsal root ganglia until they reach the central nervous system. The pain stimulation then travels from the dorsal root ganglia to the trigeminal nerve near the temple. The trigeminal nerve has three different divisions that the pain stimulations can travel: ophthalmic, maxillary, and mandibular [3]. The first-order neurons at the trigeminal nerve will develop pain signals that will travel to the trigeminal ganglia. Later the pain signals are sent to the second-order neurons located at the trigeminal nucleus caudalis. Lastly, the signals are sent to the third-order neurons at the thalamus which is the brain’s relay station [8]. At the thalamus, the signals will be transmitted to the

cortex; the electric simulations will result in a painful sensation [9]. However, there isn't only one pathway when transmitting oral pain.

VI. Process of Neural Communication

For neural communication to be possible, the neurons undergo action potential. When the neurons are at the resting stage, there is a negative charge inside the membrane and a positive charge outside; the imbalance of electrical charge is referred to as the resting potential of the neuron [1]. This imbalance of electrical charge is maintained by the sodium-potassium pump, with more sodium ions outside of the neuron and more potassium ions inside the neuron. When the neuron receives a stimulus, the ion channels inside the membrane open. This stage is known as depolarization. When the ion channel gates open, sodium ions enter the cell which makes the inside of the membrane more positive. If the change in voltage can exceed a specific threshold, an action potential will occur [12]. As shown in Figure 3, the threshold needed for action potential to occur is approximately -55 mV. When an action potential is triggered a chain reaction results in more sodium channels opening further down the axon. During an action potential, the inside of the cell becomes more positively charged. At the end of the action potential, the neurons release chemicals called neurotransmitters [7]. The neurotransmitters are responsible for relaying messages between cells and aiding in bodily functions.

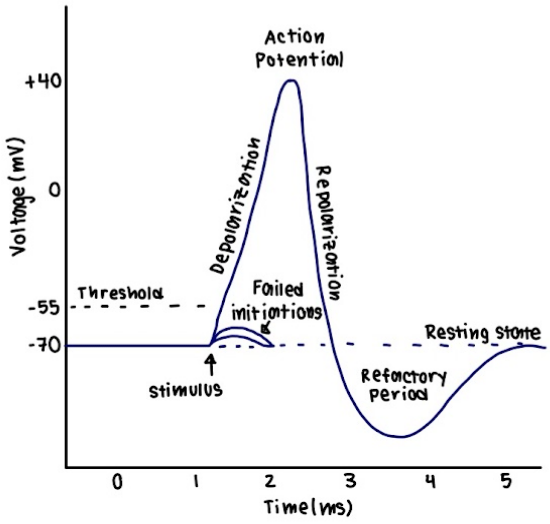

Figure 3 - As indicated by the graph, the threshold is approximately -55 mV; once depolarization hits around -55 mV, action potential will fire. This will follow up with repolarization, the refractory period, and the resting stage.

VII. Newly Discovered Pathway

It's believed that the temperature change puts pressure on the fluid in the dentin's tunnels, causing the nerves to be stimulated. But not much was known about how an individual's body perceives the change. Dr. Katharina Zimmerman at Friedrich-Alexander University discovered a new pathway via TRPC5, a channel protein inside the odontoblasts that is activated by a GPCR when she was completing postdoctoral research at Harvard Medical School [2]. When experimenting with mice that had the TRPC5 protein, Zimmerman's team discovered that the mice's teeth sensed the cold; Zimmerman referred to this protein as a "cold sensor" protein [4].

GPCR (G-protein-coupled receptor) is a protein found in a cell's membrane. They're responsible for receiving extracellular signals and passing them into the cell. When a specific ligand fits into GPCR, it prompts GPCR to send a signal into the cell. In this case, the cold

stimulus acts as the ligand that triggers GPCR. TRPC5 is similar to a gate that allows specific ions such as calcium into the cell. This gate is typically closed but it opens on one exception; if the temperature drops, TRPM8 opens which allows calcium ions into the cell. The movement of calcium ions creates an electrical signal that is passed along the nerve cells up to the brain. As shown in Figure 4, the GPCR activates TRPC5 which causes calcium to enter the cell. When the channel opens, a message is sent to the nerve cells [2]. This signal is perceived as a cold, painful sensation.

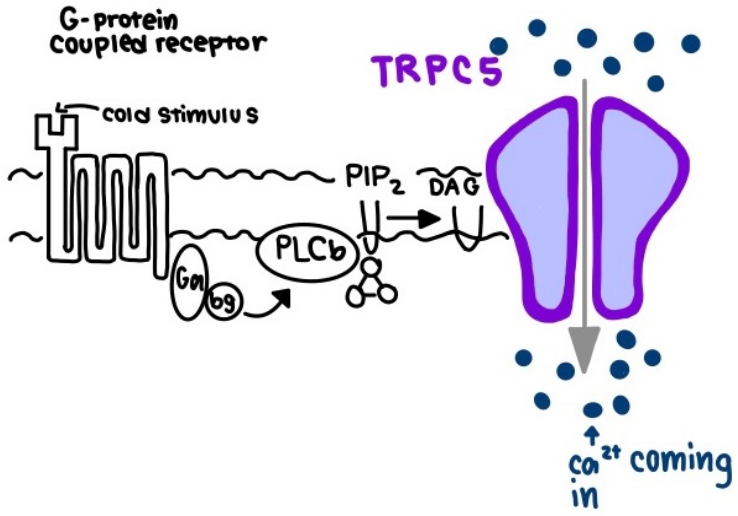

Figure 4 - when exposed to cold stimulus the GPCR (G-protein coupled receptor) activates TRPC5, which causes calcium to flood into the cell.

VIII. Conclusion

The understanding of the pathways and mechanisms behind oral pain has come a long way, but there is still much to uncover. Dental pain, a prevalent global health issue, has complex roots in both bacterial infection and our body's nervous response to it. Recent findings such as Dr. Katharina Zimmerman's discovery of the TRPC5 channel protein in odontoblasts bring us closer to understanding the different pathways behind oral pain, however, further research is

needed to elucidate other potential pathways and mechanisms at play. A comprehensive understanding of the different pathways and their individual roles in transmitting oral pain could pave the way for the development of novel, more effective preventative measures and treatments for dental pain. These advancements could bring significant relief to the billions of people worldwide affected by oral diseases, enhancing their quality of life and well-being.

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Deep Sea Ecosystems

Mihika Srikrishna

Introduction

Climate change, which is a natural phenomenon- as it has been seen throughout history and the multiple ice ages. However, many times, along with climate change the term “global warming” is used.

Global warming is essentially the climate change caused by human activities that release significant amounts of greenhouse gasses into the atmosphere. The burning of fossil fuels, for energy production and transportation, is a major contributor. Additionally, deforestation and changes in land use further increase this problem.

Due to the rising levels of carbon dioxide in the atmosphere of the earth, Earth's oceans are severely affected. One of the sub-groups that get affected is deep-sea ecosystems.

As CO2 is deposited in the atmosphere, it heats the ocean. Deep-sea habitats are typically characterized by cold conditions, and any increase in temperature can be incredibly harmful to the species that live in these regions. Many of these organisms have a low thermal tolerance, making them vulnerable to even minute changes in temperature.

To slow down climate change and safeguard these important ecosystems for both current and future generations, rapid action is required.

For my research, I will be exploring deep-sea ecosystems and the adaptability of different organisms to survive in such extreme conditions. I will also conclude my research with my findings and suggestions.

RQ: What are the specific adaptations of deep-sea organisms to survive in extreme conditions, such as high-pressure environments or complete darkness

Biology:
Deep-sea ecosystems, one of the most extreme environments on Earth, foster a remarkable diversity of life and showcase organisms with biological adaptations that allow them to survive in these challenging conditions. Deep-sea ecosystem life is influenced by a variety of elements, including as high pressure, darkness, freezing temperatures, and a scarcity of food.

Pressure:
One of the most prominent adaptations observed in deep-sea organisms is their ability to withstand the high pressure of the deep seas. In the depths of the ocean, the water exerts tremendous pressure due to the weight of the overlying water column. The pressure increases by 1 atm with every 10 meters below the ocean. Many deep-sea creatures have evolved body structures and compositions to withstand this pressure.

For example, certain fish and invertebrates possess cartilaginous skeletons, which are more flexible and resistant to compression compared to bony skeletons found in more shallow-water species.

Lophiiformes (Deep Sea Anglerfish)

One example of a deep-sea organism that demonstrates the ability to withstand immense pressure is the deep-sea anglerfish, scientific name- lophiiformes.

The Anglerfish has a special type of skeleton known as a cartilaginous skeleton, which is flexible and can withstand the pressure of the deep sea. Cartilaginous skeletons are composed primarily of cartilage, a tough and flexible connective tissue (which is the same thing our ears are made of!) as compared to bony skeletons found in more shallow-water species. This adaptation allows deep-sea anglerfish to maintain their structure under extreme pressure conditions without the risk of being crushed.

Furthermore, the bodies of deep-sea anglerfish are compact and streamlined, which in turn reduces the surface area, minimizing the effects of pressure.

Bathynomus (Giant Isopod)

Another example of an organism with pressure-resistant adaptations is the giant isopod, the scientific name- bathynomus. They are crustaceans that possess a rigid exoskeleton that helps shield their internal organs from crushing pressure.

These pressure-resistant adaptations are vital for deep-sea organisms to survive in their environment. By having specialized body structures and compositions, they can thrive in the deep ocean.

Light:
Another critical adaptation in deep-sea biology is related to the scarcity of light. At great depths, sunlight is unable to come through, leading to nothing but pitch-black darkness. To survive, many organisms of the deep have developed bioluminescent capabilities. Bioluminescence is the ability to produce light through biochemical reactions and it enables organisms to communicate, attract prey or mates, and even defend against predators.

In the cells of the organisms, luciferin and luciferase are the molecules responsible for bioluminescence. As they react with oxygen, they produce a colored hue- which can be red, violet, blue, or green. In the ocean, we usually see bioluminescence in the form of blue-green light.

Vampyroteuthis infernalis (Vampire Squid)

A deep-sea mollusk known as the vampire squid employs bioluminescence-related adaptation to avoid dangers in gloomy waters. The vampire squid changes into a living "molecular cloud" of bioluminescence when threatened, which causes it to glow. The squid confuses and startles predators by lighting up the surrounding water with a dazzling display of light to defend itself.

The vampire squid's bioluminescent defense system involves the activation of light-generating cells called photophores. When activated, these photophores release flashes of bright light. The vampire squid successfully produces a bioluminescence cloud by scattering the light through the surrounding water, concealing its true location and size.

Watasenia scintillans (Firefly squid)

Deep-sea squids such as the firefly squid, show a bioluminescent ability that plays a vital role in their social interactions in the deep ocean.

Firefly squids use their bioluminescent displays to entice potential mates when looking for mates. The time light bursts, which results in an impressive display, of the pulses of each squid. The firefly squids use this synchronized show to pursue potential partners and find potential partners from a distance.

Additionally, intraspecific communication and territory assertion use bioluminescent signals. Firefly squids have developed the ability to emit particular light patterns to announce their presence or to demonstrate dominance when they face rivals or potential predators.

Overall, the biology of deep-sea ecosystems showcases a breathtaking array of adaptations that reflect life in these extreme conditions. Studying these remarkable organisms holds the potential for valuable insights into biotechnological applications and the search for life beyond our planet.

Ecology:

Deep-sea ecosystems encompass diverse and distinct habitats, each displaying remarkable ecological adaptations that allow organisms to thrive in the extreme conditions of the deep ocean.

Hydrothermal vents:

One such deep-sea ecosystem are the hydrothermal vents, which are found on the ocean floor where tectonic plates meet. These vents release mineral-rich, superheated water into the surrounding cold seawater, creating a unique environment.

At hydrothermal vents, specialized organisms have evolved to utilize the rich chemical compounds and unique energy sources available. For instance, tube worms, such as Riftia pachyptila, have formed symbiotic relationships with chemosynthetic bacteria which live within their bodies. These bacteria convert the chemicals from the vent emissions into organic compounds through chemosynthesis, providing sustenance for the tube worms.

Abyssal Plains:

The abyssal plains are ecosystems of the ocean floor which is flat and sandy. One of the organisms that thrive here is the abyssal sea cucumber (Enypniastes eximia), which plays a crucial role in nutrient cycling. Adapted to the nutrient-poor environment, these scavengers feed on organic detritus that slowly descends from the surface waters above. Additionally, they extend their tentacles to capture the nutrient-rich particles, which they then devour voraciously. They contribute to their breakdown by eating organic waste, effectively recycling the nutrients back into the ecosystem. They play a significant role in the plains as they recycle nutrients within the ecosystem. By consuming organic detritus, they help break them down, effectively recycling the nutrients back into the ecosystem. Their feeding activity disturbs the sediment, creating areas of increased oxygenation in the otherwise oxygen-depleted environment. This supports the activity of other benthic organisms like worms and bacteria, further helping the ecosystem thrive.

Food in deep-sea ecosystems:

The food web in deep-sea ecosystems is often dependent on "marine snow," a continuous flow of organic particles from the upper layers of the ocean. This marine snow provides a source of food for many deep-sea organisms, including filter feeders like giant sea spiders (Pycnogonida), which trap and consume these particles suspended in the water.

The deep-sea dragonfish (Grammatostomias flagellibarba) is known to attack smaller organisms such as copepods, and the gulper eel (Eurypharynx pelecanoides) has an elastic stomach that enables it to consume prey larger than itself.

Whale carcasses play a vital role as an abundant and valuable food source in the deep sea. When a whale dies and sinks to the ocean floor, it becomes a feast for many deep-sea organisms. This process, known as "whale fall," supports entire ecosystems, sustaining scavengers like hagfish, crabs, and sleeper sharks. As the carcass decomposes, microbes break down the organic matter, and unique species thrive in different stages of the decomposition process.

Conclusion:

Deep-sea ecosystems host a diverse range of organisms that have evolved unique adaptations to thrive in extreme conditions. From hydrothermal vents to abyssal plains and trenches, organisms surviving here have developed specialized physiological traits to thrive in darkness, high-pressure, and nutrient-poor environments.

Understanding and conserving these ecosystems is vital for preserving Earth's biodiversity and delicate balance.

Deep-sea ecosystem concerns require several important answers and recommendations that must be taken into account. First and foremost, it is crucial to encourage more research to uncover more about the deep seas and help conservation efforts. Additionally, raising public understanding of the significance of deep-sea ecosystems and their function in world processes can help conservation efforts gain more support from the public.

Advantages and Disadvantages of the Pyrolysis of Plastic Waste

Riya R. Kapadia

I.Introduction

The accumulation of plastic waste is one of the most pressing environmental issues and is detrimental to water, air, soil, animals, and humans (Oa, 2019). Almost $8 billion of plastic packaging is put into landfills every year (Woodring, 2015), and the additives found in plastic can cause it to take over 400 years to disintegrate (Parker, 2019). Efforts have been put into reducing plastic waste and converting it into fuel, such as implementing mechanical recycling, combustion, waste plastic disposal, and more. However, the cost of recycling leads to over 400 million tons of plastic waste generated per year, with only 9% recycled, according to the United Nations. Additionally, multi-layered plastics with harmful additives like brominated flame retardants and phthalates result in plastic recycling becoming more complex (Qureshi et al., 2020). Therefore, alternative options are necessary to reduce the accumulation of plastic waste.

Pyrolysis is a chemical recycling technology that offers a promising solution to create energy and reduce plastic waste. Pyrolysis is the thermal degradation of organic materials at temperatures ranging from 200°C to 1000°C without oxygen. It produces gas, oil, and other fuels from plastics depending on the temperature, waste composition, and more (Basu, 2018). This literature review will describe the different types of pyrolysis as well as the benefits and drawbacks of implementing pyrolysis based on the environment and economy. First, catalytic pyrolysis, plasma-assisted pyrolysis, and microwave pyrolysis will be described. Next, the benefits and drawbacks of pyrolysis will be discussed.

II. Types of Pyrolysis

Pyrolysis has many approaches depending on the conditions, parameters, time, and process requirements. Based on the temperature and time needed, pyrolysis is divided into slow pyrolysis, fast pyrolysis, and flash pyrolysis. Slow pyrolysis produces biochar at a process temperature from 350℃ to 550℃, with a heating rate of 10℃/min (Lee et al., 2012). Fast pyrolysis yields 60–75% of liquid bio-oil, 15–25% of solid char, and 10–20% of noncondensable gasses and charcoal (Fig. 8.). The process temperature ranges between 500℃ to 700℃, and the heating rate is higher than 100℃ (Barik, 2018). Flash pyrolysis involves temperatures over 700℃ with a heating rate greater than 200℃, and offers a high yield of bio-oil compared to the gas and biochar.

Classifications of pyrolysis based on process conditions include catalytic pyrolysis, microwave pyrolysis, and plasma-assisted pyrolysis. Catalytic pyrolysis involves a catalyst whose presence in a mixture helps with thermal degradation (Luna-Murillo et al., 2020). Catalytic pyrolysis allows for the creation of a product with a higher value than traditional pyrolysis (Matuszewska et al., 2022). In the catalytic pyrolysis of plastic wastes, catalysts are either homogeneous or heterogeneous. Heterogeneous catalysts—zinc oxide, magnesium oxide, and calcium carbonate—are more commonly used because they can be easily separated from the liquid pyrolysis product (Papuga et al., 2022).

Microwave pyrolysis involves microwave dielectric heating and is used with polyethylene and polypropylene. Microwave pyrolysis allows thermochemical reactions to quickly take place, thus leading to the rapid conversion of biomass into liquid fuel (Jacob-Lopes et al., 2022, pp. 1211–1133). However, this method may result in an uneven distribution of the reaction temperature throughout the material, which yields undesirable products.

Plasma-assisted pyrolysis converts waste plastics into fuel through thermal currents and electromagnetic radiation. This method is characterized by a higher energy density and temperature than conventional pyrolysis (Matuszewska et al., 2022). Depending on the temperature of the gas, plasma pyrolysis can either be thermal or non-thermal. During thermal plasma pyrolysis, the particles are in thermodynamic equilibrium at the same temperature, which creates gaseous products. In non-thermal plasma pyrolysis, the particles are not in thermodynamic equilibrium and are at different temperatures, which produces biomass pyrolysis gas (Blanquet & Williams, 2021).

III. Advantages of Pyrolysis

Pyrolysis offers several advantages, making it a promising waste management technique with environmental and economic advantages. For instance, slow pyrolysis systems can achieve greenhouse gas emission reductions between 108.57 to 122.18 g CO_2- eq MJ^{-1} through the sequestration of biochar (Yang et al., 2021). The carbon cycle may be renewable for pyrolysis, and additional fossil carbon is not used from Earth's geosphere. For instance, utilizing environmental footprint and ReCiPe impact assessment methods, chemical recycling through pyrolysis has a 50% lower climate change impact and life cycle energy use compared to energy recovery options, as shown in Figure 2 (Jeswani et al., 2021).

Pyrolysis is a promising option for energy recovery from waste plastics due to its ability to generate sustainable fuels. Bio-oil, derived from the pyrolysis of biomass, is a clean and renewable form of energy that can be utilized as fuel for engines and boilers (Inayat et al., 2022). For example, fast pyrolysis operations yield approximately 29 pounds of renewable gasoline and diesel blendstock per 100 pounds of hybrid poplar feedstock with 7% moisture (Jones et al., 2009). This leads to the production of 76 million gallons of gasoline per year. Bio-oil can be utilized further to produce electricity and heat through combined heat and power (CHP) plants (Inayat et al., 2022).

Pyrolysis offers significant economic benefits by fostering a circular economy. According to Jeremiah et al. (2021) establishing multiple pyrolysis plants in Kenya could save 41.832 billion annually. Since the Kenyan national budget is 3 trillion, this leads to an economic reduction of 1.3994% (Jeremiah et al., 2021). Pyrolysis also allows for the separation of the primary components of feedstock, facilitating a circular economy (Amirhossein et al., 2023). Current waste management methods are not sustainable in a linear economic system, but the benefit of pyrolysis on the circular economy provides long-term economic benefits and reduces resource scarcity (Amirhossein et al., 2023). In addition, in a study (Pacheco-López et al., 2021) comparing fossil-based fuels, biomass-derived fuels, and plastic waste-sourced fuels for diesel engines, plastic-based pyrolysis oil was the most promising diesel substitute. Plastic waste

pyrolysis oil demonstrated a reduction of 25% in production costs compared to regular diesel. In terms of the "well-to-tank" life cycle impact, compared to diesel, the use of plastic waste pyrolysis oil resulted in a 54% reduction in impacts on human health, a 40% reduction in impacts on ecosystems, and a 98% reduction in resource consumption (Pacheco-López et al., 2021).

IV. Disadvantages of Pyrolysis

The pyrolysis process, while offering many benefits, comes with several notable disadvantages. For instance, from life cycle assessments, the fast and flash pyrolysis of plastic packaging leads to greenhouse gas emissions that are nine times higher than that of mechanical recycling emissions. Figure 3 demonstrates that a shift away from chemical recycling toward mechanical recycling results in increased carbon efficiency. Based on the medium scenario, an increase of 5% in waste treated by mechanical recycling carbon efficiency is improved by 2% An increase of 30% in mechanical recycling leads to a 13% improvement in carbon efficiency (Möck et al., 2022). Therefore, pyrolysis leads to less carbon efficiency compared to mechanical recycling methods (Möck et al., 2022).

Biomass pyrolysis of plastic wastes releases nitrogen oxides which harm human health and the environment. Nitrogen oxides are greenhouse gasses with a global warming potential 298 times higher than CO_2 and a half-life between 100 and 150 years (Balogun et al., 2021). However, techniques are currently emerging to mitigate the impact of nitrogen oxides on the environment during pyrolysis. For instance, studies demonstrate that a DeNOx catalyst with urea added can assist in constructing an in-situ NH3-SCR system that achieves low levels of NO_x (Osman, 2020).

The variability of the feedstock in the pyrolysis of plastic waste is another challenge because different types of plastics fed into the pyrolysis reactor break in varying patterns. For instance, polyethylene terephthalate and polyvinyl chloride plastic are not suitable for pyrolysis since they produce harmful chlorine gasses, which corrode the metallic parts of the pyrolysis condenser and reactor (Osman, 2020).

V. Conclusion

This review described catalytic pyrolysis, microwave pyrolysis, and plasma-assisted pyrolysis. This review also discussed the advantages and disadvantages of pyrolysis. Slow pyrolysis results in lower greenhouse gas emissions and a lower climate change impact than alternative methods. Pyrolysis is an effective method of converting waste plastics into fuel and can generate bio-oil, heat, and electricity. Pyrolysis is beneficial to the economy by fostering a circular economy. However, one notable drawback of implementing pyrolysis is that fast and flash pyrolysis both result in high greenhouse gas emissions and the release of oxides of nitrogen. Additionally, the amount of plastics that pyrolysis can be used for is limited. With the implementation of technologies that result in fewer greenhouse gas and oxide emissions in the future, pyrolysis can become a more sustainable and widely-used technology. While there are disadvantages to pyrolysis, overall, it is a promising method of converting plastic waste into a sustainable form of energy, while positively impacting the environment and economy.

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The Integration of Artificial Intelligence within Medical Practices

Saee Joshi

Introduction

Artificial intelligence (AI) is expanding into various fields including medicine. This review article will explore how AI is currently making an impact in the medical field and the correlation between AI and human intelligence. By assessing AI technology, decisions on how to proceed with implementing AI can be made.

Defining Artificial Intelligence

Pavel Hamlet and Johanne Tremblay define AI as " a general term that implies the use of a computer to model intelligent behavior with minimal human intervention" [1]. Artificial Intelligence covers fields such as robots, research, programming, speech, education, and countless others; therefore, when in an attempt to describe AI, it is imperative to focus on the correlation of AI technology with a specific field. AI has the capabilities to simulate and expand upon human intelligence, and this aspect of the technology is critical for use in medical diagnosis, medical practices, and research. It may "revolutionize disease diagnosis and management by performing classification difficult for human experts and by rapidly reviewing immense amounts of images" [2]. AI functions differently from human brains because it acts independently and has a different physiological structure.

Methods in Artificial Intelligence

Artificial Intelligence consists of several software systems, however, one distinct system that powers AI technology is machine learning. Machine learning is a method and algorithm that drives the function of artificial intelligence. A branch of machine learning is

deep learning which is the main method used as a basis for AI technology within the medical field. Deep learning consists of "mathematical algorithms that improve learning through experience" [1]. The functions of these algorithms continue to improve as more research regarding AI expands. For instance, "Deep learning…has gotten rid of structural restrictions and acquired problem-solving strategies through learning human experiences" [3]. Advances in computation and data sets continue to drive deep learning algorithms toward exceeding human performance and human intelligence. This is observed in AI's "performance in visual tasks such as playing Atari games, strategic board games like Go, and object recognition" [4]. In the medical field, "machine learning is … widely used in interpreting medical images. It recognizes the pattern of imaging information and renders medical diagnoses … mimic[ing] the human brain, using multiple layers of artificial neural networks" [5]. Artificial intelligence's function is dependent on data sets and what is necessarily "fed" to them. The objective of deep learning and machine learning is to take data and analyze, interpret, and apply it to other situations where it stores memory to be used on another data set. Machine learning can also be classified as the support vector machine (SVM) and the artificial neural network (ANN). Where SVM is useful for categorizing objects and ANN mimics biological neural networks [5]. Thus, SVM implements AI in clinical imaging and diagnosis and ANN applies itself to various data sets, but it does involve a lengthy computation process.

Current Knowledge-Based Systems in Medicine

Contrasting deep learning is knowledge-based systems (KBS) which are used " where knowledge is predominant rather than data and requires heuristic and logic in reasoning to derive a new set of knowledge" [6]. Therefore, KBS is best applied to mutually exclusive

diseases and symptoms that are correlated with only one cause rather than multiple causes and the suffering of multiple diseases concurrently. Some current KBS that are in use in the medical field are crucial for the diagnosis and treatment of various diseases and fields.

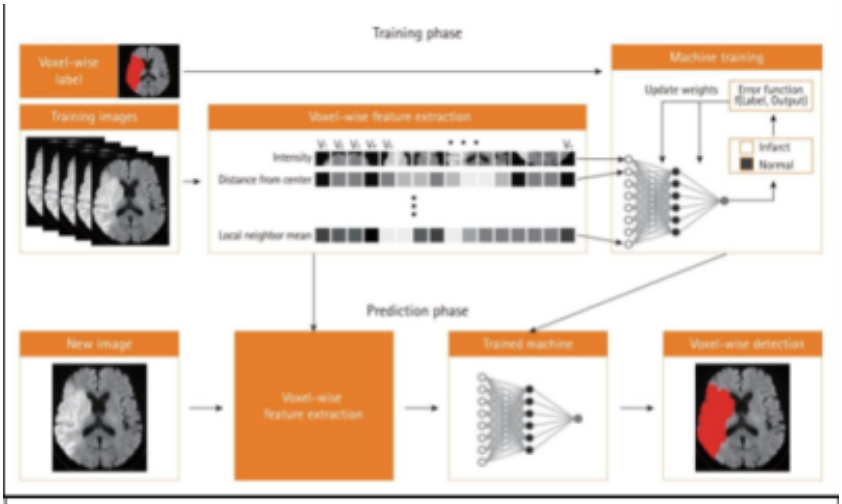

Figure 1: Machine Learning System Process A depiction of the process of feeding data into a machine learning system and then later using the system for stroke imaging. The top half of this figure depicts the initial training of the system as it analyzes and sorts through images. The bottom half of this figure depicts the prediction process as a new image is presented to the system and the system uses previous data to apply to and analyze the new image. (Source 5)

However, by using machine learning systems, we could expand on medical diagnosis even further. Machine learning systems like ANN are beneficial to process larger sets of data and reduce limitations in processing and classifying diseases because of their capability to recognize patterns and apply them in the future.

Usage of AI in the Medical Field

Currently, AI is already being implemented in medicine and research. Progress with developing the technology and results of the output are showing positive signs for the expansion of AI technology. AI's methods have the potential to enhance patient care and improve clinical practice overall, according to Fabrice Jotterand and Clara Bosco [7]. For instance, AI technology may be used for therapy and care for a patient's mental health by being a companion that a patient can rely on [8]. AI may also restore and repair functions of the human body [3]. AI is used for medical diagnosis, protein structure predictions, speech decoding from the brain, diagnosing and examining skin cancers, stroke imaging, and more, and its usage in the medical field will be further explored in this article.

KB/RB system	Application
MYCIN [29]	Infection in the blood and central nervous system; diagnosis & treatment
EMERGE [30]	Chest pain; diagnosis
RBES [31]	Fibrillation; diagnosis
ES for diagnosis [32]	Chronic venous insufficiency; diagnosis
CORONARIA [33]	Ischemic hear diseases; diagnosis and treatment
SBS [34]	Interpretation of ultra sound images; diagnosis
ESPRE [35]	Platelet transfusion decisions; treatment
ESTER [36]	Respiratory weaning therapy; treatment
M-HTP [37]	Monitors heart transplant patients; treatment
KBS [38]	Anemic patients (hematology); Treatment and Planning
HERMES [39]	Chronic liver diseases; (gastroenterology) diagnosis
KB system [40]	EMG abnormalities; diagnosis
ERIC [41]	Chest pain; diagnosis
Probability-based ES [42]	Pacemaker-related complications; diagnosis
Psychiatric treatment [43]	Psychiatric; treatment
ES [9]	Pace maker problem; diagnosis
KBS [44]	Ectopic pregnancy and neural tube defects; diagnosis
HEPAXPERT-I [45]	Interprets the results of routine serologic test for infection with hepatitis A or B;diagnosis
DIABETES [46]	Therapy of types I or II diabetic patient; treatment
DIAVAL [47]	Echocardiography; diagnosis
TOXOPERT-I [48]	Interpretation of serological test for toxoplasmosis; diagnosis
OPERAS [49]	Error detection and elimination in the picture archiving and communication system; diagnosis
PRISM [50]	Menu planning; planning
MES [51]	Cardiac diseases; diagnosis
MUMIN [52]	Neuromuscular diseases; diagnosis
ESEDED [53]	Eye diseases; diagnosis
RBES [54]	Managing medical appropriateness criteria; treatment
EDSS [55]	Multiple sclerosis; diagnosis
Anorexia ES [56]	Anorexia; diagnosis
Bone Browser [57]	Bone tumors; diagnosis
ES [58]	Evaluation of risk in type I diabetes; diagnosis
MES [59]	Lung problems; diagnosis
ESMIS [60]	Dangerous infection; diagnosis and treatment
MES [10]	Hepatitis infection; diagnosis

Figure 2: Applications of Knowledge-based and Reading-based systems This table exemplifies how knowledge-based systems of learning can be applied to medical practice and diagnosis. On the left, several different KB and RB systems are listed, and we can see how each of those systems are applied in medicine. This helps strengthen our understanding of the relationships between AI technology and medical diagnosis and treatment and how versatile AI is. (Source 6)

Virtual Us Versus Physical Use

The capabilities of AI are beneficial in overcoming limits in humans' abilities. These limits range from the amount of time it takes to learn and apply new knowledge or work more efficiently and quickly. We see AI overcoming human limits in practices such as efficiently keeping electronic medical records and improving organizational performance. Accompanying the virtual aspects of AI previously discussed, are its physical branch. Robots are being used as helpers and are seen in various places globally, such as cafes and homes. However, in the medical field, robots may also be used in surgical procedures or monitoring the delivery of drugs [1]. This implementation of robots in the medical field has aroused some

controversy, but what is clear is that there still needs to be further studies of robotic systems, especially when considering health and psychology.

AI Predicts Protein Structures

AI is also making a large impact on research, specifically protein research. Protein structure determines a protein's function [9, 10]. AlphaFold, a deep learning program, has predicted the 3D shapes of over 200 million proteins [9]. AlphaFold combines several deep-learning methods to recognize and classify protein structures. The program relies on patterns of previous experimental work regarding protein structures found through the use of electron microscopes. AlphaFold then applies the data and the patterns to further analyze new proteins. However, it is imperative to keep in mind that the results that AlphaFold provides are not always accurate rather, they are predictions. Another AI, RoseTTAFold can predict accurate shapes of known protein profiles [10]. These predictions can be used to develop new vaccines, understand diseases such as Parkinson's disease and other mutations in DNA, protect honeybee health, and have a deeper insight into the process of human evolution [10]. The results from using this technology are promising and have relatively high accuracy.

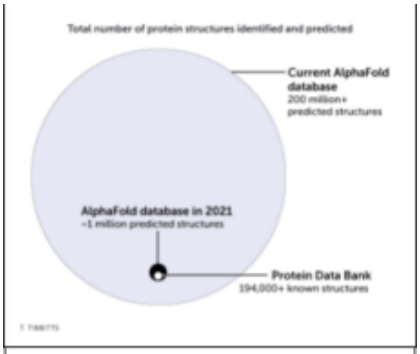

Figure 3: AlphaFold Progress AlphaFold is a current deep learning system. This figure shows how extensively the protein structure database has grown. This system has revealed structures of over 200 million proteins whereas compared to the Protein Data Bank, which revealed above only 194,000 proteins through a longer experimental process. (Source 10)

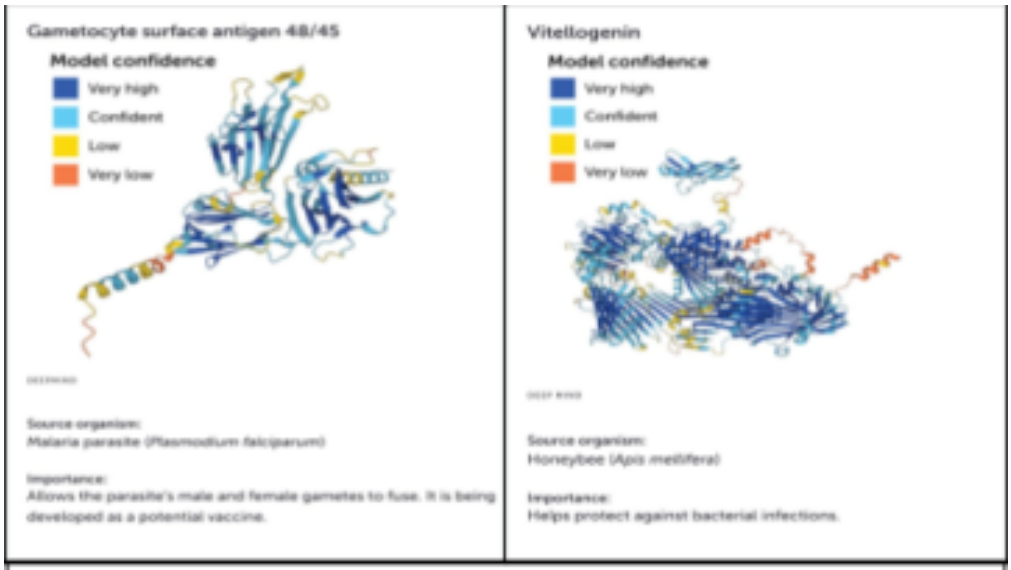

Figure 4: Predicted protein structures from AlphaFold Illustrations of models of predicted protein structures produced by AlphaFold. Many of these structures are mostly confident and closely compare with the actual protein structures of the given organisms. This figure also explains the significance of knowing the protein structures and the medical applications of the structures. (Source 10)

Decoding Speech from the Brain Activity

In addition to predicting protein structures, AI technology can also predict speech from brain activity. The technology decodes words and sentences using magnetoencephalography and electroencephalography, which involves studying the magnetic and electrical components of brain signals [11]. The technology has been trained extensively. Being able to implement speech decoding from brain activity is beneficial to strengthening interactions between patients that are unable to communicate and their caretakers. These patients include those that are unresponsive, minimally conscious, or have communication defects. Originally, those patients would have to go through risky brain surgeries and reimplant electrodes to communicate, but using AI predictions is a safer and more effective way for these patients to communicate.

Classifying Skin Cancers from Neural Networks

Another application of deep learning algorithms within the medical field is dermatology. The CNN program is trained with 757 disease classes and organized 2,032 diseases that could further branch out into other nodes. [4] "When a test set is fed through the CNN, it outputs a probability, P, or malignancy per image. We can compute the sensitivity and specificity of these probabilities." [4] The technology classifies skin cancer using photographic and dermoscopic images and then uses prediction from patterns in other data sets for classification. Its high performance exhibits the reliance on the program within dermatology.

Artificial Intelligence in Stroke Imaging

The implementation of artificial intelligence in stroke imaging contributes to improved accuracy of diagnosis and an improvement in patient care. AI can analyze data from stroke imaging which later plays a role in predicting the prognosis of stroke patients [5]. "Prediction of treatment complications may be useful for screening a high-risk group receiving acute treatment, such as thrombolysis" [5]. Additionally, machine learning CT images and MRI images have been used for predictions for stroke patients. This technique is important for future efforts in analyzing large amounts of layered data and determining stroke treatment options.

Use of AI for Medical Diagnosis

Being able to sort through and classify large amounts of data makes AI technology, especially deep learning, exceptionally reliable and efficient for medical diagnosis. Doctors apply image-based deep learning to identify diseases and treatments. The program, with minimal computation power, can recognize aspects of an image much faster and with less practice than a human [2]. This program involves a transfer learning algorithm. This

algorithm can then be used for things like diagnosing retinal OCT images. By diagnosing diseases, the treatment and understanding of those diseases are also revolutionized. In a study, a general AI platform was used "for the diagnosis and referral of two common causes of severe vision loss: diabetic macular edema and choroidal neovascularization seen in neovascular AMD" [2]. Using AI studies in diagnosing and classifying images is more clinically relevant and expands both the understanding and the treatment for these cases.

The Effect of Human Intelligence on the Development of Artificial Intelligence

Artificial intelligence is developed from human intelligence, and therefore, as human intelligence expands and is inputted into the program, AI must also expand and become more advanced. Technologies' capabilities are now starting to match those of humans. Researchers have found that technology can be "invented by 'the machine's intelligence'… 'producing intelligence with the machine's intelligence" [3]. As the brain continues to develop, human potential is also increased, therefore allowing the simulation of the human brain and the ability of AI to extend human intelligence and consciousness. It is evident that AI can learn like a human due to its evidence-based learning ability [3]. "The rapid development of artificially intelligent technology allows it to produce the same levels of objective understanding as a human and "take the cognition and value discovery of information and data as the main goal" [3].

After understanding that AI depends on human intelligence, it is important to understand it is due to the human unconscious processes. An artificially intelligent technology naturally interacts with its given environment, and so, "the relationship between technology and humans is framed and defined by [conscious or unconscious] narratives, which influence each moment, from design to use" [8]. An AI program known as Replika exhibits these

human unconscious dynamics in its interface design, a process known as extended unconsciousness.

The Effect of Artificial Intelligence on Human Intelligence

While human intelligence contributes to the development of AI, the contrary is also true. Artificial intelligence can extend the human brain [3]. This mutual relationship allows for a deeper understanding of things and an increased enrichment of the consciousness of the brain. Using technology such as an EEG brain-computer interface allows us to acquire knowledge more efficiently. Revisiting speech decoding from brain activity, AI technology will improve the development of our minds as we could "communicate with each other without using language" [3]. This combination improves our communication as we realize and communicate more accurately at a faster speed. Therefore, AI development is related to human consciousness development.

Some critics may argue that the implementation of AI technology will cause humans to have a dependence on the technology and "lose their critical thinking skills…(and) cause irreversible mistakes or disasters" [3]. The progression of AI is also raising some warning signs in terms of losing personal identity. An individual's personal identity can be changed by many factors, but often, overcoming this requires therapeutic interventions. Therefore, we must assess the possibility that using AI-enabled neurotechnology "to diagnose and treat brain disorders may change a personal identity and character traits in a person" [7].

Assessing the Ethics of Artificial Intelligence

In the case of Replika, the unconscious AI, responses learned from other humans are replicated as answers for another user. However, this program is not capable of recognizing positive and negative data, and rather, interprets it all as neutral. This may become

complicated as a patient may require to hear positive words, but data from other humans generate a more negative response, which can ultimately put that patient's life at stake. Therefore, programs such as Replika are seen as social agent and needs to be examined from an ethical perspective. When questioning the ethical perspectives of AI, we must also look into its relation with humans. "Mankind still has the right to determine future technologies and life" [3]. AI technology is continuously developing, but human intelligence should continue to stay relevant and true. It is vital to understand the significance of human intelligence over AI. In the medical field, AI technology shouldn't dehumanize medical practices. The integration of AI "affects concepts such as free will, agency, responsibility, and perception" [7]. We should take into account the inability of artificial intelligence to process social and cultural conditions and rather, act as a neutral source. Therefore, AI in the medical field should perform data-based tasks such as diagnosis and classification, but "allow physicians to spend more time with patients" [7] Rather than dehumanizing the medical field, the implementation of AI should "serve human ends...respect personal identity,…(and) promote human interaction" [7]. Medical practices should continue to follow ethical norms and not substitute human interaction and the well-being of a patient with a technology that cannot simulate that human connection.

Limitations of AI and Future Progressions

Many current AI technologies, such as deep learning, produce predictions and do not always have accurate answers. Therefore, it would be unwise to eliminate professional methods of medical practices such as disease diagnosis and protein structure analysis due to the expansion of AI technology. Many current AI technology programs are time-consuming and not cost-effective, so there is an economic aspect of the implementation of AI in

medicine that needs to be further researched before AI technology can expand further. Some training datasets are not versatile or applicable to other datasets, so "the performance of the machine depends strongly on the quality of the data that are used in the training session" [5]. However, using transfer learning algorithms and further studies "could potentially be employed in a wide range of medical images across multiple disciplines" [2]. Also, AI in medicine requires further research regarding the relationship between human-computer interactions. Medical staff will need to be trained in newer medical practices that involve AI technology. Further research to evaluate how AI technology will perform in the medical field is necessary before extensively implementing new techniques as a replacement for current medical practices.

Conclusion

When analyzing the expansion of artificially intelligent technology, it is crucial to examine it in its current setting and how it may affect different specialties, specifically the medical field, in the future. We can assess AI technology through its impact on research and medical practices as well as the correlations of machine intelligence to human intelligence. The integration of AI technology forms a relationship with machine intelligence and human intelligence as both are given respective advantages as they coexist in a setting. However, we must proceed with the implementation of AI with caution, as our goal should be to enhance, not replace the role of the human brain in society. "The health care system must not be stationary but must learn from its own experiences and strive to implement continuous process improvements" [1]. We must understand the controversy and ethical issues regarding AI and plan to further understand the nature of artificial intelligence to succeed in this change as a society.

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The Integration of Robotics in Rehabilitation Therapy

Sashata Rudra

Rehabilitation therapy plays a crucial role in improving the treatment of individuals with limb loss or impairment. The integration of robotics into rehabilitation techniques has been shown to enhance recovery through creating diverse opportunities for patients and health care facilities to incorporate for higher progressions in a patient's health. By engaging patients through robotic devices and machinery patients will gain more precision and accuracy in their treatment. This will allow clinicians to offer personalized and effective treatment options to aid patients in their journey to recovery further employing technology that can provide more advancements in patients health. Incorporating robotics into the rehabilitation process can allow more embellished results for patients provided by robotic-assisted devices and exercises.

For individuals with limb loss or impairment, relearning to walk independently can be challenging. Robotics offers solutions through assistive devices, which allow patients to be assisted in moving their impaired limb. This approach allows doctors and physical therapists to target specific muscle groups, facilitating the rehabilitation process. These can provide the necessary support and balance to help patients regain confidence and mobility. Advanced sensors in these devices can adapt to the patient's specific needs, making them more efficient and effective. These devices allow physical therapists to facilitate proper biomechanics and reduce the risk of additional complications. One recent clinical study investigated the importance of assistive devices through experimenting and allowing patients to feel the simulation of the NeReBot (MD; Armani, Masiero, Rosati, et al., n.d.) More research has also been done that is designed to play a pivotal role in limb rehabilitation allowing assistive movements for shoulder and elbow stimulation potential real-life experiences for the patients to experience (MD;Armani,

Masiero, Rosati, n.d.) More research has also been done to support assisted devices like exoskeletons and robotic controllers that have opened the door for experimentation on stimulation for motor recovery allowing more personalized treatment and gaining patients further developed treatment plans for their recovery (Chang, & Kim, et al., 2013). Alongside research has been orchestrated to witness the needs of patients been meet in their specific methinds through these assisted devices (Samuelsson & Wressle, et al.,2008).These recent enhancements in movement control, supported by evolutions in robotic controllers, have allowed patients to achieve improved mobility and become more self reliant and self sufficient as well as have targeted therapy where they can aim towards moving into more ranged enhancement in their therapy progression. This enhancement occurring is due to movement control being supported and robotic controllers allowing patients to have more versatility.

Figure 1 (MD; Armani, Masiero, Rosati, et al., n.d.)

In addition, virtual reality (VR) and augmented reality (AR) have significantly impacted how patients learn to control their prosthetic limbs. By creating interactive environments, patients can practice using their prosthetic limbs in a protected yet challenging setting. These simulations can mimic real-life scenarios, allowing patients to develop natural movements. It increases patient engagement and motivation. The simulation environment allows more personalization as the patients simulation can be catered to their specific needs to assist them in custom scenarios to improve their conditions. This maximizes their functional recovery and utilizes all aspects of their treatment. VR and AR also has the ability to provide updated feedback to patients as soon as their experience ends allowing faster testing periods correlating with faster recovery and growth. Due to simulation saving features it also allows the patients progress to be tracked, moritried and saved allowing patients, doctors, researches and health care facilities to have access to the growth of the patients and allows them to gain the ability to track and see the instant results of what worked efficiently for the patient and what won't be sufficient. These rehabilitation techniques allow better motor learning as well as the patient's brain and muscles are given time to naturally react while recovery through gaining back its memory. More research has been conducted to dwell on the deeper aspects VR and AR may have on patients' health and allow their post-recovery journey to be settled into (*Exoskeletons With Virtual Reality, Augmented Reality, and Gamification for Stroke Patients' Rehabilitation: Systematic Review*, 2019). Alongside research has been directed after the rise of it due to the pandemic caused by the coronavirus allowing it beneficial such as cost reduction to be recognized (Berton et al., 2020). By combining technology and physical therapy exercises, patients are able to tackle the learning curve and adapt to the functionality of their prosthetic devices.

Through immersive experience through virtual and augmented reality researchers have the ability to implement brain-computer interfaces (BCIs) which have introduced new possibilities in rehabilitation therapy. BCIs allow direct communication between the brain and external devices, such as prosthetics. BCIs can decode the patient's intention to move, translating it into real-time control of robotic limbs. This technology embodies a more seamless transition between patients and their prosthetic devices. Neurofeedback combined with robot-assisted therapy can also promote neural plasticity, aiding in the rewiring of the brain and improving motor function. Further, a recent study has dueled on the importance of incorporating BCIs to further develop prosthetics and expand rehabilitation (Miguel-Fernández, et al., 2023). Another study has been conducted upon research of the importance of BCIs play while combining technology and medicine to improve reaction progression as it highlighted how it treated brain activity and its design for motor assistance for paralyzed patentees (Chaudhary, et al., 2016). Upon this research further has been concluded through the BC robotics controlled actions allowing the interface between man and machine to create potential feedback systems to implement while the device is developing the brain signals (*Emerging Trends in BCI-robotics for Motor Control and Rehabilitation*, 2021). Alongside another study that has conducted the results of this interface has the promise of colluding potential post-stroke motor rehabilitation (Mane, et al., 2020).

Through BCIs exploring new depths through direct communication from human to machine it allows researchers to segway into the next step of upgrading rehabilitation for patients through robotic-assisted therapy. Robot-assisted therapy has shown transforming results. It is cost-effective through its targeted exercises and monitoring of recovery time; it reduces health care expenses as a result of its efficient time path. Robotic devices offering controlled

movements to exercise the affected limb. The devices can be programmed to precisely tailor the exercises to each patient's needs, challenging them as they regain mobility. This therapy can also provide support to the limitation the patient may be experiencing allowing the patient to perform beyond what may have been holding them back. It allows patients to face the limitations and difficulties patients may experience from a certain moment of their injured limb. Additionally, these robots track the patient's progress, providing data for therapists to adjust treatment plans. By incorporating robot-assisted limb training, rehabilitation specialists can effectively address the challenges faced by patients. They can also alter the patient's treatment plans as a result of these devices as the progress and timeline of the recovery is well monitored and tracked to fit the patients needs and can be customizable to fit the patients evolving needs.

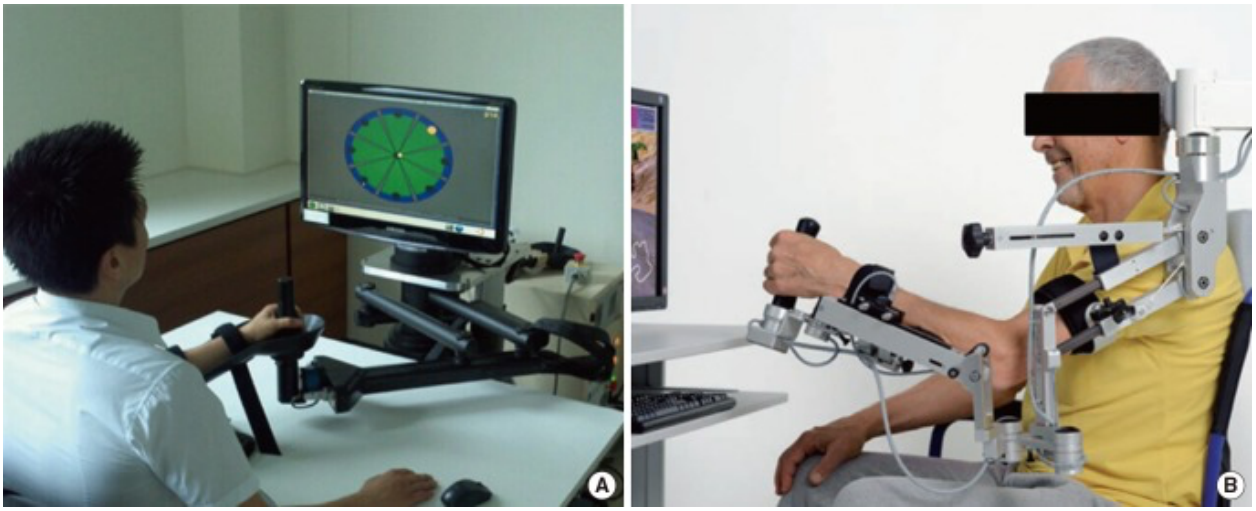

Figure 2 (Chang, & Kim, et al., 2013)

Authors	Robotic device	Number of participants	Stroke stage	Intensity	Concomitant therapy	Summary of results in comparison with conventional therapies
End-effector-type devices						
Werner et al., 2002	Gait trainer	30	Subacute	20 minutes, 5 times per week for 4 weeks	No	No difference
Peurala et al., 2005	Gait trainer	45	Chronic	20 minutes, 5 times per week for 3 weeks	No	No difference
Tong et al., 2006	Gait trainer	54	Subacute	20 minutes, 5 times per week for 4 weeks	Yes	More effective
Dias et al., 2007	Gait trainer	40	Chronic	40 minutes, 5 times per week for 4 weeks	No	No difference
Pohl et al., 2007	Gait trainer	155	Subacute	20 minutes, 5 times per week for 4 weeks	No	More effective
Peurala et al., 2009	Gait trainer	56	Subacute	20 minutes, 5 times per week for 3 weeks	Yes	More effective
Morone et al., 2011	Gait trainer	48	Subacute	20 minutes, 5 times per week for 4 weeks	No	More effective
Exoskeleton devices						
Mayr et al., 2007	Lokomat	16	Subacute	30 minutes, 5 times per week for 4.5 weeks	No	More effective
Husemann et al., 2007	Lokomat	32	Subacute	30 minutes, 5 times per week for 4 weeks	Yes	More effective
Hornby et al., 2008	Lokomat	62	Chronic	30 minutes, 12 sessions total	No	Less effective
Jung et al., 2008	Lokomat	25	Chronic	30 minutes, 3 times per week for 4 weeks	Yes	More effective
Hidler et al., 2009	Lokomat	72	Subacute	1 hour, 12 sessions total	No	Less effective
Westlake & Patten, 2009	Lokomat	16	Chronic	30 minutes, 3 times per week for 4 weeks	Yes	More effective
Schwartz et al., 2010	Lokomat	67	Subacute	30 minutes, 3 times per week for 6 weeks	Yes	More effective
Chang et al., 2012	Lokomat	37	Subacute	40 minutes, 5 times per week for 2 weeks	Yes	No difference

Figure 3 (Chang, & Kim, et al., 2013)

However, robotic technologies have facilitated the extension of rehabilitation therapy beyond clinical settings. Tele-rehabilitation allows therapists to provide guidance through video conferencing. This creates accessibility to rehabilitation services, particularly for individuals in rural or underserved areas. Patients can receive personalized exercises, promoting consistency in their recovery programs. Tele-rehabilitation enables a comprehensive approach to recovery, ensuring that patients receive the necessary support ageless of traditional clinical settings. A recent study has observed the possibility of prevention for stroke survivors through tele-rehabilitation that may allow more versatile therapies for the patients (*Tele-Rehabilitation After Stroke: An Updated Systematic Review of the Literature*, 2018). Alongside another research has been conducted that has dwelled on the path tele-rehabilitation may take through offering digital technology to build a communication system to benefit patients (Salawu, et al., 2020). More research has been conducted to test the efficiency of tele-rehabilitation and its benefits to patients experiencing problems in specific muscle areas (Azma, et al., 2017).

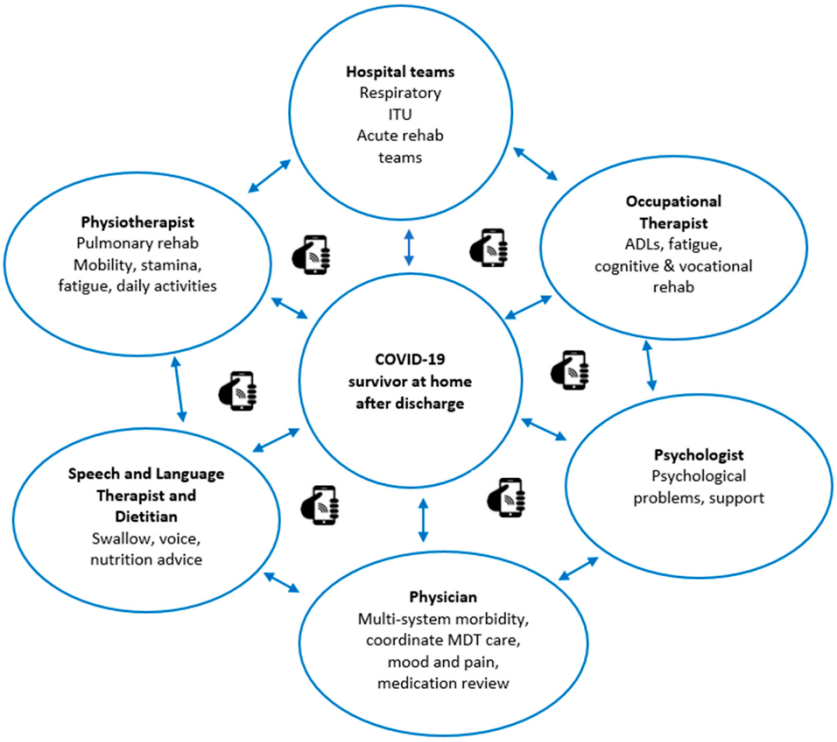

Figure 4 (Salawu, et al., 2020)

The integration of robotics into rehabilitation therapy has opened new possibilities for individuals with limb loss or impairment. By offering assistive devices, virtual and augmented reality training, brain-computer interfaces, and robot-assisted exercises, patients can endure improved prosthetic control. This combination of technology and human expertise allows for personalized recovery plans, addressing individual needs and challenges more effectively. As robotics continues to advance, the future of rehabilitation therapy looks promising, offering renewed hope and independence to those on their path to recovery.

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The Nature of HIV

Sohila Waleed

INTRODUCTION

HIV remains a major public health issue, which claimed 40.1 million lives so far with ongoing transmission in all countries of the World . There were an estimated 38.4 million people living with HIV at the end of 2021, two- thirds of whom are in the African (WHO,2023). For the purpose of this article, we are going to focus on 6 areas which are

Key Terms: HIV's history, HIV's symptoms, how do I know if I have HIV?, How does HIV transport from one person to another, HIV's cure, (ART)'s side effects.

Note: ART is a drug course for HIV's patients.

HIV's history

HIV is the human immunodeficiency virus, which are two species of lentivirus. HIV is a virus that attacks the body's immune system's cells (T-cells) and (CD4+) which causes progressive decline of immune system and leads to acquired immunodeficiency syndrome "AIDS"(Osmosis from Elsevier ,2016). For many years HIV was called the gay men disease or "GRID" gay related immunodeficiency (**Raceniello v.,2023)**. The first isolated HIV cell from human was in Paris in 1983 from the lymph node of a patient with lymphadenopathy (**Raceniello v.,2023)** .There are two types of HIV "HIV-1 and HIV-2". SIV "HIV-1 and HIV-2" was first isolated from chimpanzees in 1989 (SIVcpz), it was transmitted among chimpanzees by sexual intercourse, mother to child and blood-blood during aggression. The animals got HIV a few hundred years ago and passed onto people, studies show that chimpanzees gave it to humans as far back as the late 1800s (**Raceniello v,2023)** .it infected humans by cut hunter "bush meat hunting" in Africa. It spread on to the world because of the European colonization of Africa in the beginning end of the 19th century , establishment of large population centers , large scale of prostitutes , health care with unsterilized needles.

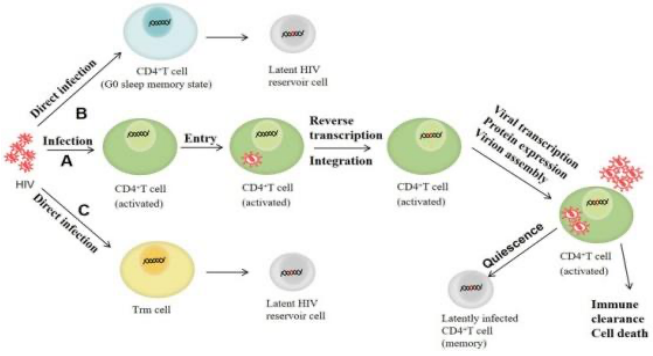

Figure 1 The formation process of latent HIV reservoir.

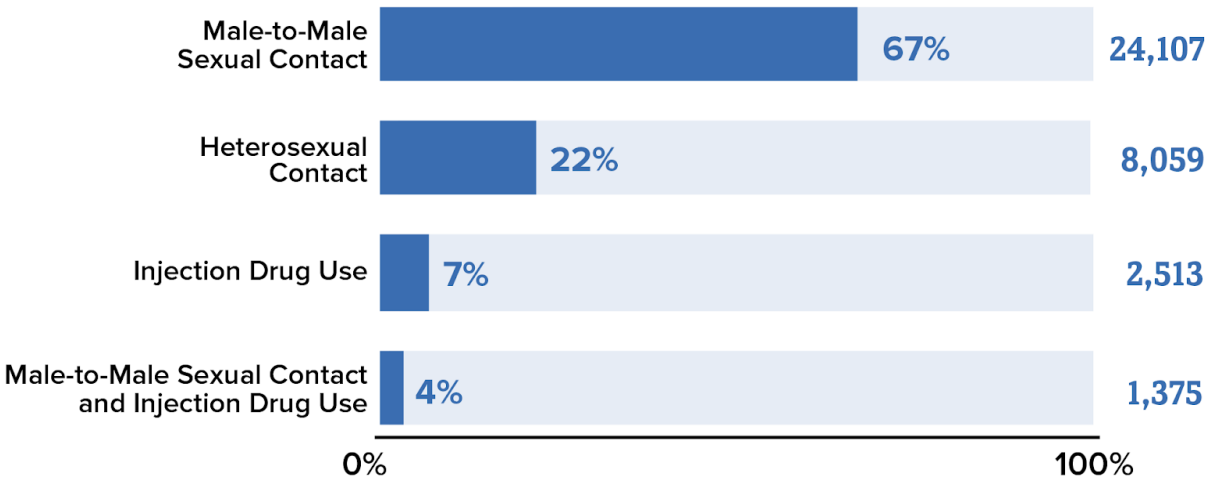

Figure 2 HIV Diagnoses in the US by Transmission Category in (2021)

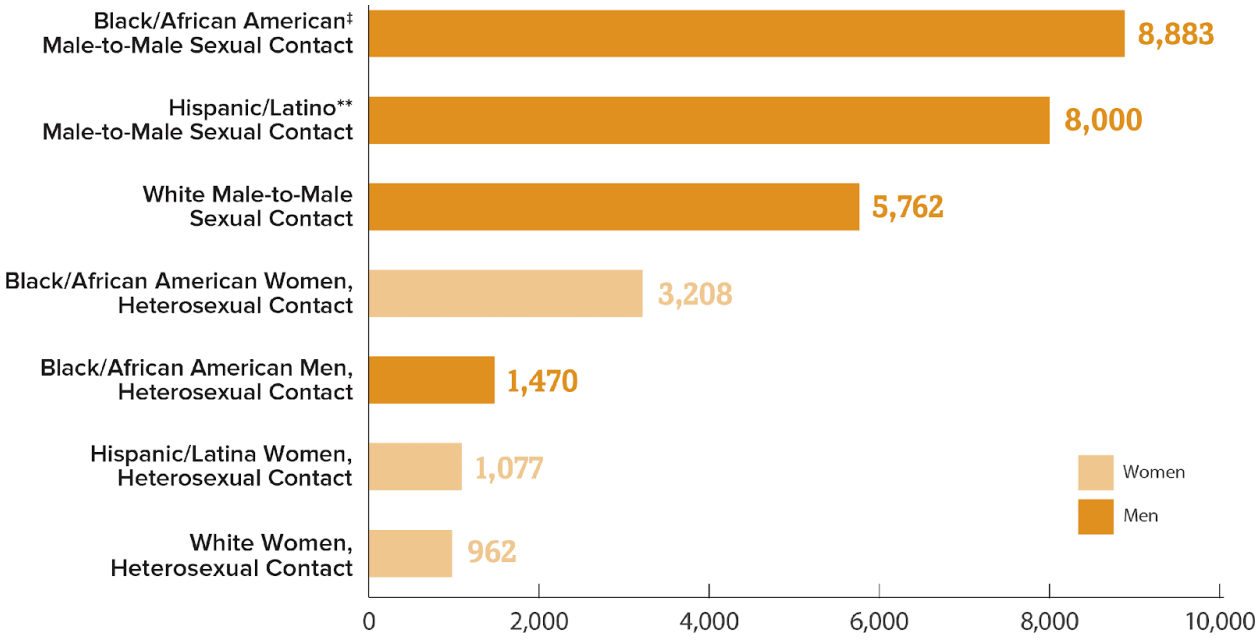

Figure 3 HIV Diagnoses in the US for the Most-Affected Subpopulations in (2021).

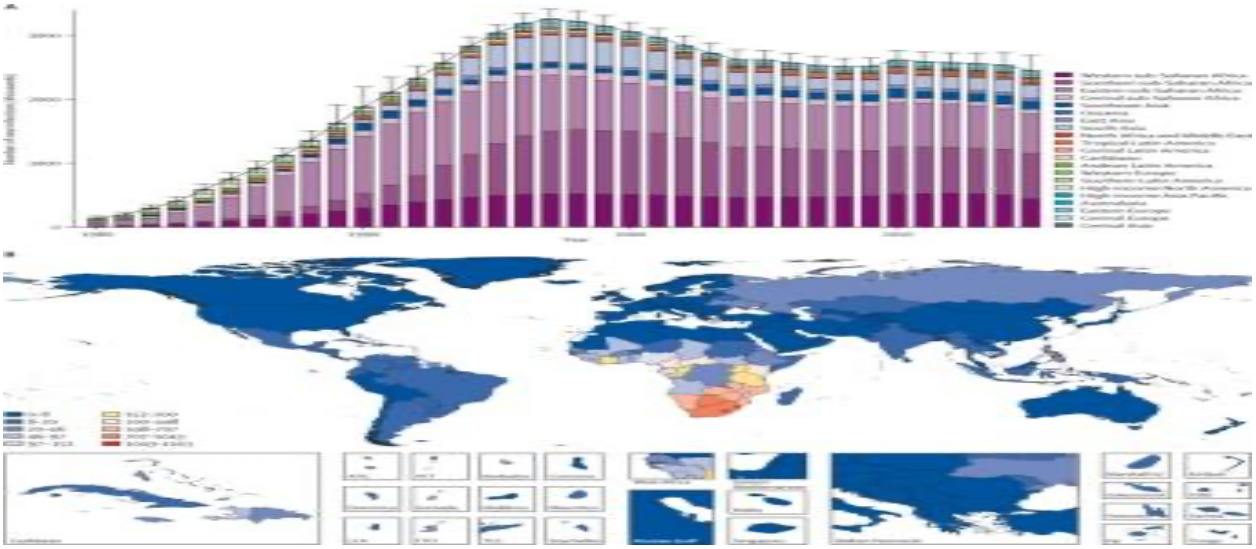

Figure 4 new HIV infections from 1980 to 2015

The virus has existed in the United States since at least the mid to late 1907s (CDC,2023).

HIV's symptoms

For most people they have a flu-like symptoms within two to four weeks after infection. Symptoms may last for a few days or several weeks. Having these symptoms alone does not mean you have HIV, other illness can cause similar symptoms , some people have no symptoms at all. The only way to know if you have HIV is to get tested (Division of HIV prevention, 2022).

How do I know if I have HIV?

The only way to know if you have HIV is to get tested by these tests antibody tests, antigen/antibody tests and nucleic acid tests (NAT). (Division of HIV prevention, 2022).

How does HIV transfer from one person to another?

HIV can spread by sex, intravenous drug use and mother-child at birth.

It does not spread by respiratory, alimentary or vector routes.

Male to male transmission is the most common mode of transmission in the United States. Male to female is the most common mmode in resource-limited settings, although less common female to male transmission. Over 75% of all cases of HIV are contracted from sexual intercourse(**raceniello v,2023)**.

HIV's cure

There is no cure for HIV yet, but there is ART (antiretroviral therapy) which considered a treatment (WHO,2023). ART does not cure HIV but it prevents or delay the progression to AIDS, it also reduce the transmission rate and reduce HIV's mortality and morbidity, it also helps patients live longer and healthier (CDC,2023). ART is not a single medicine but a combination of medicines that is also known as an HIV regimen. These helps slow down HIV replication, which gives the immune system a chance to recover and help fight off other infection more effectively (CDC,2023).

ART's side effect

During modern ART with complaint, initially treated patients, virologic treatment failure is rarely observed (essar, A. et al ,2007). Therefore, in choosing individual drug for permanent ART , side effects play an important rule. Side effects are frequent during ART (Caroline A. Sabin.et al, 2013). Over 25% of patients discontinue ART within the first year due to side effects (essar,A.,2007). All organs can be affected by ART associated side effects and interdisciplinary management is needed.

Lipodystrophy syndrome

Lipodystrophy syndrome (LDS) denotes metabolic aberrations and abnormal fat distribution in HIV patients during ART. In this case usually irreversible loss of subcutaneous fat occurs especially on the buttocks, limbs and face. In the course of lipohypertrophy, fat accumulates potentially reversibly, especially in visceral locations, and somewhat more rarely subcutaneously in the nape of the neck (lipohypertrophy) (essar, A.,2007).

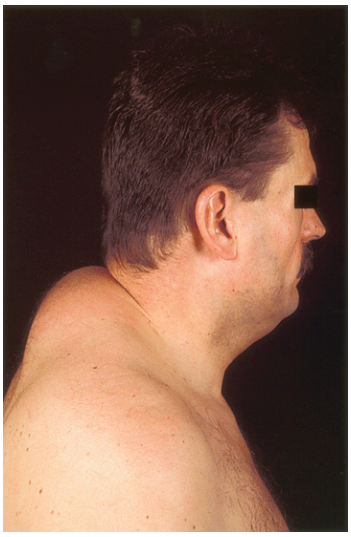

Figure 5

Buffalo hump due to hypertrophy of subcutaneous fat in the nape of the neck in lipody-strophy syndrome in an HIV patient during treat-ment with the boosted protease inhibitor lopinavir. (essar,A.et al , 2007).

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Pioneering a New Frontier in Cognitive Treatment

Zion Wright

Attention Deficit Hyperactivity Disorder (ADHD) is characterized by inattention and hyperactivity/impulsivity, which may result in negative outcomes in terms of academic, social, and professional outcomes. “According to the 2016 National Survey of Children’s Health (NSCH) - 5.4 million children in the U.S. between the ages of 2-17 suffer from ADHD of which 62% received pharmacological treatment, 46.7% received behavioral therapy, and 23% received no treatment (Danielson et al., 2018).” That was why a group of scientists, doctors, and researchers came together to create the first Game-based Digital Therapeutic Device called EndeavorRx. Developed with the goal of offering another treatment option for ADHD that can be accessed from home, EndeavorRx’s purpose is to help treat the majority of children in the United States and the United Kingdom who need mental health services but cannot access them for financial reasons. EndeavorRx presents exciting possibilities since it could open the door for many more game-based treatments for neurological or behavioral issues and illnesses.

In addition to being found in many different app stores, EndeavorRx is a game available throughout the world. Moreover, you can find the application in a wide range of different app stores such as the Google Play Store, the Apple Store and a variety of other apps that cover a variety of phone types. This is done to ensure that no matter what type of device a user is using, they can easily find and access the game in a format that is compatible with their device. As a result, users will be able to access the game on their preferred platform while still receiving the therapy they require.

For instance, the game has been made available on both iOS and Android platforms, allowing users to access the game on both iPhones and Android phones. As a result, increased dopamine is released, which in turn has many positive effects as will be discussed.

It has been noted by many parents that their children's social behavior, academic performances, and attention have changed as a result of the research that they have conducted. ADHD is caused by an imbalance between dopamine and epinephrine, which is due to an increase in dopamine transporter density and anatomical changes in the basal ganglia and the prefrontal cortex. According to studies there has been evidence that states that there is an increased dopamine release due to video games; which results in positive impacts such as enhanced concentration, better moods, and a prosocial effect. This proves that EndeavorRx probably helps with focus from its increased amount of dopamine than medication. Furthermore, EndeavorRx is non-invasive and has fewer side effects than medication. Though medication has definitely proven to be an effective treatment. Especially with the various types of medication that have been prescribed. According to Harvard School of Medicine, “methylphenidate is the most commonly prescribed drug for ADHD worldwide.” Though widely prescribed the medications have to be monitored by doctors and parents closely for the side effects. The most common side effects of ADHD medication are loss of appetite and trouble sleeping. It has also been proven that medications such as Adderall and Vyvanse don’t help with sustained focus, whereas EndeavorRx has been found to help with both focus and sustained focus. EndeavorRx is a video game-based therapy which has been found to increase dopamine levels in the brain. By increasing dopamine levels, EndeavorRx helps to improve focus and sustain focus better than medication.

In addition, since it is a non-invasive therapy, it has fewer side effects than medication, and the most common side effects are mild and short-lived, whereas medication has some effects of suicidal thoughts. EndeavorRx has also been proven to be more effective in treating Attention Deficit Hyperactivity Disorder (ADHD) than medication. It is also more affordable than medication and provides long-term benefits. In terms of being able to treat more children that deal with ADHD on a daily basis, affordability is a huge barrier to treatment. As the statistics show that means a tremendous amount of children are left struggling with the symptoms of ADHD simply because of affordability.

EndeavorRX is not intended to replace traditional treatments; rather, it serves as a valuable complement to existing therapeutic approaches. By integrating cognitive training with other interventions, such as counseling or medication, healthcare providers can create comprehensive and personalized treatment plans for their patients, optimizing mental health outcomes. Endeavor RX has been found to be an effective complementary therapy in research studies. Using cognitive training in combination with other interventions such as counseling in participants with attention deficits improved their cognitive abilities and psychological well-being more robustly and sustainably, according to a study published in Nature Communications (2020). It has been shown in a variety of studies that the use of digital therapeutics in combination with traditional treatments can improve patient outcomes. The combination of cognitive training and counseling specifically has a synergistic effect, which means that the combination of the two interventions results in an effect that is greater than the sum of their individual effects. This is because cognitive training and counseling target different aspects of attention deficits, which allows them to work together to create a greater overall effect.

The cost of EndeavorRx may limit its availability to some families or healthcare systems, potentially making it less accessible to those who would benefit from it. EndeavorRx is specifically intended for children aged 8 to 12 years old with ADHD. It may not be suitable or effective for adolescents or adults with ADHD or for children outside this age range. EndeavorRx is not a substitute for traditional ADHD treatments, such as medication, behavioral therapy, or educational interventions. It is meant to be used as part of a comprehensive treatment plan and should not replace evidence-based treatments. EndeavorRx should be discussed with a healthcare professional to determine if it is an appropriate treatment option. It is important to remember that EndeavorRx is not a cure for ADHD, but rather a tool to help manage the symptoms.

ADHD is caused by an imbalance between dopamine and epinephrine. Dopamine levels are increased by video games, which enhances concentration, mood, and social interactions. An imbalance between dopamine and epinephrine can cause the body to become overstimulated, leading to symptoms of ADHD. The dopamine released from playing video games can help to restore the balance of dopamine and epinephrine, which can reduce the symptoms of ADHD. In research studies, using EndeavorRx in combination with counseling improved the cognitive abilities and psychological well-being of participants with attention deficits. This is because the combination of cognitive training and counseling targets different aspects of attention deficits. It is not a substitute for traditional ADHD treatments, such as medication, behavioral therapy, or educational interventions. This discovery will open up more opportunities for research, allowing scientists to further explore the potential of this type of therapy. In a few years' time, the remaining health insurance will have moved toward covering all of the bills which are $100 per month, $300 for the entire 3-month period. This would allow more people to benefit from the

therapy and its positive effects. It could also lead to breakthroughs in age-related diseases and disabilities, improving the quality of life for many people.

If scientists continue building upon this advancement in game-based medicine like EndeavorRx in the future then within years to come scientists will have found a way to expand the age group that can use EndeavorRx. This will give even more people access to the benefits of game-based medicine, such as improved cognitive abilities, mood, and overall well-being.

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Resilience Tested: The Lifelong Impact of Childhood Trauma on Adult Survivors

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Childhood is often seen as a time when adolescents are surrounded by a bubble of innocence shielding them from the horrors and negativity of the real world. It's a time when children are filled with wonder, but for many, that facade is shattered as adolescents are enshrouded with the darker reality of the world using a deadly weapon: childhood trauma. This weapon encompasses a wide spectrum of adverse events, including loss, abuse, neglect, and more, and the scars they leave are often permanent [1]. They often persist even when the child has grown into an adult, and current efforts are looking into improving the treatment options available for those who have experienced childhood trauma to help their scars scab [2]. Research conducted on childhood trauma has stemmed into smaller areas of research - for instance, some researchers have studied the neurobiological effects of childhood trauma with the help of advanced technology, while others have studied specific types of trauma such as intergenerational trauma [2]. This paper will cover the long-term/permanent psychological and biological effects of childhood trauma on adult survivors.

To understand childhood trauma, one first has to understand the foundational concepts. While many don't talk about this due to it being viewed as a taboo topic by many, statistics reveal the great prevalence of this among adolescents, as 2 in 3 adolescents report that they've experienced childhood trauma before turning 16. Many psychological impacts have been studied that stem from childhood trauma, and many of them are linked to low-self esteem. One important fact to keep in mind is that the various effects of childhood trauma can differ among children. For instance, while preschool children tend to have recurring nightmares and poor eating habits, high school children tend to abuse drugs and alcohol and end up with depression [1]. Those who tend to use denial as a coping mechanism tend to develop feelings of shame and trouble with acceptance, leading to having trouble seeking for help [2]. Most of the treatment options help with easing the psychological stress that comes with childhood trauma, and current research studies reveal warning signs and how to treat children with patience so that they aren't further traumatized.

Psychological impacts aren't the only implications of childhood trauma. Not only does this affect the brain, but it also impacts one's endocrine system by elevating and depressing

certain hormone levels. For instance, trauma can induce a rise in the levels of CRH, which consequently leads to the rise of ACTH from the pituitary gland of the brain. These two hormones are involved in an organisms's adaptation to stress. This connects to the hypothesis of allostasis, which states that the weight of chronic stress can lead to complex interactions between different physiological systems to adapt. Furthermore, these two hormones are not only presented at higher levels when a survivor of childhood trauma experiences stress, but also at baseline conditions. In a study conducted, cortisol activity was elevated among sexually abused girls versus those who weren't abused. The rise in levels of CRH can lead to higher levels of anxiety, depression, aggression, and more, reflecting the domino effect childhood trauma has [4].

In terms of the effects of childhood trauma on the brain, it can lead to the untimely ends of neurons and glia cells. This can seen through pediatric brain imaging reflecting smaller cerebellar and cerebral sizes in those who experienced childhood trauma. Those who had PTSD that stemmed from childhood trauma also had a smaller prefrontal cortex, which is responsible for controlling one's actions and thoughts. In comparison, the amygdala didn't reflect differences in sizes between those who experienced childhood trauma vs those who didn't. The portion of the brain that controls emotions, also called the hippocampus, did reflect differences in size, as it was much smaller in victims of abuse. Differences in brain parts can also be seen between males vs females who experienced childhood trauma. The former had larger lateral ventricles, which indicate they are more susceptible to neurotoxic effects of this trauma [4]. Through the power of advanced technology, researchers are able to find biological and objective markers of childhood trauma.

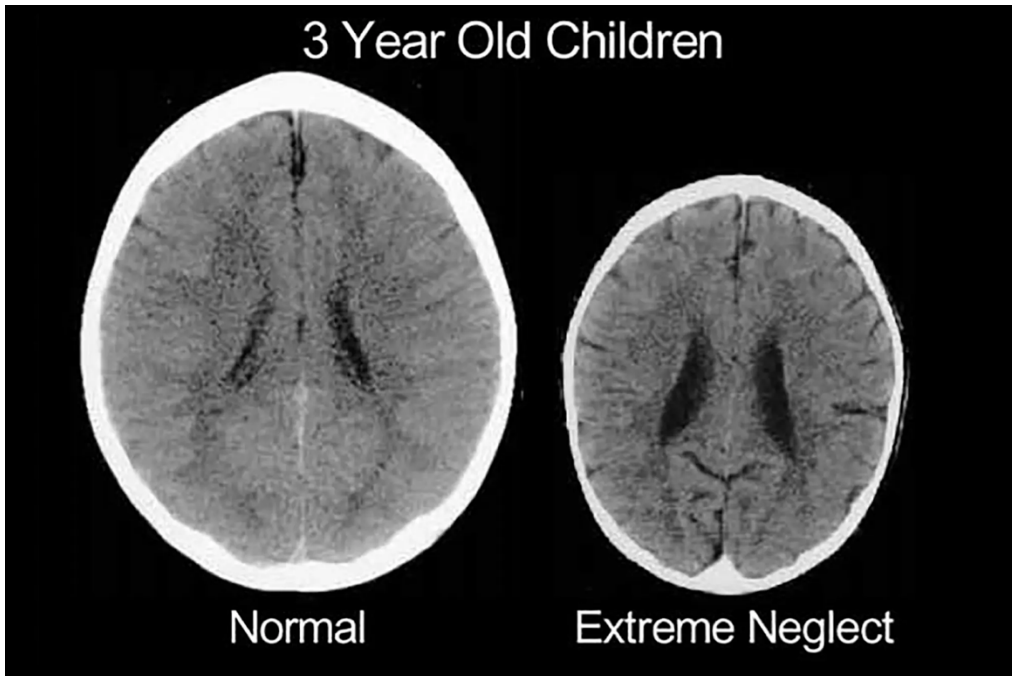

Figure 1: Brain size of healthy 3-year old child vs neglected 3-year old child
The above brain image reflects the drastic difference in size of the cerebrum due to the lack of proper development of the brain induced by childhood trauma.

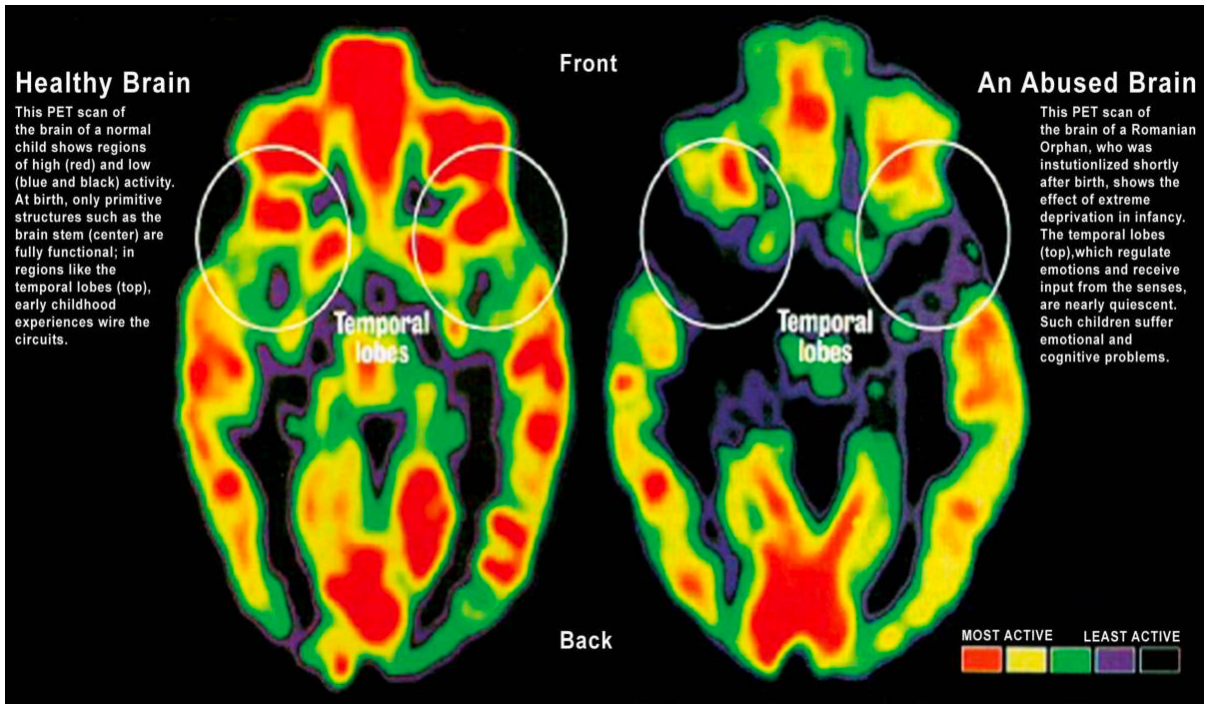

Figure 2: Difference in activity of temporal lobe of a healthy brain vs. abused brain
The above brain image reflects the drastic difference in brain activity of the temporal lobe, which controls emotions. The lack of activity in this lobe can lead to emotional problems in adults with childhood trauma [6].

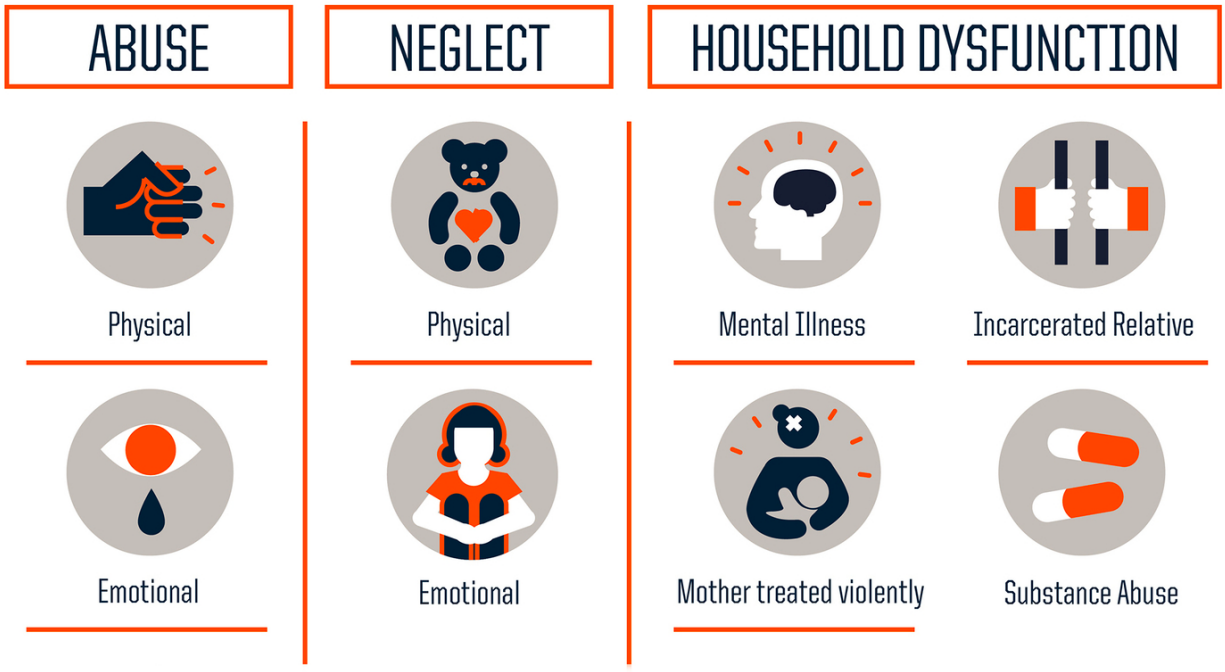

Figure 3: Effects of childhood trauma
The above brain image reflects the various chain of effects triggered by different categories of childhood trauma [9].

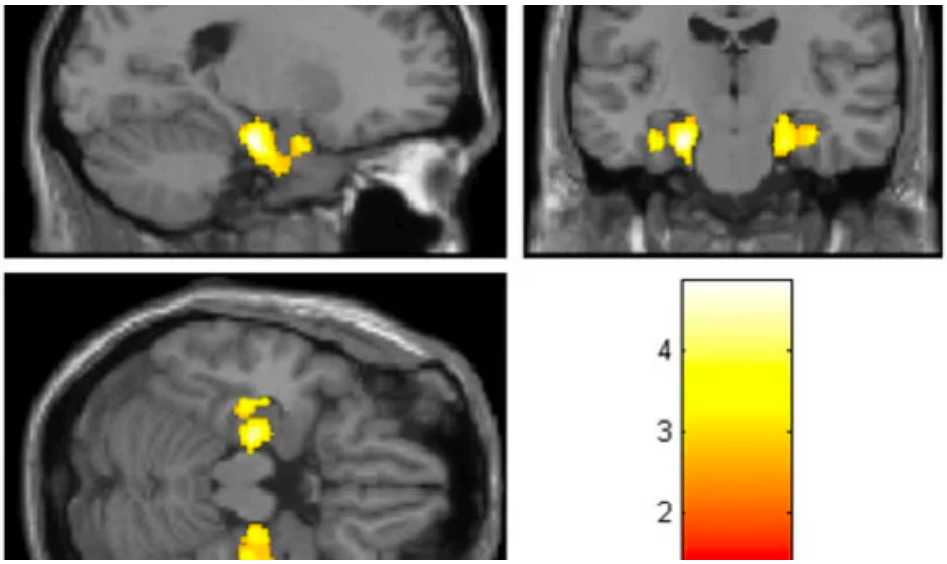

Figure 4: Levels of retention of childhood trauma
The above brain image reflects how childhood trauma is sustained in the brain through the size of the hippocampus. This portion of the brain controls emotions and memory [10].

Within the long-term effect of childhood trauma on adult survivors, there is a major socio-economic factor that plays into this. The risk of experiencing childhood trauma increases for those who are disadvantaged in these two categories. Given the great expenses involved with treatment for childhood trauma, including therapy sessions and prescribed medications, those who cannot afford such treatments have more chronic conditions and worse social skills stemming from childhood trauma. Furthermore, growing up in harsh conditions as a child due to a low socioeconomic status can give rise to childhood trauma, as this study conducted reflected that lower economic status and education are associated with higher risk of childhood trauma. Future research should focus on studying other possible social determinants of health to get a more rotund view and therefore change various health measures to reduce rates of childhood trauma [3].

As childhood trauma has mainly been studied through psychiatric lens, current research diverges into studying various social determinants of health that can raise the risk of experiencing childhood trauma, adopting different safety and health measures, and the biological

impacts of this. A major social determinant is the socio-economic factor, as those who are more affluent have a safety net to help them heal as compared to those of low economic status [3]. Studies also show that family dysfunction makes up a large part of an area where childhood trauma stems from [4]. For instance, those who are neglected from their parents create a false identity to hide their true selves because of the resulting low-esteem and feeling of shame [5]. Various limitations arise in childhood trauma - for one, the poor healthcare system which hasn't adapted much to help those who are at a poor socioeconomic status leads to higher rates of childhood trauma. Many pediatricians and healthcare providers can also miss signs of child abuse, leading to many cases of childhood trauma being undocumented and untreated. To improve this, healthcare providers have provided courses and teaching materials for practitioners in regards to what signs to look for and what to do whenever faced with a situation such as this [11]. Limitations also exist with the research being conducted, as if research is being conducted on children who have recently experiencing childhood trauma, biases may arise and can lead to the need for more complicated and creative frameworks to conduct studies. This paper sheds light on the psychological and biological consequences of childhood trauma, and hopefully in the future, further research can help with the implementation of better treatment measures.

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