SRO: Student Showcase

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About the SRO: Student Showcase

The *SRO: Student Showcase* presents research papers and literature reviews as well as graphic representations, data analysis, and abstracts. This issue of the *SRO* also collects some of the finest finalist papers submitted to our platform.

It is hoped that by presenting this special issue the scholarship on display will reach a wider specialist and non-specialist audience and generate feedback and a scholarly profile for the authors. Every paper in this collection has gone through a rigorous internal review process.

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Dealing with invisible scars of war: PTSD in Veterans

By Alexandra Dimitrova

AUTHOR BIO

Alexandra Dimitrova was born in Crescent City, California and is of Bulgarian descent. She is a student in the 11th Grade at University High School in Fresno, California. She dedicates much of her time to a variety of activities such as academic decathlon, musicianship, and pre-med; all of which have led to her interest in the ways that music is interpreted by the brain, human behavior, and microbiology. Specifically, she hopes to study the physical underpinnings behind the brain's responses, and, by extension, how the mind incorporates new information and uses it to learn and adapt. She plans to major in psychology.

ABSTRACT

The long-term effects of war are extremely present in modern society. However, mental injuries such as posttraumatic stress disorder are commonly overlooked, as they are more obscure than physical wounds and casualties. Today, PTSD continues to affect veterans, and many treatments that have been developed so far are still lacking in effectiveness or have not been thoroughly tested. Prevention treatments can target groups that match characteristics such as deployment details and demographics of those who are most likely to develop PTSD. These can include both demographics and details about deployment. HRVB and CBM-I have been able to decrease PTSD scores in certain populations. Social support, specifically from civilians, is also crucial in protecting veterans from developing PTSD or worsening the severity of PTSD symptoms. Various first-line treatments such as evidence-based psychotherapies and pharmacotherapies show significant lowering in symptoms as well as PTSD remission rates, but these treatments are still ineffective for many patients, whether this is because of personal preference or a general lack of efficacy of therapies. The use of psychedelics and psychedelic–assisted psychotherapy, alcohol interventions, breathing-based meditative sessions, and potentially 3-MDR have shown a decrease in PTSD symptoms for those who preferred not to use first-line treatments or found them to be ineffective. More research should be done to find and assess the current alternative treatments. They have generally proven to be less effective than other, common evidence-based treatments, but are still possible replacements for traditional treatments for some veterans with PT

INTRODUCTION

Humanity has always been evolving and will continue to do so, developing new technologies and life-saving medications to improve society, and discovering new regions of the world and universe; however, there seems to be a perpetual, unavoidable pitfall that has followed society during all of its successes: war. Its effects can easily be observed by simply viewing and comparing maps, as the world's countries' borders are constantly being established and fluctuate throughout history. Earth is divided by extremely precise borders of nations, and relentless wars and conquests have been the primary factors in determining these barriers. There are various types of wars, some of which hold much more devastating effects on life than others. The world is perhaps most familiar with traditional, physical, army-against-army warfare. However, there are types of silent wars which precede actual combat. Physical war is often the last resort, and it, along with its devastating effects, could perhaps be prevented if we invest in these preceding events before engaging in physical war–which has devastating effects on all sides.

Combat has terrible consequences in the surrounding environment, which is demonstrated in the enormous amounts of both civilian and military deaths. Casualties of United States military personnel reached a total of 364,511 in the Civil War, 116,516 in World War I, 405,399 in World War II, and 58,220 in the Vietnam conflict (DeBruyne, 2017). These statistics do not account for injuries or the multitude of additional civilian deaths, which are harder to accurately survey and record. In addition to these reductions in physical health, many veterans are subjected to posttraumatic stress disorder as a result of enduring horrendous events. During recent wars, high percentages of returning US soldiers were recorded to have PTSD: a population-based survey of 30,000 participants concluded that PTSD's prevalence in Gulf War veterans was 10.1% or about 70,000 deployed troops (Kang, et al. 2003), and a RAND study conducted with 1,965 participants showed that the probable rate of PTSD in Operation Iraqi Freedom and Operation Enduring Freedom was 13.8% (Tanielian, et al., 2008).

PTSD can present long-term limitations in veterans' ability to re-assimilate to their society and return to civil life. PTSD can also predict lower quality of family relationships and work function in addition to dissatisfaction with life (Vogt, et al. 2016). Studies are necessary to determine which current and new treatments can reliably reduce PTSD symptoms and cause remission in patients. This field is still somewhat lacking in data since most studies conducted to test the severity of symptoms and improvements are undertaken by self-response surveys administered to groups with limited diversity.

Certain preventive measures and various treatments, including pharmacological and physiological therapies, psychedelics, and various new alternatives to first-line treatments can reliably diminish the severity and development of PTSD and improve the quality of life in returning veterans. Although current treatments have limited success rates, more experiments and research will further our knowledge of new improvements and alternatives and will allow us to deal with the invisible wounds of war.

RISK FACTORS

Although we are unable to make completely accurate predictions about which individuals may be subjected to the development of PTSD, certain demographic factors and characteristics have been found to result in an increased risk. Such factors are observable in pre-trauma characteristics as well as in during and post-trauma situations. These factors primarily include age, gender, the area of deployment, whether or not the military agent had previous exposure to deployment, and, importantly, the overall amount (or lack) of social support upon returning from deployment.

A meta-analysis of 32 studies (comprised mainly of studies using self-surveying methods) shows pre-traumatic demographics and peri-traumatic characteristics which a majority of veterans who suffer from PTSD are more likely to have; these include having prior traumatic experiences or psychological health problems, lower education, being of the female gender, being non-white, undergoing more or longer deployments as opposed to little or no combat exposure, weapon discharge and extreme conditions (Xue et al., 2015). Perhaps military leaders can watch out for peri-traumatic risks and retain contact with individuals. They can also administer specific prevention treatments to those who have been exposed to prior trauma, mental problems, or the aforementioned demographics to limit the possibility of developing PTSD before it has already affected veterans' lives and requires treatment. Higher levels of social care after deployment contribute to a positive environment which can also lower the advancement of PTSD in veterans (Xue et al., 2015).

PREVENTION

Preventative measures and training have been developed to prepare military personnel for coping with the events of the war. While they may not result in a major, observable effect, they have been shown to profoundly help certain sub-groups. Two of these interventions are heart rate variability biofeedback (HRVB), a mechanism that may be able to regulate cognitive control, and cognitive bias modification for interpretations (CBM-I), a "cognitive vaccine" that can build resilience to the development of PTSD symptoms (Pyne et al., 2019). A randomized control trial tested the effectiveness of these two preventative interventions; it should be noted that the use of interventions during deployment was largely untrackable and determined by self-report methods and that soldiers encountered multiple circumstantial challenges in using these apps. Results showed that the use of the intervention app BreathPacer (HRVB) demonstrated a

3-month benefit after deployment in reducing PCL scores in groups of older age and had no prior combat exposure than in the control group which did not receive this intervention, as well as producing a noticeable 12-month benefit in soldiers who were of ages 45 and older (Pyne et al., 2019). IMAT (CBM-I) was able to also lower symptom scores in soldiers with previous combat exposure and with ages ranging from 23 to 42 (Pyne et al., 2019), while no benefit was observed during the 12-month follow-up.

In addition to prevention apps, long-term memory inhibitors can be used to block the formation of posttraumatic memories. However, some of the primary drugs used in prevention, which are administered before a possibly traumatic event, may affect the health or critical performance during a mission–unlike HRVB and CBM-I. Sympatholytic medications such as alpha and beta blockers, drugs that prevent the binding of norepinephrine and epinephrine to certain receptors and therefore suppress their stress effects, were shown to have some undesirable physical effects and relatively no undesirable mental effects, but had the highest potential to be effective out of other tested drugs when used in PTSD therapy (Burbiel 2015). Further research is needed to continue to test alpha and beta blockers and other methods' true efficacy, especially since current primary prevention methods can contribute to decreased tactical performance.

Social support after traumatic combat-related experiences functions as another crucial protector against the development of PTSD in returning veterans. A meta-analysis of 37 studies noted that lower levels of social support were associated with higher levels of posttraumatic stress disorder symptoms, along with indicating that support that veterans received from non-military sources was more effective in protecting against PTSD as opposed to that of military sources–although support from both populations led to a significant decrease in PTSD symptom severity (Blais et al., 2021). This means that support from the veterans' civilian community and families is

critical in preventing PTSD, and more protective community measures should be established to help veterans who have experienced scarring events.

PSYCHOTHERAPIES

Among current first-line treatments for PTSD are cognitive processing therapy (CPT) and prolonged exposure therapy (PE), which are both non-pharmacological therapies. Cognitive processing therapy is one of the most commonly used evidence-based treatments in war veterans. The United States Departments of Veterans Affairs and Defense recommend first-line psychotherapy treatments which include cognitive processing therapy and prolonged exposure therapy (Card 2017). A small controlled trial that used both a control and test group evaluated veterans with chronic posttraumatic stress disorder, demonstrating that the test group, to which individual, 12-session cognitive processing therapy was administered by thoroughly-trained therapists, showed a reliable decrease in PTSD symptoms in about 50% of patients; a regression analysis of change also revealed that average Clinician administered PTSD scale (CAPS) scores decreased by about 20 points (a score of 35 or less is considered remission on this scale) from baseline scores to the 1-month follow-up, and re-experiencing and emotional numbing symptoms significantly improved when compared to the control group (Monsoon et al., 2006). During CPT, a type of cognitive behavioral therapy, instructors teach participants how to identify and manage memories and unwanted re-experiences of such traumatic events. Although it is one of the more effective and reliable treatments for PTSD, many patients are still unresponsive to CPT and drop-out rates are high. These individuals require other methods to improve their quality of life and mitigate the effects of PTSD. Prolonged exposure therapy is another commonly used evidence-based treatment. Guided by instructors, patients can process traumatic memories and manage PTSD symptoms. In a randomized clinical trial in which 67 participants attended 13

sessions of prolonged exposure therapy over 24 weeks (and no other treatments), CAPS scores declined by about 29.4 points (Rauch et al., 2019). Both cognitive processing therapy and prolonged exposure therapy in these studies met the criteria of a significant change of 20 points and can be considered effective treatments.

Compressed and intensive outpatient programs have been gaining popularity in treating PTSD. A recent study with 234 randomized participants conducted a randomized clinical trial comparing massed prolonged exposure therapy (M-PE) and intensive outpatient prolonged exposure therapy (IOP-PE), both of which are compressed forms of prolonged exposure therapy. This study showed that CAP-5 scores declined from a mean of 37.5 to 22.5 for both treatments and 53% remission rates for patients who went through IOP-PE and 52% remission rates of participants in M-PE after a 6-month follow-up, and it demonstrated that compressed treatments likely will result in more patients completing the treatment program and smaller drop-out rates (Peterson 2023). Intensive treatments can quickly deliver therapies and still significantly improve symptoms and remission rates. Another IOP study (self-report reliant) recorded data from 191 patients undergoing a 3-week long intensive outpatient program comprised of group and individual CPT, mindfulness, yoga, and psychoeducation in 15 daily sessions; its results showed that 92.1% of participants completed the program and PCL (self-report PTSD checklist containing 20 items) scores declined from a mean of 57 to 40 (Zalta et al., 2018). These two studies imply that compressed formats of widely used psychotherapies can effectively decrease symptom scores and retain remission rates/scores over time, despite patients learning the material in a short period.

PHARMACOTHERAPIES

A common form of pharmacological therapy is selective serotonin reuptake inhibitors (SSRIs). These pharmacotherapies prevent the

reabsorption of serotonin and are used to relieve depression. The Departments of Veterans Affairs and Defense recommend pharmacotherapy–including SSRIs such as sertraline and paroxetine as first-line treatments–when individual psychotherapy is unavailable or is not preferred (Card 2017). SSRIs are a viable alternative to psychotherapies if patients do not achieve either desired effects or wish not to use cognitive processing or prolonged exposure therapies. The least emotional regulatory brains likely stand to benefit the most from SSRIs since they appear to adjust abnormal BOLD signals in the prefrontal cortex (MacNamara 2016).

A randomized clinical control trial testing the effectiveness of SSRI sertraline and its combination with prolonged exposure therapy demonstrated a decline of the mean CAPS score from 75.5 to 41.7 when 71 patients were only administered sertraline and similar scores of 76 to 43.3 in 69 participants when administered both the psychotherapy and pharmacotherapy (Rauch et al., 2019). This result was also similar to the control PE group, whose scores declined 29.4 points, showing that sertraline, its combination with PE, and PE did not show any significant differences in treatment effectiveness.

PSYCHEDELICS

Individual veterans may be either reluctant to use first-line therapies or might find that they, along with popular pharmacotherapies such as SSRIs, have limited efficacy in treating PTSD. Lesser-known psychedelics such as ibogaine and 5-MeO-DMT have been used in assisted therapy as an alternative method to treat such individuals. In a study testing the effectiveness of these drugs in Special Operations Forces (SOF) military personnel (many of whom served in either Operation Iraqi Freedom or Operation Enduring Freedom and had previously attempted various psychotherapies, yoga, and pharmacotherapy), therapy assisted with psychedelics was shown to significantly reduce cognitive impairment and

PTSD symptoms (change in symptom score was -34.2) after a small amount of time and limited doses of ibogaine and 5-MeO-DMT, and 84-88% of participants reported this experience as being extremely spiritually significant, psychologically insightful, and personally meaningful (Davis et al., 2020). Unlike some SSRIs, continued consumption of psychedelics seemed to not be required for significant, lasting effects. However, for potential adverse effects and other qualities to be determined, further research is needed.

In addition to the effectiveness of psychedelics in mitigating PTSD, they can potentially also be paired with evidence-based psychotherapies for improved effects. After a preparatory phase in which participants are briefed about the treatment and expectations, the psychedelic drug can be individually distributed to patients in a relaxed environment, potentially allowing participants to open up about their conditions and thoughts during a final integration session; this process is thought to allow a comfortable exchange between participants and their therapist(s) and allow them to work through painful memories together (Reiff et al., 2020). The use of psychedelics may also encourage veterans suffering from PTSD to meaningfully interact with therapists.

ALTERNATIVE TREATMENTS

Although conventional methods are extremely effective in some cases, they have limited success rates among certain individuals and alternative methods have similarly been proposed and tested. These include non-trauma-focused, breathing-based meditations such as Sudarshan Kriya yoga (SKY) as well as brief alcohol interventions. A clinical trial with 21 Iraq and Afghanistan war veterans, which tested the efficacy of the Sudarshan Kriya yoga experiment, expressed a mean 36.6 to a 25.6 PTSD checklist score as opposed to the control groups in which PCL scores increased over the same time, as well as showing high completion rate (over 90% of

participants remained in the program), implying that the program yielded high acceptability among veterans (Seppala et al., 2014). A study with a moderate sample size of 88 participants presented a claim that SKY met non-inferiority criteria to traditional CPT since PCL-C score symptoms presented a mean decline of 6.8 with CPT and 5.2 with SKY (Bayley et al., 2022). The SKY form of breathing-based meditation yielded a score decline that was comparable to first-line treatments, suggesting that it is a feasible alternative to psychotherapy. Sudarshan Kriya yoga also correlates with more improvement in emotional regulation (poor emotional regulation is a symptom of PTSD) than cognitive processing therapy (Mathersul et al., 2022).

Alcohol misuse tends to be common in veterans with PTSD as demonstrated by misuse in Operation Enduring Freedom and Operation Iraqi Freedom veterans; furthermore, emotional numbing and hyperarousal post-traumatic stress disorder symptoms are correlated with alcohol misuse (Jakupcak et al., 2010). Successful alcohol interventions have therefore been associated with higher PTSD scores. A larger clinical analysis trial with 523 participants showed a positive correlation between PTSD symptom severity and alcohol misuse, and participants with higher PCL scores had a greater reduction in alcohol misuse than scores of patients with lower levels of PTSD symptoms (Brief et al., 2018). This meant that veterans who had high levels of PTSD stood to benefit the most from alcohol interventions, and, in addition to improving misuse issues, PTSD symptoms could also be addressed during alcohol interventions. Another study of 68 combat veterans undergoing a brief, one-session alcohol intervention to decrease alcohol misuse and distribute individualized feedback on coping with PTSD revealed decreased CAPS scores from 51.22 at baseline and 35.56 during the later 6-month follow-up (Luciano 2019). PTSD symptom scores were found to decrease along with the decrease in alcohol misuse after a short intervention, indicating an important relationship between the two.

Moral injury also highly correlates to treatment-resistant posttraumatic stress disorder, and, in an attempt to provide alternative treatments for resistant PTSD and moral injury, Multi-modal Motion-Assisted Memory Desensitization and Reconsolidation (3MDR) can potentially be used to reduce PTSD symptom severity. A mixed methods study explains that 3MDR is an exposure-based therapy assisted by technology that has been used in treating PTSD; it determines that it may be a potential treatment for treatment-resistant PTSD since participants reported that 3-MDR was accepted by veterans as an acceptable treatment and repaired damaged global beliefs and re-interpreted meaning and purpose, based on a small preliminary study (Smith-MacDonald 2023). 3-MDR seems to be a possible solution for treatment-resistant PTSD, but more research must be done to determine its full quantitative efficacy.

CONCLUSION

Since the war, and therefore combat and deployment-related posttraumatic stress disorder, continues to plague our society, traditional psychotherapies, and pharmacotherapies, which are known to cause relatively high remission rates and significantly lower symptom severity, and potential new treatments continue to be tested and improved. As a result, the effects of both these traditional and newer treatments (both positive and adverse) are becoming more well-known. In addition to treatments after the fact, prevention methods are also being developed to address the risks of certain populations–such as age, gender, deployment length, and frequency–and protect against PTSD development. Although first-line treatments recommended by the VA/DoD are effective for a majority of individuals, many others may seek different, yet still effective, non-trauma-focused alternatives. The use of psychedelics and psychedelic-assisted psychotherapy, breathing-based exercises, and alcohol intervention have all shown a decrease in PTSD symptoms for those who preferred not to

use traditional first-line treatments or attempted to use them and found them to be ineffective.

FUTURE DIRECTIONS

It should also be noted that studies of these treatments are subjected to multiple limitations. Many lack generalizability to other non-veteran populations suffering from posttraumatic stress disorder, while others have relatively underpowered test groups. Some studies were also unable to retain contact with participants for a longer period for follow-up appointments to track participant retention of positive effects. Additionally, many studies were conducted with self-surveying methods, which can be subject to user bias. For these reasons, additional research is crucial in understanding and managing combat-related PTSD in veterans.

More resources and effort should be put into creating more extensive research on both PTSD and its treatments which could take the form of clinical trials assessing more diverse populations' reactions to treatment methods and prevention methods that are effective for a larger variety of veterans. They can also examine new potential solutions to treatment-resistant PTSD. Becoming knowledgeable about treatments may also expand the scope of their effectiveness, and allow use for various other groups, including civilians exposed to war, and suffering from posttraumatic stress disorder.

Involvement and awareness in communities with veterans is also a vital factor in protecting against PTSD. This can take both the forms of military leaders keeping watch for potential, well-known risk factors and civilian community and family support.

ACKNOWLEDGEMENTS

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Implying community vitality index through housing factors

By Mark Li

AUTHOR BIO

Mark Li, a 16-year-old Junior at Avon High School, CT, excels in math, finance, computer science, and physics. He has qualified for the American Invitational Mathematics Examination through the American Mathematics Competition (10th grade) and won a silver medal in the United States Coding Olympiad. Mark's passion extends to machine learning and social science research, where he combines machine learning techniques with social sciences to explore complex issues. Beyond academics, he enjoys absorbing new knowledge and finds fulfillment in mentoring and guiding his peers. In the future, Mark aspires to tackle societal dilemmas by applying machine learning and mathematics perspectives to make a meaningful impact on the world's challenges.

ABSTRACT

The Community Vitality Index (CVI) is pivotal in assessing community well-being, informing decision-making processes, encouraging community participation, and efficiently distributing resources to enhance residents' overall quality of life. Leveraging contemporary housing data and sophisticated multivariate regression algorithms allows us to train a machine-learning model for a real-time vitality index. This enables prompt recognition and response to evolving community dynamics, all without delays.

INTRODUCTION & BACKGROUND

Persistent disparities have existed in various aspects of life within American communities. To combat these inequalities, a concerted effort has involved collaboration with academic societies, policymakers, consulting firms, governmental agencies, and non-profit organizations.

Academic societies: Dr. LaPlante at the University of Southern Maine and her team defined 'community vitality' as the well-being that attracts residents, identifying key indicators, including aesthetics, infrastructure, services, recreation, and transportation, while considering social and economic factors.

Think Tank: The Economic Innovation Group, a bipartisan public policy think tank, releases its Distressed Communities Index (DCI) to gauge the economic well-being of U.S. communities and highlight disparities nationwide. The DCI categorizes zip codes by evaluating factors that include adult education levels, property rates, median income ratios, and more.

Consulting Institutes: Fourth Economy, a consulting firm, has developed a comprehensive community index that evaluates vital metrics of flourishing communities. This index comprises 20 factors, such as gross domestic product per employee, the per capita ratio of college students, local food availability, net migration, and other elements. This evaluation is conducted county-wide.

Nonprofit organizations: DataHaven, supported by the Hartford Foundation for Public Giving, creates the Greater Hartford Community Well-being Index, which includes economic, health, and educational well-being indicators applicable to Hartford and its neighboring towns.

Community indices typically rely on data from the 5-year U.S. census survey, which limits their capacity to capture real-time community dynamics. Furthermore, some of these indices operate at the county or metropolitan level, potentially lacking the detailed community-level insights that local governments require.

This paper proposes incorporating a house price-based index into assessing community vitality. House prices can reflect a community's overall health, including investments, local economic conditions, and government policies. They also provide insights into a region's economic development and urban vibrancy, with higher housing prices often correlating with improved living conditions that benefit residents' physical and mental well-being. Moreover, house price fluctuations can significantly impact economic growth and consumer spending, with sharp declines potentially triggering recessions.

Two main categories of factors influence house prices: those directly linked to the physical structure of the house, such as square footage (referred to as "location-independent factors"), and those tied to the overall health of the community, like crime rates (referred to as "location-dependent factors"). By focusing on the factors related to location, we can create an index for comparing community vitality. The resulting index will also provide real-time insights since housing data is updated with every transaction, such as buying or selling a house.

The Indiana State Vitality Index was developed by combining weighted factors like "income, education, [and health]" (referred to as IUPPI). However, this dataset doesn't cover all the elements influencing community vitality. To comprehensively understand all factors related to communities, this

paper suggests using an exclusion-based method, which involves filtering out irrelevant location-dependent factors from housing prices.

RELATED WORKS

How a community index is calculated commonly: A CVI can be directly calculated by amortization. According to Benson, the primary factor of price appreciation is the location of the home, essentially, the location-dependent factors. Closeness to work, services, or recreational areas increases the CVI. "Homes adjacent to natural resources like parks and open spaces hold an 8%-20% higher value than comparable properties"(University of Washington). This quote demonstrates the value of natural resources in improving community vitality. Crime rate is also a significant factor that impacts a community's vitality. A study by Florida State University [10] shows that a 10% increase in violent crimes within a neighborhood reduces house values by 6% in Miami-Dade County, Florida. These studies indicate the importance of safety and a low crime rate in relation to community vitality.

While these factors are essential, they only constitute a fraction of the comprehensive variables required to create a strong vitality index. Other crucial factors, including population size, median household income, and various socioeconomic indicators, substantially impact the overall vitality index. However, these data points are typically updated every five years during the census, resulting in significant delays between updates. Additionally, gathering and updating this extensive dataset is both resource-intensive and time-consuming. Furthermore, collecting and updating this extensive dataset is both time-consuming and labor-intensive. In contrast, a vitality index centered on housing prices, excluding location-independent variables, benefits from real-time updates through fresh housing transaction data.

A particular case highlights the importance of the community index: Zillow's 2021 loss of more than $400 million was associated with its failure to consider the vitality index, additionally, its neglect of rapid inflation during that period and the overall housing market's stagnation (What happened at Zillow? CNET). However, according to Purdue, population was the most significant factor impacting the CVI. The COVID-19 pandemic, which led to more people working from home due to increased remote work, strongly influenced community vitality.

PREVIOUS RESEARCH

The Indiana government employed the grid-based partitioning method, specifically INDIANA-GSS (Grid Scanning System), to develop a vitality index for its communities. However, the index values generated by INDIANA-GSS were inaccurate for certain regions characterized by low house density and sparse populations. The paper adopts a digressing approach known as locational clustering to address this limitation.

According to the Indiana government, most smaller and larger counties have an inaccurate vitality index value at 49.34% accuracy, in contrast to the 80.00% accuracy threshold. These counties behave similarly to outliers, where population-related factors are in the 1st and 4th quartile in the regression process and too extreme for the regression model to produce the vitality index. By normalizing the population density in each subdivision, the clustering method generates a functional index of those areas within the previous density distribution's 2nd and 3rd quartile, ensuring there are no outliers concerning population density.

Although clustering processes the data to detect outliers high-dimensionally, the data could form a circular cluster and negatively affect the model's accuracy. The following section describes using HDBSCAN and K-Means++ to fix the circularization issue.

According to Azemlu, their data cleaning used a similar cluster algorithm to process the data used in the regression. In this paper, the algorithm cleaned "cluster data using different methods such as K-means [and] DBSCAN." (House Price…Comparative Study) In the model, DBSCAN eliminated some outliers, which are data points in a region with a data density of below 0.1 points per square unit, and the K-means clustering improved R^2 value to accuracy above 70% by finding houses with similar values in each factor, and comparing house prices. However, upon using clustering, the cleaned data points in the price calculation model had a tendency to resemble a round-shaped cluster, which considerably impacted the regression's accuracy and decreased the R^2 value by 18.34%. Data circularization occurs in multidimensional datasets, where outliers are excluded through clustering to lower regression accuracy.

Preventing the data cluster from becoming elliptical was solved in the Price Determination model outlined in this paper. When the clusters become elliptical, accuracy decreases significantly by 28.12%. In this paper, to obtain the accuracy and reliability model, a function for preprocessing data was created to remove outliers based on location-independent factors in the three steps below.

1. HDBSCAN clustering produces a membership score for every data point. All data points with a membership score of 0.7 or higher were excluded, creating a lenient and controllable outlier removal system.
2. Linear regression analysis estimates the coefficient for each variable in the housing dataset.
3. The slope values defined two parallel hyperplanes, and the y-intercept was adjusted to encompass 65% of the data within the range of hyperplanes; other data was dropped.

For Hartford County locational clustering graphed by MatPlotLib below, K-means was paired with K-means++ to find the optimal number of clusters[1]. K-means identified outliers via the longitude and latitude of houses and clusters to control location-dependent factors.
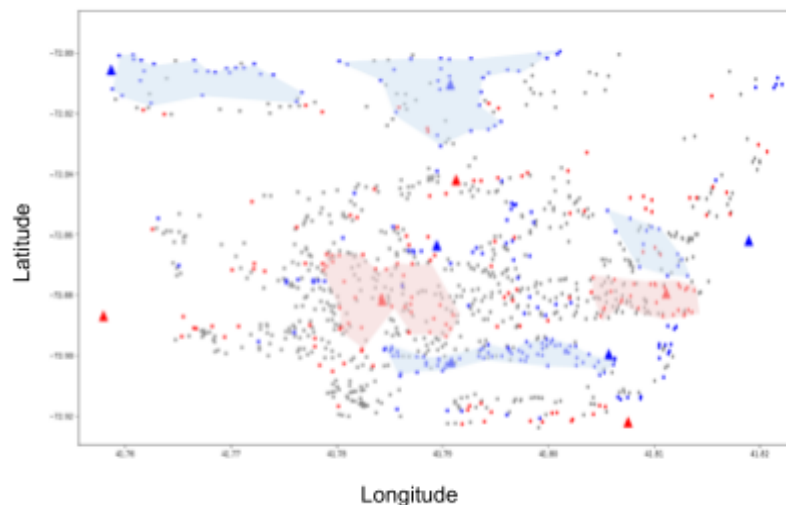

Figure 1. Housing Clusters in Hartford County, CT

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[1] Kmeans++ identified four 6 high priced clusters, 5 low-priced clusters, and 10 medium-priced clusters

Figure 1 reflects low and high house prices. Red denotes house prices below 350,000 dollars, and blue indicates house prices above 750,000. The shaded regions represent actual clusters of houses. Triangles represent potential clusters of houses.

METHODOLOGY & DATA PREPARATION

Location-independent and location-dependent are two overarching parts of the regression model.

Location-independent: Square Footage, Square Footage of Heated Area, Lot Size, Number of Rooms, Number of Bedrooms, Number of Bathrooms, The Number of Garages, Whether the house has a pool, Flooring material, External Siding material, Heating fuel type.

Location-dependent: Crime Rate, Police Count, Number of Nearby Highways, Number of Nearby Local Roads, Number of Nearby Service Roads.

All houses missing important information were dropped from the dataset in the file. The categorical variables were split into several categories of binary variables for usage in machine learning algorithms.

MODEL-PD (PRICE DETERMINATION)

SciKit-Learn is the primary machine-learning Python library, including linear regression and logistic regression packages that provide classification, clustering, and regression algorithms.

MODEL-PD is an agglomerative hierarchical regression model to determine housing prices and create a CVI normalized for the migration classification model. Initially, the regression model used square footage as an independent variable and house prices as a dependent variable, partitioned by the year built, controlling time in terms of decades. Increasing the location-independent dataset from two dimensions to five also turns the regression model into a multiple linear regression model to control location-dependent variables. Next, adding K-means accounted for the location, and adding HDBSCAN removed outliers in the location-independent dataset. Then, MODEL-PD split the dataset into binary and non-binary variables and converted categorical variables into a series of binary variables. Finally, an additional proportional weighting splits the house price between these two types of variables. MODEL-PD development consists of two interactions.

Variable Selection
1. Square Footage as an independent variable and house prices as a dependent variable were chosen for the linear regression with OLS because they were the most strongly correlated, at 0.6092.
2. Segmenting the year built and controlling the sold year improves the correlation to 0.6792.
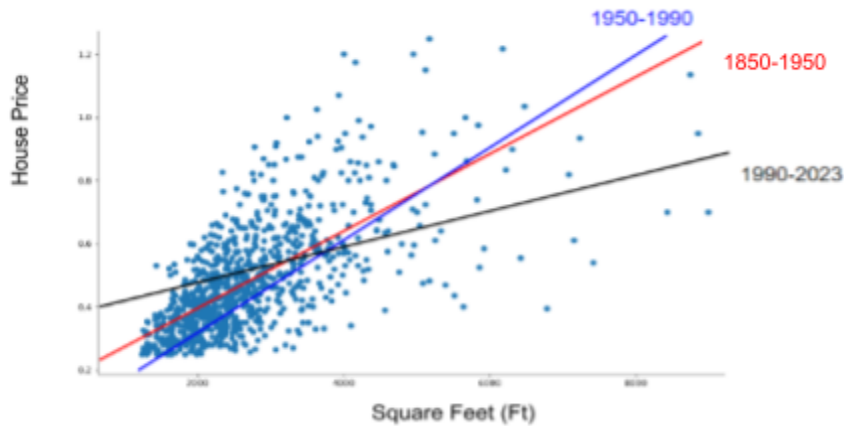   The following graph depicts the time-segmented relationship:

Figure 2. Year Partitioned Comparison of Sq. Footage and House Price

The R^2 value of the data segments was originally 0.6792±0.3059. Introducing location-independent variables decreased the R^2 value and variance to 0.5381±0.2101.

Data Cleaning
1. HDBSCAN clustering removed noise and outlier points, and K-Means clustering found clusters of houses with similar prices and attributes, whose means were subtracted respectively. The accuracy improved to 0.7302±0.2113.
2. Additional categorical and binary location-independent variables were added to help HDBSCAN identify noisy points more efficiently by increasing the distance between data points.

Model Selection
1. A hierarchical regression method processed the categorical, binary, and continuous numeric variables separately.
2. Adding Crime Rate measured the effects of a location-dependent variable. The coefficient of the Crime Rate was consistent across all houses and time series, suggesting that location-dependent variables can be calculated separately from location-independent variables, indicating a proportional weighting to calculate the community index.
3. By weighting proportion, the price was split into 71.42% for location-dependent price determination and 28.58% of the price for calculating the CVI.
4. To adjust for inflation from COVID-19, housing prices increased by 30% since 2019.
5. Next, the CVI was normalized into the final index by the following formula:

   Unprocessed Community Index / Population in Community x 1000 - 1000

   The minimum index calculated was 1192, so subtracting 1000 would keep the index in the positive range.

MODEL-PD Results

The table below lists all the independent variables and coefficients for location-independent factors used in the regressive location-dependent variable analysis.

Table 1: Independent variables and coefficients

Variable		Coefficient	Confidence[2]
Y-Intercept		-129,352	N/A
Numerical Variables (71.2%)			
Square Footage		2618*	0.088
Square Footage of Heated Area		149*	0.075
Lot Size		125*	0.018
Number of Rooms		1724*	0.047
Number of Bedrooms		1392	0.715
Number of Bathrooms		1102	0.692
Roads	Number of Nearby Highways[3]	-5161	0.654
	Number of Nearby Local Roads	4353	0.476
	Number of Nearby Service Roads	1043	0.142
Location Independent Factors	Crime Rate (Normalized by a factor of 1000)[4]	-4.76	0.276
	Police Count	-102	0.445
Binary/Categorical Variables (28.8%)			
Has a Pool		19983*	0.045
Flooring Information	Has Hardwood Floor	19276*	0.098
Exterior Siding Information	Exterior Siding Includes Wood or Other	-912	0.158
	Exterior Siding Includes Brick or Stone	15407	0.466
Heating Utility Information	Heating Uses Natural Gas or Oil	93	0.539
	Heating Uses Electric power	-463	0.572

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[2] The margin for statistical significance is 0.1 or less. The value used is a P-value. Categorical and Binary variables are handled separately in the regression model.

[3] Road type is defined by the standards in the OSM API: https://wiki.openstreetmap.org/wiki/Key:highway
 Nearby is defined as being within a 5 km radius of the house.
 Highways are roads that are motorway, trunk, or primary.
 Local Roads are secondary or tertiary
 Service Roads are service, residential, or living streets.

[4] Crime and police count are used as a factor that shows the effect of a location dependent variable on the price.

MODEL-MC (MIGRATION CLASSIFICATION)

MODEL-MC is a multivariate logistic regression model that predicts the trend in population migration and validates the accuracy of the CVI. The normalized CVI was created by taking 28.58% of the total actual price because this percentage produced the best correlation between location-independent factors in MODEL-PD. Model-MC then performed regression using the CVI to produce the NMR[5]. Population data was collected from government census sources (census.gov), and MODEL-PD calculated the CVI. The logistic regression model used the NMR as the dependent variable and CVI as the independent variable to determine whether the NMR would increase or decrease. According to Cato, the vitality index and NMR reflect the collection of location-dependent variables. (Immigration and Community Vitality) Population changes also reflected these variables and established a causal relation between the vitality index and the net migration rate by logistic regression.

TESTING MODEL-PD USING MODEL-MC

The CVI and population rate change trained MODEL-MC and produced a confusion matrix that proves the index accurately predicts population rate change and validates the index. The confusion matrix compares predicted population rate change with census migration information recorded below.
The accuracy of the CVI calculated by MODEL-PD is 0.7123 ± 0.1092, which is sufficiently precise and accurate for use with MODEL-MC, which had an accuracy of 0.9064. With the location-dependent factors, logistic MODEL-MC was accurate, with this confusion matrix:

Table 2: Model MC with hierarchical predicted CVI

Model MC with hierarchical predicted CVI	Census Information Indicates Migration Rates Increased	Census Information Indicates Migration Rates Decreased
Predicted Migration Rates Increase	True Positive: 64 (49.6%)	False Positive: 8 (6.2%)
Predicted Migration Rates Decrease	False Negative: 4 (3.1%)	True Negative: 53 (41%)

According to the National Academy Press, 0.906 of the values produced were correct, showing that the MODEL-MC demonstrated sufficient accuracy for community population migration prediction, with an acceptability threshold set at 81%.

Compared to the multiple logistic method of predicting the trend in migration, the number of correct results was considerably more significant, as shown in the following confusion matrix.

Table 3: Model MC with Multivariate logistic CVI

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[5] Net Migration Rate can be calculated at the difference between Influx and Outflow

Model MC with Multivariate logistic CVI	Census Information Indicates Migration Rates Increased	Census Information Indicates Migration Rates Decreased
Predicted Migration Rates Increase	True Positive: 29 (25%)	False Positive: 26 (22.4%)
Predicted Migration Rates Decrease	False Negative: 23 (19.8%)	True Negative: 38(32.7%)

MATHEMATICAL EXPLANATION

The two models are meant to (1) find the CVI, and (2) validate the CVI by comparing predicted NMR with census NMR. The location-independent factors and the housing price are compared in MODEL-PD. The relationship can be represented as the formula below, where f(x) cumulates location-independent factors into a price, g(x) cumulates location-dependent factors into a price, *P* is the final house price, and *e* is the error:

P = *f* (Location-independent factors) + *g* (Location-dependent factors) + e

The Cumulative Location-independent factors are the price from location-independent factors. Cumulative Location-dependent factors are the unprocessed CVI. Error is composed of unaccounted location-independent factors. The Price is the housing price.

MODEL-PD uses a proportioning algorithm to split Price between CVI and location-independent price, and exclude errors caused by unaccounted location-independent factors, so the CVI is unaffected by location-independent factors. The proportioning algorithm finds the optimal distribution of price value between the proto-CVI and location-independent regression with respect to the regression R^2 value. Proportioning splits the Price for MODEL-PD and location-dependent factors for CVI determination.

With the Price split, the equation is as follows:

Price – Cumulative Location Independent Factor Index
= Cumulative Location-dependent factors + Error

The Cumulative Location-dependent factor is the unnormalized CVI, which is then scaled. According to "Immigration and Community Vitality," the "[NMR] acts as a community indicator," as many location-dependent factors, like the CVI, influence it.

$$\sum \frac{|O_i - E_i|^2}{|E_i|}$$

EXPLANATION OF POSSIBLE FACTORS

Location-Independent: Location-independent factors are directly proportional to the house price that will increase as construction costs.

Location-Dependent: By predicting the house price in the future, it is possible to calculate the CVI, as the amortized location-independent variables are unlikely to change significantly in a decade in a well-developed community.

Examination of two specific clusters

Table 4: Details of two clusters with different location-independent prices and different CVIs

Details	Avon Cluster	Farmington Cluster
CVI	889	793
Location-independent price	601202	773764
Centroid Location	(41.8088,-72.8882)	(41.7319,-72.8227)

The CVI of the Avon Cluster is higher because of the centroid's proximity to Avon High School. At the same time, the Location-independent price is higher for the Farmington Cluster due to an average 20% house size increase.

CONCLUSION

This paper adopts two different machine-learning models. The agglomerative hierarchical regression model creates and examines the Community Vitality Index and its close correlation with other community well-being indicators. CVI reflects a holistic view of the indicators showing a community's well-being.

NMR is an essential component of CVI, predicting population immigration. The logistic regression model provides a validation module to interpolate NMR, which is used to verify the CVI introduced by comparing it with the NMR value from the census. CVI can be updated based on the latest house sales data and does not have to wait for the 5-year census data to show the community's ever-changing dynamics.

The house price determination model derives CVI from house sales information. The level of details in the house sales information determines the CVI's granularity, such that the CVI's flexibility for both small and large areas allows users to create their search criteria on either a city, a county, or a region controlled by zip code combinations.

The CVI, along with other measures such as unemployment rate, poverty rate, household income, etc., can be used to measure the comparative economic well-being of communities and helps illuminate ground-level disparities across the country. These measures together can provide real-time insights into the spatial distribution of economic well-being during economic and social volatility.

DISCUSSION

Use Case of MODEL-PD

The figures below depict the average house price of each grid square by regions of Zipcode combinations. High prices are shown with lighter colors and low prices are displayed with darker colors.

Figure 3. Heatmap of average Connecticut suburban housing prices (Greater Hartford County*)*

Figure 4. Heatmap of average Texas housing prices (Plano, Houston)

Figure 5. Heatmap of average Minnesota suburban housing prices(Plymouth, Minnetonka)

Figure 3 shows a cluster of high-valued houses concentrated around (0, 5) and (6,0); the cluster for Figure 4 is at (1,8). The cluster for Figure 5 is at (2,1), which shows that the locational structure of data in different areas is similar. The similarity and high accuracy enable the utilization of MODEL-PD for any community. It will produce a community region and a CVI for it.

Predicting Migration Rate using CVI

MODEL-MC with the CVI can ascertain whether the population of a given area will increase and the extent of the increase. Extrapolating the people was done through logistic regression, as only four grades of NMR were recorded. These indexes are correlated reasonably well through their correlation on the quartiles. The logistic model can be visualized as such:
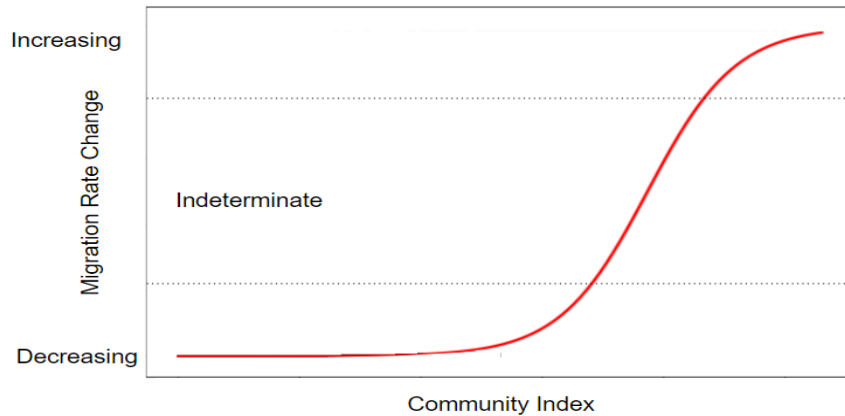

Figure 6. Comparison of CVI and NMR change

Figure 6 shows the relation between CVI and migration rate change. The index range is around 1200, with the chance of an increase in NMR having a threshold of 623. This graph used amortized data.

COMPARING CALCULATED CVI WITH OTHER COMMUNITY STATISTICS

Calculated CVI vs. Existing DCI

The CVIs for the cities of Greater Hartford County are displayed below, as well as the indexes produced through amortizing census information, the Distressed Community Index (DCI):
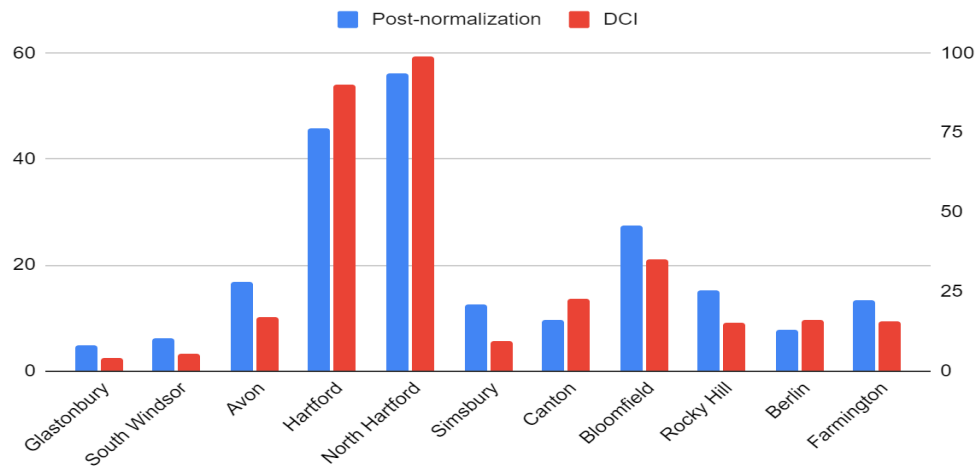
Figure 7. Comparison of DCI and Scaled CVI[6]

These indexes are correlated with each other in terms of their ranking, showing how the index produced from housing prices is accurate. However, because the vitality index used an exclusive method to produce the index, location-independent variables still needed to be removed, leading to a base value of around 1,000 in the index. This is subtracted after population normalization from the normalized value. Here is a graphical depiction:

Here, the rankings are pretty well correlated, showing that this index complements the indices produced from census information. The scale on the left describes the post-normalization scaled CVI and the scale on the right represents the DCI.

School quality was a way to compare these indexes in terms of their order, followed by crime and air quality.
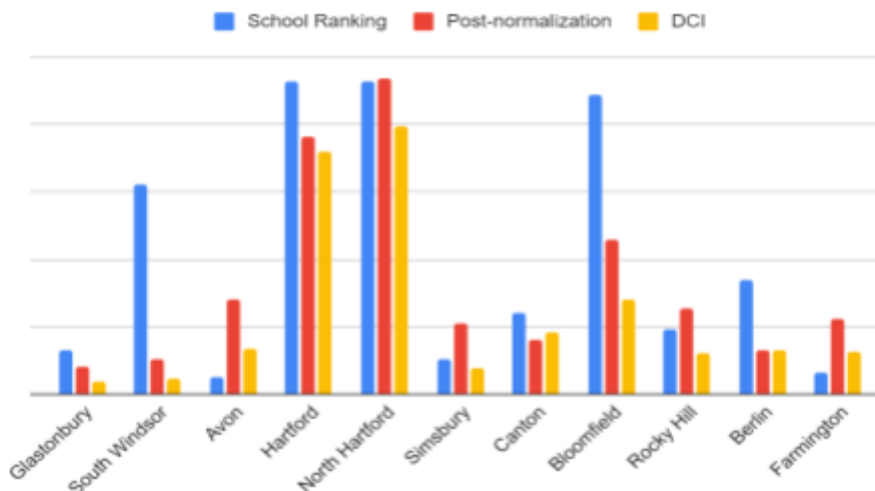

Figure 8. Comparison of School Ranking, Scaled CVI, DCI

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[6] Normalization was conducted by dividing the unprocessed index by the city's population.

Figure 8 shows that school quality is pretty well correlated with the CVI, with both indexes coinciding with the rankings of the schools. [7 and 8] The school ranking, DCI, and normalized CVI are scaled to fit in one graph.
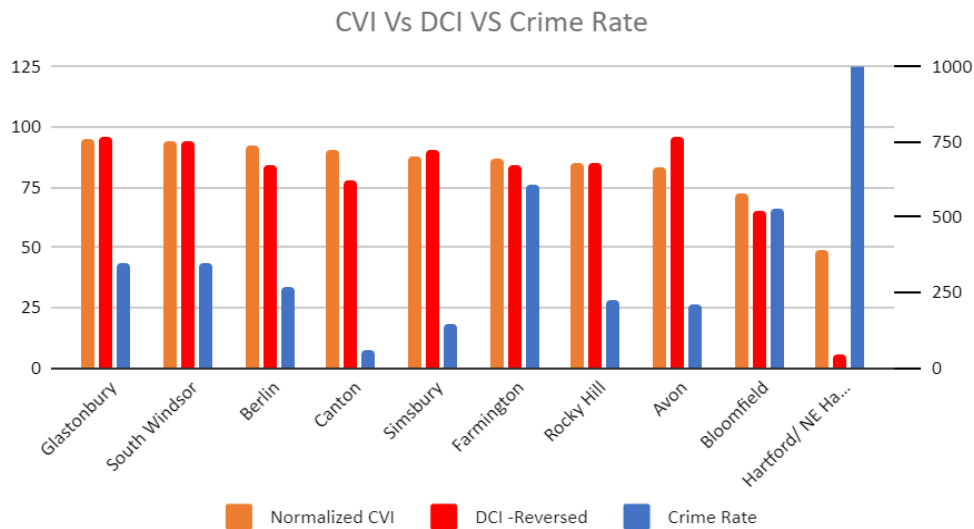

Figure 9. Comparison of Crime Rate, Scaled CVI, DCI[9]

There is a slight trend in terms of the crime rate.[10] The crime rates are similar in communities with a higher vitality index or lower DCI. However, crime rates in areas with high DCI or low vitality index are much larger. Hartford was not included due to its exceptionally high crime rate and DCI preventing scaling of the other crime rates.

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[7] School rankings were obtained from Niche.com
[8] Northeast Hartford does not have a school district.
[9] Note that the data for Hartford/NE Hartford overshoots the graph
[10] Crime rate was obtained from Census Information

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Achieving sustainability: PepsiCo's ESG and Customer Perception

By Xinning Liu

AUTHOR BIO

Xinning Liu is a grade 10 IB student interested in economics, business, and sustainability. She is currently at Weiyu High School in Shanghai. Xinning has participated in business competitions in her high school to further her interest in finance, and she hopes to receive her BBA, and eventually, MBA, at a selective university in the United States. Once her schooling is completed, After completing her studies, the field of work that Xinning wants to engage in focuses on business analysis and sustainable business. When she isn't studying business and planning for the future, Xinning likes to play tennis.

ABSTRACT

The purpose of this study is to explore consumer perceptions of PepsiCo's sustainability efforts by analyzing the opportunity cost of their ESG investments. As a leading company in the food and beverage industry, PepsiCo has made outstanding contributions to environmental sustainability, and their ESG decisions are best for investors, consumers, and the environment. Main elements of methodology include estimation of the opportunity cost of Pepsi's ESG program, survey through questionnaires, and interviews with PepsiCo employees. PepsiCo's contribution to reduce environmental impact is undeniable, and the choices are in the best interests of the business. This study found that consumers' awareness of PepsiCo's ESG commitments is low, resulting in some consumers having concerns about the environmental impacts of PepsiCo's operations and preventing consumers from appreciating PepsiCo's commitment to reducing carbon emissions. Awareness must be increased to achieve the desired environmental impact, avoid consumer attrition and render the opportunity cost of PepsiCo's ESG commitment equal to zero.

Keywords: *PepsiCo*, *product marketing*, *ESG*, *sustainability*, *environmental impact*, *opportunity cost*, *corporate investment*, *multinational corporation*, *consumer perception*, *behavioral economics*

INTRODUCTION

Opportunity cost refers to what you have to give up to buy what you want in terms of other goods or services ("Opportunity Cost," 2023). When we discuss opportunity cost in business, OC (opportunity cost) $= FO$ (return on best forgone option) $- CO$ (return on chosen option) (Fernando, 2023). Due to the high utilization rate of environmental resources and the damage suffered by the environment, many businesses are thinking about reducing their environmental impact. At the same time, the switch to sustainable practices will consume a lot of money. Therefore, some enterprises give up the goal of sustainable development to obtain higher profits. In practice, sustainable development and business are not contradictory. For instance, in Mexico, PepsiCo partnered with local farmers to switch from corn to sustainable sunflowers. PepsiCo thinks that investing in environmental, social and governance (ESG) investing is essential and will help their business thrive in the long term ("PepsiCo ESG Summary," 2023).

PepsiCo created a goal of zero carbon emissions by 2040, and made a detailed plan for agriculture, packaging, direct operation, third-party manufacturing, and more ("Climate Change," 2023a). Several changes have been made to the production steps and raw materials. In this study, the application of opportunity cost in PepsiCo's business decision will be explained in detail, and the rationality of the choice will be compared through calculation. Furthermore, this study combines consumer preference literature, primary data obtained by questionnaire, and professional suggestions for sustainable development collected in interviews to analyze and explain in detail the impact of ESG business decision on customers, partners, and even society. Benefits and disadvantages to ESG are explained. Much of the existing business literature overlooks sustainable development in major companies. This article will focus on PepsiCo and analyze its decisions using an economic framework.

This paper is divided into seven parts: literature review, purpose, research methods, case analysis, results, conclusion, and references.

PURPOSE

Through this research, I want to (1) explain the relationship between opportunity cost and business choices made by companies regarding sustainable development, and (2) understand consumers' opinions on their measures through questionnaire surveys. The paper will explain when the ESG decision is a benefit or loss for an enterprise, as well as the impact ESG commitments have on consumers and society.

RESEARCH METHODS

The study uses an opportunity cost estimation to determine whether ESG investments can bring economic benefits to PepsiCo or contribute to sustainable projects. Second, a questionnaire survey was conducted on consumer responses in the early stages of the project. The survey data will also be used to support the interpretation of consumers' perception of PepsiCo's plans to achieve its sustainability goals along with interviews with PepsiCo employees who are committed to sustainable development.

CASE ANALYSIS

Consumer Perception of ESG

Employees and customers are willing to pay significantly more to do business with a company with an ESG policy (Finger & Rosenboim, 2022). There are direct positive effects of social and governance dimensions of perceived ESG on brand credibility, brand image, and perceived quality (Koh et al., 2022). Food and beverage companies' ESG management activities directly affect consumers' brand trust and word-of-mouth intention (Bae et al., 2023). However, company performance does not seem to be affected by ESG commitments (La Torre, 2020). ESG reporting does not fully explain customer perception of social innovativeness (Aksoy, 2022).

Opportunity Cost at PepsiCo

PepsiCo's definition of sustainable development goals does not align with the traditional sense of reducing carbon emissions or making positive contributions to the environment. Through this project, they also hope to combine different regional characteristics to expand sales scale and social influence to improve affinity and company image (PepsiCo, personal communication, July 2023). For example, in South Africa in April 2021, PepsiCo built a football field with 100% recyclable turf and shock-absorbing layers ("Lay's Replay," 2021). The shock-absorbing layer is made from recycled potato chip packaging. The move required the consumption of more than three million potato chip packages. These potato chip packages built a football field and reduced greenhouse gas emissions by 128 tons compared with traditional construction methods, which is equivalent to taking 27 cars off the road for a whole year ("Lay's Replay," 2021).

In terms of opportunity cost, what PepsiCo loses is more than three million potato chip packages and the money to build the stadium, and what it gets is the reduction of 128 tons of greenhouse gasses ("Lay's Replay," 2021), which slows down the greenhouse effect. At the same time, they let refugees play football. In other words, what they get is social influence in South Africa and a corporate image that cares about the underprivileged. This is a very worthwhile trade. They have gained far more than they have lost. Social influence is sometimes considered to be unreliable, but in this case, it's the key to making a profit. The numbers speak volumes for what PepsiCo has achieved. After the public, especially the South African people know about this, they will be positively influenced, and they will be willing to buy PepsiCo's products because they feel that their purchase of products is also helping PepsiCo reduce more carbon emissions. As sales increase, profits naturally increase. The profits obtained can be used for further research and development on recycling product packaging, use of renewable energy, production chains, and more.
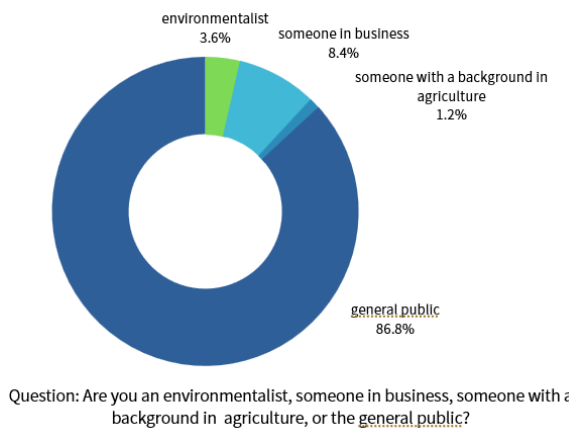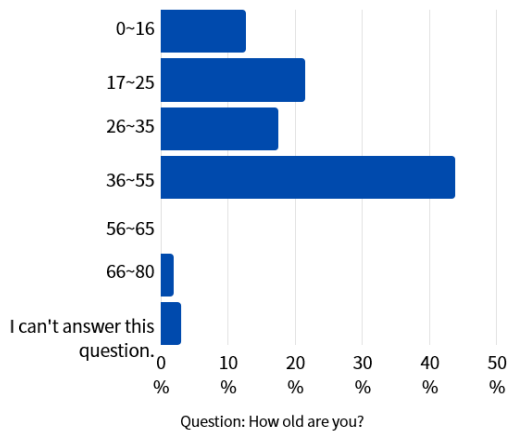
A second example concerns technologies that recycle water. First, it is common knowledge that drinking water resources are very scarce. As a result, PepsiCo has chosen to use recycled water technology in India to reduce water consumption at its factories. The team has reduced water usage by 70 percent at the Channo facility since 2016 (Manpreet, personal communication, July 2023). The team is creating rainwater harvesting ponds and collecting water from villages, which is treated and being reused locally. Second, The Fanta factory is in Colombia, one of the rainiest countries in the world ("PepsiCo ESG Summary," 2023b). They thought of using rainfall to recycle water and purify it for reuse in production. They just needed to figure out how to keep the rainwater out of contact with the groundwater and to be able to collect a lot of rainwater. Later, the factory achieved the result of zero use of freshwater, and the factory has a water circulation system. Considering the water usage rate, PepsiCo will replenish 100% of the water used by the factory back to the river in 2021 and has replenished 6.1 billion liters of water. PepsiCo intends to invest $2.1 million to support wetland restoration in Winter Haven, Florida. PepsiCo and the PepsiCo Foundation have helped deliver to more than 80 million people globally over the past 15 years ("PepsiCo ESG Summary," 2023b).

The proportion of PepsiCo's investment in recycling and reuse of water resources is huge, even without return. In terms of money, *FO* includes the cost of hiring a team, the technical cost of recycling rainwater (very high), the treatment cost of separating rainwater from groundwater, and the cost of resupplying water to the factory, and even PepsiCo invested 2.1 million dollars to help wetlands achieve water recycling and reuse. Economically, the choice of *FO* is close to *CO*, meaning the opportunity cost (*FO* - *CO*) is not equal to zero. This business choice helps PepsiCo grow. From a business perspective, this choice has helped PepsiCo make progress in its sustainability program. At the same time, it has gained good social influence and corporate image. This is also technological progress, and it is a very big progress in reducing greenhouse gas emissions.

This choice is correct, it reflects PepsiCo's sense of responsibility and his original intention to bring smiles to customers and the planet.
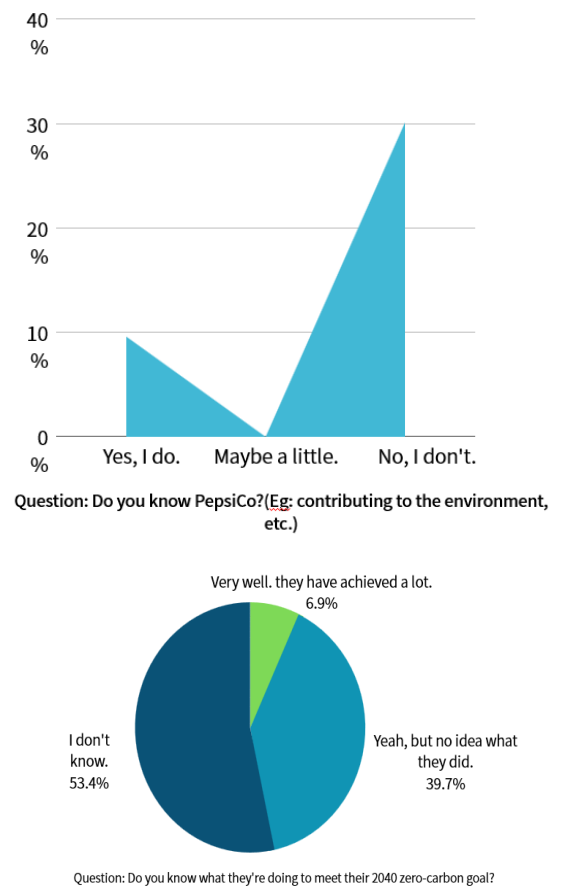
Survey Results

Figure 1
Basic Information on Questionnaire

Question: How old are you?

Question: Are you an environmentalist, someone in business, someone with a background in agriculture, or the general public?

The total number of questionnaires released was 102, and the people are distributed in different age groups. Most of the age groups surveyed by the questionnaire are in line with PepsiCo's wide-ranging target customer group. Most of the respondents are members of the general public, but there are also professionals: 3.6% were environmentalists, 8.4% were someone in business, and 1.2% were someone with a background in agriculture (Fig. 1).

Figure 2

Questionnaire Respondents

Question: Do you know PepsiCo?(Eg: contributing to the environment, etc.)

Question: Do you know what they're doing to meet their 2040 zero-carbon goal?

The survey found that 53.4% of the total number of respondents did not know about this project (Fig. 2). It shows that PepsiCo's contribution to sustainable projects is not understood by most people, but according to PepsiCo's Sustainability Manager, they hope that the contribution they make will be perceived by consumers. They want consumers to see the value behind the product. They released surveys targeting consumers in China, Thailand and elsewhere (PepsiCo, personal communication, July 2023). Unfortunately, the survey data shows that consumers' perception is not high. The customer base does not understand PepsiCo's contribution to the environment. Therefore, PepsiCo must strategize to publicize this achievement or increase changes at the consumer level to attract consumers' attention.

Figure 3
Questionnaire Consumer Perception

Question: As a consumer, do you have a better impression of PepsiCo after knowing their contributions to the environment?

Question: If you are interested in or have a good impression of their contribution to environmental protection, will you buy their products because of this?
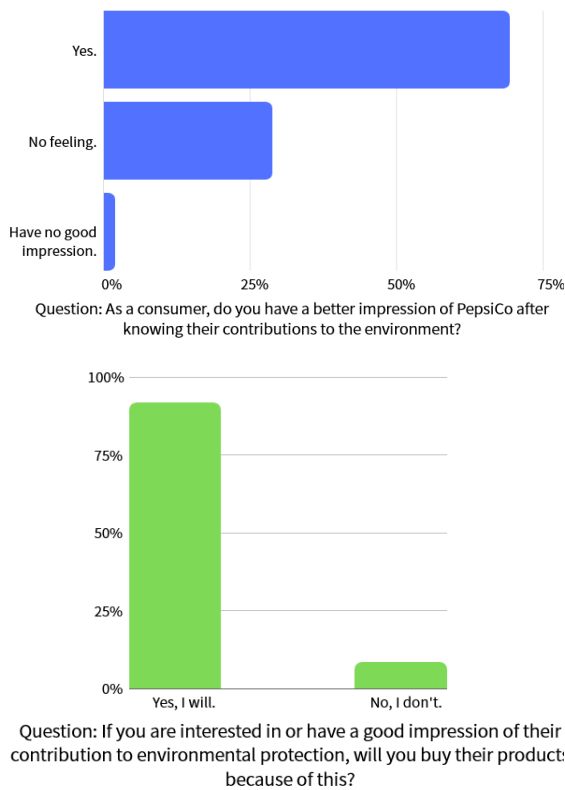
The data gathered for these two questions reveals low consumer awareness of PepsiCo's sustainability program. The survey data shows that once consumers perceive PepsiCo's measures to reduce environmental impact, they will have a good impression and even be willing to buy PepsiCo's products (Fig. 3). If PepsiCo can do this, it will increase their income and attract many consumers because consumers are concerned about corporate responsibility and the environment.

LIMITATIONS

This study explores consumer awareness of PepsiCo with several significant limitations. There was a relatively low number of survey respondents considering the global nature of the PepsiCo brand. This results in the survey data are not universally applicable on a global scale. This study also does not address the general role of ESG as a part of an investment package or the specific details of PepsiCo's ESG plan. This study does not discuss different customer responses based on location or demographics. This research is intended to inspire many questions, but does not answer all of them definitively.

CONCLUSION

The business choices made by PepsiCo for sustainable development projects are all valuable, and from an economic point of view, $FO = CO$, which shows that the decision is economically preferable. However, their contribution was not perfectly perceived by customers. Affinity marketing initiatives, especially social marketing initiatives, have the potential to improve consumers' attitudes about the PepsiCo brand.

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Distribution of galaxy morphological types with redshift

By Aryan Harkawat

AUTHOR BIO

Aryan Harkawat is a rising senior at Westwood High School. He attended a summer research session at University of Texas at Austin that combined astronomy and computer science and has been interested in it ever since.

ABSTRACT

This research focuses on the relationship of the redshift of the galaxy cluster and the amount of elliptical galaxies it contains. We looked for trends or patterns that could be drawn from the data collected of the galaxies and their redshifts. The purpose behind the research is scattered online conjecture that states the merging of two galaxies will create an elliptical galaxy. While not complete proof, the findings of this research do allow further exploration into this statement. Galaxy Clusters are large groups of galaxies that are bound together through gravitational forces and can range in size and other properties. Galaxies can take on different shapes, most notably elliptical and spiral, and the goal of this study is to find if there's a link between the redshift of a cluster and the morphological distribution of elliptical and spiral galaxies in a cluster. Using Galaxy Zoo, a morphological database, galaxies and their correlating morphology were gathered. Using a script, the data was matched to NASA's Extragalactic Database to obtain their redshifts. Each galaxy was grouped to a certain redshift to get the percentage of ellipticals at each redshift, which was graphed using a scatter plot. A line of best fit was drawn and with it we calculated a Pearson's Correlation Coefficient to get the correlation strength between percentage of ellipticals and redshift. This ended up as 0.9427, which signified a strong positive correlation between the two variables. Our correlation strength demonstrates that generally, higher redshifts mean higher percent of elliptical galaxies.

INTRODUCTION

Galaxy Clusters are large groups of galaxies that are bound together through gravitational forces, and they can range in size, shape, and other properties. Galaxies can take on different morphological types, most notably elliptical and spiral, and the goal of this study is to find if there's a link between the redshift and the morphological distribution of elliptical galaxies in a cluster. Redshift is a property that relates to an increase in wavelength and decrease in frequency of electromagnetic radiation. Through Hubble's Law and the expansion of the Universe, it can be related to the age of observable objects, and thus provides a strong foundation to base our research on. Galaxies with higher redshifts are further away and generally older, meaning there's a higher probability for more galaxy mergers to have occurred. This theoretically would mean that there would be a higher percentage of elliptical galaxies at higher redshifts.

GATHERING AND ORGANIZING DATA

Galaxy clusters were the initial starting point due to the close proximity of the galaxies within them, allowing for more galaxy mergers to occur over time. A large amount of time was spent researching in order to look for the morphological data of known galaxy clusters. However, very limited morphological data is available for galaxies, and getting proper data to make a good conclusion and analysis is realistically speaking, not possible. Partial morphological data for the galaxies in a cluster would require large amounts of extrapolation for each cluster, diminishing the value of the analysis and conclusion. However with certain concessions made with regard to how data would be collected, a strong result can also be achieved by focusing on galaxies individually. Using Galaxy Zoo, galaxies with morphological data were selected. Afterwards, a database match was performed with NASA's Extragalactic Database to get and store the redshift of each galaxy. Each galaxy was grouped based on the redshift from 0 through 0.6, with an increment of 0.1. Finally, at each

redshift increment, the percentage of elliptical galaxies was calculated.

GRAPHING THE DATA

With the different percentages of elliptical galaxies, the next step was to graph the data so it could be properly analyzed. A scatter plot is the best option as it is capable of showing patterns in this scenario much better than other methods. They also allow for a line of best fit to be drawn, which is necessary for determining the correlation strength between the two variables.

Galaxy Morphology based on Redshift
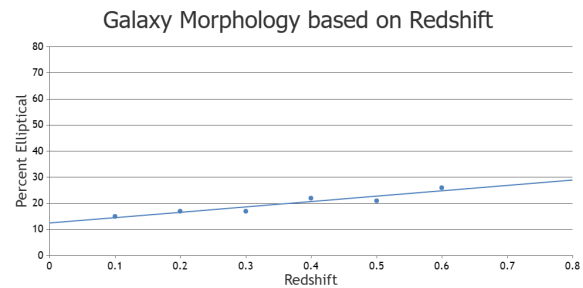
CORRELATION STRENGTH

The Pearson Correlation Coefficient is a method that allows you to assess the strength of the correlation between two sets of values. The closer the final result is to 1, the stronger the correlation, and the closer it gets to 0, the weaker the correlation. Calculating the Correlation Coefficient for the above scatter plot, we arrive at a value of 0.9427, which signifies a very strong positive correlation between a higher percentage of elliptical galaxies and higher redshifts.

CONCLUSION

Our correlation strength shows with a reasonable degree of certainty that the higher the redshift, the more elliptical galaxies there are. Looking back towards our initial purpose, the findings help support the idea that two galaxies merging will produce an elliptical galaxy. As discussed previously, redshift can help us determine the age of faraway objects. The further out you go in the universe, the more galaxy mergers there would be, leading to higher

percentages of elliptical galaxies. There is a lot of potential for further research in this area, especially towards a scientific explanation for why this happens. Another idea that could be explored more, especially with more complete morphological data, is involving the different types of elliptical galaxies so that we could make more complex observations and further our understanding behind the phenomenon of two galaxies merging to create an elliptical galaxy.

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The influence of media on the New Brazilian Republic: From the 1989 elections to the January 8th attacks

By Elisa Oliveira

AUTHOR BIO

Elisa Oliveira, Born in Recife, Northeast Brazil, is a gap year student dedicated to the studies of social sciences and humanities. Passionate about languages, education, and journalism, as well as literature, music, and the arts. She is a member of the Latin American Leadership Academy and seeks to promote social transformation in the Brazilian landscape through education.

ABSTRACT

The Brazilian media wields significant influence over popular thought and ideals, a substantial portion of the population regards the information provided by the mainstream media as absolute truth, granting them near-absolute power over shaping popular thinking. What stands out is that the Brazilian media is funded by major businessmen, politicians, and oligarchs who manipulate information for their own benefit. Much of this can be traced back to the country's political history. The media played a crucial role in shaping this new political phase in Brazil, influencing election outcomes, supporting protests, and inciting popular thought to align with their ideals.

INTRODUCTION

During the military dictatorship of 1964-1985, institutional acts imposed strong censorship on the press of the time. Journalists could only publish articles that aligned with what the dictatorial government preached. Nevertheless, the Brazilian press managed to strengthen itself during this period. The economic dependence that media owners had on the State led many to submit to censorship, weakening any opposition.

"The obstacles to solidarity were not created, reinforced, or exploited by the regime. The lack of solidarity was a disadvantage generated by the press itself," says political scientist Anne-Marie Smith in her book "A Forced Agreement."

With the "Diretas Já" movement that began in 1983, in which the people advocated for direct presidential elections and the end of the dictatorship, and intensified in 1984 when the people took to the streets, the media gained significant prominence in the Brazilian political and social landscape by aligning with public opinion and supporting the movement.

Sociologist Alzira Alves de Abreu argues that the media played a crucial role in the country's democratization: *"The press, by disseminating facts and events, triggers reactions that tend to quickly expand the participation of political actors in the process. When censorship was lifted, the press became a key element in uniting social forces in the struggle for democratization."*

FIRST DIRECT ELECTIONS IN 1989

In the wake of the 1988 constitution, which heralded the restoration of freedom of the press in Brazil, the influence wielded by the media assumed an even more pronounced role during the landmark first direct presidential elections in 1989. This election, conducted in two decisive rounds, brought forth Fernando Collor and Luiz Inácio Lula da Silva as the final contenders, who would then engage in a pivotal debate broadcast by TV Globo. However, what truly stands out about this debate is the revelation made years later by Armando Nogueira, the director of journalism at Rede Globo during that period. He boldly asserted that there had been manipulative actions at play in the broadcast orchestrated by the network. Nogueira disclosed that the manipulation had been carried out by individuals occupying lower rungs in the organizational hierarchy, and he only became privy to these machinations after the broadcast had already reached the public domain.

The Marinho family, who were the proprietors of Rede Globo, maintained significant business ties with the Collor family in the state of Alagoas. Consequently, the manipulative tactics deployed transcended the mere enhancement of a candidate's public image; they were driven by the vested interests of those operating behind the corporate façade. The Former General Director of TV Globo, José Bonifácio de Oliveira Sobrinho, exerted his influence over Collor's election. *"We managed to take Collor's tie of , put a little sweat on him with some glycerin, and we put all those folders there with supposed allegations against Lula - but the folders were entirely empty or contained blank papers."* José Bonifacio's admission underscores that the entirety of the debate's formal proceedings had been meticulously orchestrated by the media conglomerate, while the content itself remained the domain of Collor.

Fernando Collor did succeed in winning the election. However, in a shocking turn of events in October 1992, with just two years into his presidency, he faced impeachment proceedings. These were instigated by none other than his own brother, Pedro Collor, who accused him of fraud and corruption. What becomes patently evident in revisiting this pivotal first election is that the Brazilian media, during this epoch, invariably assumed the characteristics and leanings of its corporate magnates. Notably, in Brazil, these business owners often harbored political biases aligned with the tenets of liberal right-wing ideologies.

Consequently, the concept of impartial journalism, which is the bedrock of a functioning democracy, was compromised, and this tendency became progressively more conspicuous in the subsequent electoral processes. It is a stark reminder of the intricate interplay between media, power, and politics in shaping the trajectory of a nation's democracy.

MEDIA MONOPOLY

The Brazilian Federal Constitution of 1988, in Article 220, paragraph 5, stipulates that "The social communication media shall not, directly or indirectly, be the object of monopoly or oligopoly." However, there is a clear divide between what the constitution mandates and what actually occurs. In reality, the monopoly of media production is growing within media conglomerates that control nearly all forms of media, including TV channels (both public and private), online portals, radio stations, internet and telephone service providers, and even streaming services, which characterizes an oligopoly where a few companies and families dominate the production of communication services. Consequently, the monopolization of a unilateral discourse becomes increasingly prevalent in the Brazilian mass communication landscape. The inclinations of these media groups often hinder the existence of a plurality of voices, the clash of opinions, and the coexistence of different values and worldviews, especially given that the majority of the Brazilian media is controlled, directed, and edited by an economic elite composed mainly of white men.

The press, as a shaper of public opinion, plays the primary role in influencing society. Sociologist Darcy Ribeiro, in his book "The Brazilian People," argues that the capitalist owners, aligned with the oligarchy where political power is concentrated, control the media, which consequently shapes public thought. *"They [the patronage] employ the most competent technocrats and control the media, shaping public opinion. They elect parliamentarians and leaders. They rule, in*

short, with increasing audacity." Thus, the press is one of the main agents of control in our society.

Researcher and scholar Jorge W. Queiroz believes that we are currently experiencing an information war, which can affect how citizens process news. *"We are currently experiencing a global information war that is growing openly and secretly far beyond what the general public is aware of. The presence of propaganda and manipulated information in news and social media is a threat to our democracy and our ability to make well-informed decisions."* This thought contributes to the concept of Fake News, as with propaganda and manipulated information being inserted into the media daily, more people are susceptible to falling for fake news.

Considering that we live in a media society where our social and power relations are mediated by various media activities, from print newspapers to online websites and social networks, the Brazilian media becomes a political-ideological actor that uses its instruments to manipulate tendencies in the social lives of its audience, which largely reproduces opinions that align with its points of power.

Mostly, it's crucial to note that media organizations are capitalist businesses, and therefore, their primary aim is profit rather than a commitment to truthful information. As analyzed by political science professor Francisco Fonseca in a study for the 'Instituto de Pesquisa Economica Aplicada (IPEA): *"Their mercantile role is, however, distinct from companies in other business sectors, as, in addition to the power to shape opinion, their commodity (news) is subject to more complex and subtle variables than those found in common goods and services. This is because their operation implies an unstable balance between: shaping opinion; receiving influences from consumers and, above all, from a wide range of advertisers; interacting with the State - through renegotiations of tax and social security debts, exemptions, loans, as well as regulatory*

issues, among others; and making a profit."

As discussed in the above passage, the Brazilian media, controlled by major business figures, recognizes its role as a more persistent opinion within Brazilian households and leverages this power for the benefit of its owners.

All the elements lead to a fundamental point: the owners of the Brazilian media. The Media Ownership Monitor Brazil, or MOM, claims to have contacted 50 media outlets with the highest audience in Brazil, requesting information about their shareholder composition, and none of them responded. However, what MOM found was that *"The 50 outlets analyzed belong to 26 media groups or companies. Of these, all have more than one type of media outlet, and 16 also have other businesses in the sector, such as film production, book publishing, advertising agencies, cable TV programming, among others. In addition, 21 of the groups or their shareholders have activities in other economic sectors, such as education, finance, real estate, agriculture, energy, transportation, infrastructure, and healthcare. There are also owners who are politicians or religious leaders."*

As mentioned in a few paragraphs above, the media oligopolies with the highest audiences in the country are made up of five groups that control more than half of the media outlets. This includes 9 outlets belonging to the Globo Group, 5 to the Bandeirantes Group, 5 to the Macedo family (considering both the Record Group and IURD outlets, which are owned by the same proprietor), 4 in the regional-scale RBS Group, and 3 to the Folha Group. [Data provided by Media Ownership Brazil.]

THE PT GOVERNMENT 2002-2016

Luiz Inácio Lula da Silva stood out and gained political strength and visibility for leading labor movements and strikes in the late 1970s, which were crucial for the reorganization of unions and the breaking of the military regime. Thus, with the support of left-wing

entities, labor unions, and popular forces, he was elected, despite being the opposite of all his predecessors in the presidential office, in 2002, 13 years after losing the election to Collor. What made Lula successful, after 3 failed elections, can be divided into 3 points:

- Lula sought support from other political parties. Since the other presidential candidates were facing political and fiscal problems, including his opponent, José Serra of the PSDB, from the same party as the previous government, several parliamentarians and members of other parties, including parties that supported FHC's government, lent their support to Lula.

- The second point was the marketing strategy, which was previously against him but now started working for him. Duda Mendonça, his childhood friend who managed the campaign's propaganda, transformed the PT's propaganda into a television program that was clear, light, friendly, and emotional, without compromising the political-ideological content, the trademark of the Workers' Party. Duda demonstrated that the PT was doing very well in the municipalities and states it governed, always emphasizing the principles that had always accompanied the PT: honesty, hard work, and the fight for the poorest.

- Furthermore, Lula began to adapt to the situation. In other words, he followed the system, abandoned radical unionism, and started sympathizing with big business owners. He created more comprehensive policies that helped the working class without upsetting the patronage. Thus, he shifted from a candidate with a left-wing political bias to a centrist political bias.

With Lula's government, Brazilian

politics entered a new historical era, known as "Petismo." Historian Mary del Priore described Lula's victory as the rise of a revolutionary generation, not just of an isolated individual. *"Once in power, changes in the old political projects were recorded. In fact, the world has changed, and with it, the political perspectives of left-wing parties."* Lula's government was marked by improvements for the poorer population, reducing poverty and social inequality, removing the country from the hunger map, and achieving favorable economic growth with the best GDP in two decades. Lula was a natural diplomat, and with charisma, he made foreign policy a significant part of his government. Brazil assumed the leading role in BRICS, and the expansion of Mercosur gained more relevance and visibility during Lula's government.

The crisis during his government came with the "Mensalão" scandal in 2005, an investigation into various allegations against the government's top officials who were buying legislators from the Legislative branch to get projects approved. The allegations reached José Dirceu, then Chief of Staff, and from that moment on, things started to get complicated for Lula's government. Nevertheless, Lula managed to build the political career of his successor: Dilma Rousseff, a militant who was tortured and imprisoned during the military dictatorship. She had a background in economics and got involved in politics by helping her husband found the Workers' Democratic Party (PDT) and assisting various political campaigns. In 2002, she was invited to be part of Lula's government transition team. Then, in 2005, with José Dirceu out of the Chief of Staff position, she assumed the role and eventually became Brazil's first female president in 2010.

To govern Brazil, Dilma had to form alliances with the Brazilian Democratic Movement Party (PMDB), which had a majority in Congress, and appoint Michel Temer as her vice-president. A decision that would later turn against her. By the end of her first year as president, Dilma began to clash with the Federal Supreme Court (STF) and the PMDB, who were demanding a salary increase for the Judiciary and court members. Early in her second year of office, in 2012, Dilma began to sever ties with the PMDB, removing key positions from the party, which, in turn, started opposing the president.

In her address on Labor Day in 2012, Dilma discussed banking rates and compelled banks to reduce interest rates in favor of the Brazilian economy, which did not please big business owners. *"It is unacceptable that Brazil, which has one of the most solid and profitable financial systems, continues to have some of the highest interest rates in the world. These values cannot remain so high. Today's Brazil does not justify this. Banks cannot continue charging the same interest rates for companies and consumers while the basic Selic rate drops, the economy remains stable, and the vast majority of Brazilians honor their commitments with diligence and honesty. Therefore, the financial sector cannot explain this perverse logic to Brazilians. Selic is low, inflation remains stable, but interest rates on overdrafts, installment payments, or credit cards do not decrease."* [Excerpt from Dilma Rousseff's Labor Day address]

Then the Brazilian political landscape changed, the period of post-economic stability began to collapse as the economy lost power and President Dilma Rousseff's popularity declined. It was in this context that a historic phenomenon took place in the country: the 2013 protests, considered by political scientists to be one of the most important in recent Brazilian history, with consequences that continue to reverberate to this day.

As the economic crisis escalates, Brazilians face a significant boost in fuel prices due to the strengthening dollar, which in turn affects the cost of public transportation, including buses, subways and trains, essential modes of transport for the working class. Fares increased from R$3.00 to R$3.20, causing the rise of the Free Fare Movement (Movimento Passe Livre or MPL), which protested these fare increases in Brazil's major urban centers. MPL

quickly received support from a majority of people who were deeply dissatisfied with widespread corruption and growing problems in the health and education systems. These events marked the beginning of the first phase of the protests, which quickly gained momentum and became a platform for various ideals and demands. On June 20, 2013, the largest mobilization took place, with approximately 1.25 million protesters gathering in each Brazilian state. It was at this time that the slogan "The giant has awakened" appeared, symbolizing the scale of the protests and the awakening of a new political consciousness among the people.

In this context, the media play a fundamental role in daily coverage of the protests, while social networks also play an important role in mobilization. Twitter and Facebook have become platforms to organize protests and express demands. What started as a protest against rising public transport fares quickly evolved into a series of demands, covering a wide range of issues.

It is important to note that digital media played a mobilizing and disseminating role in the protests, but traditional media, especially the mainstream press, also had a significant impact to the course of events. Media coverage shifted focus, especially after the second phase of the protests. This change was largely due to documented cases of violence by military police, who also began targeting journalists covering the protests. Furthermore, the nationalization of the protests, with growing public support, led to a change in the media framework. Protests began to be considered legitimate actions, while cases of vandalism were attributed to isolated groups.

"If, on one hand, digital media played a mobilizing and disseminating role in the protests, traditional media, primarily through formal journalism, also had their role in the evolution of events. [...] There was a shift in the focus of coverage, especially after the second phase. This was mainly due to records of violence by the Military Police, which also began to target reporters covering the protests, and due to the nationalization of the protests gaining public support. There is thus a change in media framing, which began to portray the protests as legitimate actions and cases of vandalism as the actions of isolated groups. At this point, the volume of stories about the protests increased across the country, and formal journalism also became a disseminating element: readers, viewers, and listeners began to have their daily dose of news about the protests, making the topic the primary topic of media agenda-setting." [Vozes Silenciadas, Intervozes, 2014, p.15]

On June 21, 2013, President Dilma Rousseff announced measures in response to the protests, including improved health care and education, fiscal responsibility, transportation system reforms, and political ways. However, even with these measures and the brief pause in protests, polarization of ideas and dissatisfaction with the government persist in Brazilian public opinion. Surprisingly, a year later, in the 2014 presidential election, Dilma was re-elected, demonstrating the complexity and depth of the political issues that arose during the 2013 protests.

THE ROLE OF THE MEDIA IN THE FALL OF DILMA AND THE RISE OF BOLSONARO

In an attempt to combat corruption, Dilma enacted Law No. 12,850, which defines criminal organizations, introducing plea

bargains as a means of investigation to obtain evidence, allowing for a broad investigation that would directly affect her stay in government: Lava-jato (Car wash) Operation. The leader of the operation, Judge Sérgio Moro, used the media to his advantage, and the media embraced his narrative without questioning. Lava-jato became a spectacle, with suspects held in detention without trial until they implicated more prominent figures in the political and business scene. The Brazilian people, thirsty for justice, saw 'Lava-jato' as a hunt for the corrupt, and Moro became the nation's hero.

[Images from Veja magazine during 'Lava-jato' Operation 2014-2016]

As previously mentioned, the Brazilian press wields significant influence in shaping public opinion within the Brazilian political landscape. At this critical juncture, it played a pivotal role by supporting the 'Lava-Jato' Operation and by portraying Judge Sérgio Moro as a kind of national savior, while simultaneously targeting the Workers' Party (PT), especially former President Lula and then-President Dilma Rousseff. Another noteworthy factor contributing to Dilma's downfall was her main rival in the 2014 election, Aécio Neves. Following his defeat in the election, his party called for an audit of the voting machines. When the results remained unchanged, he began advocating for Dilma's impeachment.

The flaws in the president's administration became increasingly evident as the economy deteriorated, unemployment rates surged, and more than four million people fell back into poverty. Consequently, a portion of the Brazilian population began clamoring for Dilma's impeachment. Furthermore, the 'Lava-Jato' scandals cast shadows over Lula's government, and these allegations became linked to President Dilma, intensifying calls for her impeachment. Dilma continued to assert her innocence and claimed she had committed no crimes, but her words alone were insufficient.

It's essential to note that the impeachment proceedings against the president did not stem from accusations of corruption. Instead, they were based on charges of fiscal mismanagement, primarily involving the withholding of funds meant for public banks to cover budget shortfalls. The Brazilian Democratic Movement Party (PMDB), the party of the vice president, with whom Dilma had clashed shortly before the 2013 protests, resurged with renewed strength to oppose her. Eduardo Cunha, a PMDB member who had previously been opposed to impeachment, initiated the impeachment process against Dilma when he himself became embroiled in a corruption scandal.

"(...) Without a doubt, a victory for impeachment this Sunday (April 17th) will signify, for the overwhelming majority of Brazilians, the just punishment of a government that, through incompetence, arrogance, and the delusion of its own isolation, destroyed the economy, sank into corruption, and mocked the institutions." [FOLHA, April 17, 2016, First Section/A2, p. 2].

As seen on magazine covers, sensationalism dominated the print media, as well as social media and Brazilian television news. According to a study conducted by political scientist Maria Lúcia Moritz, published in Intercom, a Brazilian communication science journal, the media tended to support impeachment, In the 146 days of observation, 56 editorials were published, with the majority by O Globo (34 published), an average of almost

one editorial every four days. Folha de S. Paulo published one per week, totaling 22 editorials in the period mentioned. Despite this slight variation in the frequency of editorials, both newspapers maintained a critical and negative tone toward President Dilma Rousseff's government, and this opinion section was always used to advocate for the President's removal. (Moritz, 2020, p.211)

Amid protests against Dilma, an important figure emerged, Jair Messias Bolsonaro. A conservative right-wing politician, Bolsonaro harnessed the growing hatred towards the PT to promote his presidential candidacy. With his slogan "God, Homeland, Family," reminiscent of fascism, and open support for military intervention and civilian gun ownership, Bolsonaro became the savior of Brazil, enjoying popular support.

While some politicians called for democracy, claiming that impeachment was a coup, others chanted "Tchau querida" (goodbye, dear) ironically in support of Dilma's departure from the presidency. In her speech on August 29th, Dilma expressed fear of the coup not out of a love for power but out of concern for the death of democracy. *"Despite our differences, I suffer once again from the feeling of injustice and the fear that, once more, democracy will be condemned along with me. And I have no doubt that, this time as well, all of us will be judged by history. [...] Today, I only fear the death of democracy, for which many of us here in this chamber have fought with our best efforts."* Thus, after six days of televised trial, Dilma was removed from office on August 31, 2016. The next day her vice president, Michel Temer (PMDB), assumed the presidency.

The Lava-jato investigations continued, and Lula was identified as the leader of the corruption scheme. But it's essential to note that Moro, in addition to being a judge, also took on the role of an investigating prosecutor. In other words, he not only handed down sentences but also gathered evidence to support his case. As the investigations neared former President Lula, a question arose: was Moro a defender of the Brazilian nation or was he merely trying to eliminate Lula from the political game?

Lula had 35% of the intended votes for the 2018 elections, followed by Bolsonaro with 15%. With Lula out of the picture, Bolsonaro's popularity continued to grow. Using Facebook and live broadcasts to promote his candidacy, Bolsonaro presented himself as a hero who used modernity to his advantage. In 2019, Lula was released from prison due to a lack of evidence for the accusations. Lula had only been incarcerated long enough for Bolsonaro to be elected.

Bolsonaro did not participate in televised political debates, citing health problems due to a stabbing incident during one of his rallies in August 2018. Nevertheless, he received support from some TV networks, granting him significant airtime on Brazilian national television, which went against electoral law. In the first round of the election, while other candidates debated their proposals on Rede Globo, Bolsonaro gave a 26-minute exclusive interview to Rede TV and a 45-minute interview to Bandeirantes.

Once elected, Bolsonaro invited Sérgio Moro to serve as the Minister of Justice of Brazil. However, in 2021, with the worsening COVID-19 pandemic and the crises in Bolsonaro's government, marked by increasing authoritarianism, he began to have disagreements with Moro, leading to Moro's departure. *"Just like Lula, Bolsonaro lies. Nothing he says should be taken seriously. He lied about supporting Car Wash, lied about being against the Centrão* (a group of centrist political parties)*, lied about vaccines, lied about Anvisa* (the Brazilian health regulatory agency) *and Barra Torres* (Anvisa's president)*, and now he's lying about me. He's not worthy of the presidency,"* Moro stated in a tweet about Bolsonaro.

2022 ELECTIONS

Bolsonaro's government, characterized by erratic behavior, turned the congress into a real circus. He feuded with his party and distanced himself from it, halted investigations into his family, dismissed ministers who disagreed with him, and, amid the COVID-19 pandemic, ignored public health precautions, encouraged gatherings, and allowed the country's death toll to reach 690 million.

Even indirectly, the media gave Bolsonaro the rise he needed to be elected, with its anti-PT discourse inadvertently fueling Bolsonaro's ideals and promoting political dualism. Political scientist Steven Levitsky explains that democracy can be undermined by elected leaders: *"Democracies can die at the hands of elected leaders—presidents or prime ministers who subvert the very process that brought them to power."* One could say that Bolsonaro's government made one of the most objective attempts to undermine Brazilian democracy.

With Lula eligible to run for president again, political dualism takes on a new face: Lula and Bolsonaro and the polarization of ideas. Brazil divides; families quarrel, friends drift apart, and violence from Bolsonaro's supporters escalates. As Steven Levitsky pointed out, *"Extreme polarization is capable of killing democracies."*

Lula was elected with 50.90% of the votes in the second round, but the polarization did not end there. Bolsonaro's supporters took to the streets on October 1st, immediately after Lula was declared president, to camp outside military barracks, continuing until January 1, 2023, when Lula assumed power.

Then, on January 8th, while Lula was fulfilling his presidential duties in the interior of São Paulo, political terrorists in support of Bolsonaro stormed the central government buildings, destroying national property, with no police intervention to prevent the attack on democracy. It is estimated that the damages caused by the attack amount to 26 million,

according to the Advocacia Geral da União (Attorney General's Office). Historical artifacts and material heritage were lost in the attacks, with historical paintings from the collection being damaged and official documents torn apart. The investigations would continue for a long time, but the damages to the nation are irreparable.

METHODOLOGY

The information contained in this article is based on research from secondary sources, including books, articles, studies, and documentaries published between the 2000s and 2020s concerning the connection between media society and historical political events in the new Brazilian republic (1988 to the present day). The events covered span from 1988 to January 2023. One of the main challenges of this research was precisely the subject matter addressed in this article; with media manipulation, there are few studies that reveal the face of the Brazilian media. At this point, the study becomes valuable for its updated perspective as of 2023 on how the power of the media politically influences public thought.

CONCLUSION

Through this research, we conclude that the media, in all its power, influences public thought, even if indirectly. It can lead to various manifestations of thoughts that may deviate from its original ideals. This influence has, for years, had a hand in shaping elections – be it the formal media with printed newspapers and television or the informal media of social networks, which gain strength with globalization – dictating the next steps in Brazilian politics.

Events such as the 2013 and 2016 protests calling for Dilma's impeachment were greatly influenced by the media, as well as the rise and fall of Bolsonaro, culminating in the fateful moment of the attack on democracy on January 8th.

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Psychological consequences of earthquake traumatized children and adolescents in Yushu

By Doris Xu

AUTHOR BIO

Doris Xu is a senior at Branksome Hall High School who plans to study psychology at university. At school, Doris is a dedicated member of her school's dance club and varsity volleyball team. In her free time, Doris loves participating in philosophical conversations with her peers and listening to music. Doris also actively engages in volunteering opportunities to better the lives of others, especially members of minority groups. In 2018, Doris traveled to Yushu, China, to help uplift the spirits of young earthquake survivors from the 2010 earthquake. Her connection with adolescents in Yushu sparked her early interest in psychology. In 2023, Doris returned to Yushu to host workshops and activities to provide hope and spread positivity within the community. After her second visit to Yushu, Doris furthered her interest by conducting this psychology review on Yushu adolescents post-earthquake.

ABSTRACT

This review dives into the ramifications of the Yushu earthquake on adolescents, exploring their vulnerability to psychological distress. The Yushu earthquake, also known as the 2010 Earthquake, was a devastating event that struck Yushu, Qinghai Province, China, on April 14. This earthquake had a magnitude of 6.9 and caused widespread destruction in the region. This earthquake serves as a catalyst for deeper explorations into the psychological outcomes of adolescents. In the review, psychological effects were pronounced, with studies revealing the prevalence of anxiety and PTSD within adolescents as an urgent matter. Biological insights into the hypothalamic pituitary–adrenal axis (HPA), hippocampus, amygdala, and prefrontal cortex provide a scientific understanding of this issue. This review also discovers educational challenges faced by the Yushu earthquake survivors, as schools were severely damaged, disrupting learning routines and affecting adolescents' daily lives. While substantial, government recovery efforts encountered challenges due to the isolation of Yushu County and the limited resources available to aid survivors. Furthermore, this report features survivors' testimonies, highlighting the urgent need for physical and psychological support. The Yushu earthquake serves as a reminder of the importance of comprehensive disaster recovery strategies, addressing both immediate physical support and long-term psychological well-being therapy.

Keywords: *Yushu, Earthquake, Adolescents, PTSD, Anxiety, Psychological, Trauma.*

INTRODUCTION

Adolescents, individuals between the ages of 10 and 19, are more vulnerable to psychological distress due to their less mature cognitive capacities and lower adaptability (Dongling et al., 2017). Given the susceptibility of adolescents to psychological distress, it is important to discuss how events such as the Yushu earthquake can have a profound impact. The Yushu earthquake that struck the Qinghai province in China in April of 2010 was a devastating disaster that deeply impacted the region and its people. Victims of the Yushu earthquake made up mostly of the Tibetan population, many of whom were already living in poverty and struggling to make ends meet. During previous psychological studies on earthquake victims, the prevalence of PTSD reported in victims ranged from 10% to 87% (Altindag et al., 2005). In another study on Yushu earthquake victims, within three months, individuals in the most severely impacted zone of Yushu County exhibited PTSD prevalence rates ranging from approximately 33.7% to 38.6% (Zhang et al., 2012). Adolescent victims of these earthquakes experienced various psychological effects, including Post-Traumatic Stress Disorder (PTSD), anxiety, depression, survivor guilt, etc. It is predicted that adolescents who experienced the Yushu earthquake registered a PTSD prevalence of 9.3%, as observed four years after the incident (Xie et al., 2019). It is important to note that the psychological consequences on adolescents who were victims of the Yushu earthquake can vary widely and depend on several factors, including age, gender, family situation, and individual coping mechanisms. The complexity of the post-disaster psychological state urges the necessity of tailored support and interventions that address the unique needs of each survivor. Many victims reported intense fear and panic during the disaster, and sentiments of panic and anxiety endured well beyond the earthquake, demonstrating a prolonged psychological impact on the victims.

IMMEDIATE IMPACT AND LONG-TERM CONSEQUENCES OF THE YUSHU EARTHQUAKE

With a magnitude of 6.9, the Yushu earthquake caused widespread damage, including the collapse of schools, buildings, and homes. According to an official report, at least 85% of houses collapsed in Yushu County (Zhang et al., 2012). Most structures in the area were constructed using a combination of rocks and mud. The collapse of these materials significantly harmed the residents, leaving at least 2,000 people dead and over 12,000 injured (Pallardy, 2023). Renowned for its profound Tibetan cultural heritage and abundance of Buddhist temples and monasteries, Yushu sites of religious and cultural importance also faced vulnerability to destructive occurrences such as earthquakes (Pumin, 2010). The earthquake also damaged historical buildings, traditional Tibetan homes, and structures with cultural and historical importance. Public buildings that provided essential services, such as government buildings, schools, hospitals, and other public facilities, were also damaged. An estimated 100,000 people were displaced from their homes (International Campaign for Tibet, 2010). This displacement forced individuals to seek temporary shelter, often in overcrowded camps or even in tents in public parks and fields (Xin, 2010). For families with children, the displacement also led to interruptions in their education. In an article published by UNICEF, reporter Xu Xin recalls teachers leading a group of students who had lost their family members to live under small tents even weeks after the disaster struck (Xin, 2010). Children could not attend school due to the lack or collapse of facilities. More importantly, many students suffered the loss of loved ones as they witnessed firsthand their bodies buried under materials of collapsed buildings. The emotional toll of such distressing experiences can be especially traumatic for adolescents.

19.5% of adolescents met the criteria on the PTSD checklist five years after the earthquake (Liu et al., 2019). A research article from 2020 indicates that the Yushu earthquake will have an impact on adolescents even after 7 years (Zhao et al., 2020). The findings from these studies are significant because they show the lasting effects of the Yushu earthquake on adolescents' mental health and well-being.

PSYCHOLOGICAL IMPACT, PTSD, AND ANXIETY AMONG ADOLESCENTS

Not only are the symptoms of PTSD distressing, but an individual with PTSD may also be more likely to develop other mental disorders, such as anxiety disorders, beyond the stage of adolescence (Jin et al., 2014). In 2015, a psychiatry study discovered that three years after the earthquake disaster in Yushu, approximately 49.3% of adolescent samples were found to have existing anxiety symptoms (Jin et al., 2014). Symptoms of PTSD can have a strong effect on a person's life. The fact that a substantial portion of adolescents continued to experience anxiety symptoms even three years after the earthquake highlights the enduring psychological impact of the earthquake. This statement highlights the importance of appropriate support for these victims. It suggests that unresolved trauma might set the stage for a cascade of mental health challenges throughout a person's life if not adequately addressed. Adolescents with anxiety may struggle with concentrating in school; forming relationships with others, including parents; and participating in normal social activities, even simple day-to-day conversations. According to the Child Mind Institute, students with anxiety symptoms experience struggles not only limited to general anxiety but also social anxiety, separation anxiety, and other specific phobias (Ehmke, 2023). Recognizing that anxiety symptoms can help educators and parents to tailor their support interventions to better address the specific needs of individual students. Furthermore, high school students were found to have scored higher rates for anxiety than middle school students (Jin et al., 2014). Researchers in this 2014 study suggested that it is caused by the stress of high school students facing college entrance

examinations at the time of the earthquake (Jin et al., 2014). The earthquake caused a severe and sudden disruption in their studies, and the need to relocate and pause their studies increased their level of anxiety. Other studies suggest that the reason for the high rate of anxiety and PTSD in high school students is their ability to cognitively and emotionally process traumatic experiences on a deeper level than younger students (Wang et al., 2014).

A study conducted in 2017 observed Post-Traumatic Stress Disorder and its predictors among bereaved Tibetan adolescents four years after the Yushu earthquake found that survivors who witnessed a burial, injury or death of a relative or loved ones were most likely to have post-traumatic stress disorder symptoms (Dongling et al., 2016). Data within this 2017 study found that adolescents who had lost their mothers had the highest scores of PTSD severity. Researchers hypothesize that this is likely because, for most Tibetan adolescents, fathers often worked and were away from home, while mothers are the closest loved parent within the family. It has been identified that the severity of psychiatric distress is associated with the degree of closeness to the lost parents (Dongling et al., 2016). Furthermore, a study in 2015 found that adolescents who had suffered a bereavement (the experience of losing someone important) were nearly three and a half times more likely to exhibit PTSD symptoms compared to individuals who had not (Jin et al., 2015). In 2010, a reporter from CNN interviewed locals, with a focus on boarding school teachers and students, to understand the severity of the earthquake. 17-Year-old survivor Samdrup Gyatso told CNN reporter a vivid description that illustrates the traumatic experience of those who survived, witnessing their peers trapped and buried in the ruins. "There are 10 people in my family, and only four of us escaped. One of my relatives died. All the others are buried under the rubble," said Samdrup (CNN, 2010). His firsthand perspective shows the emotional anguish, grief, and trauma that survivors like him endured. The consequences of PTSD on orphans are especially severe, as a report from 2020 indicated that left-behind children have been found to demonstrate more negative and

unhealthy behavior patterns than children who were still in contact with their parents post-earthquake (Zhao et al., 2020). These studies underscore the importance of support necessary for these young survivors. The findings of these studies state that witnessing the loss of loved ones, particularly the significant role of mothers within the family, can magnify the severity of post-traumatic anxiety disorder symptoms. The consequences of PTSD, especially among left-behind children, accentuate the urgency of tailored interventions for these survivors.

BIOLOGICAL IMPACT

The development of PTSD after witnessing a parental death is associated with hypothalamic pituitary–adrenal (HPA) axis hyperactivity (Dongling et al., 2016). Usually, the human body releases a hormone called hydrocortisone when we're stressed (Watson, 2023). But in adolescents of the Yushu earthquake, even when they weren't stressed, their bodies had higher levels of hydrocortisone. In addition, their bodies didn't regulate this hormone properly – it didn't decrease when it should have. This suggests that these grieving teenagers might feel more stressed in their day-to-day lives because their stress response is not working as it should (Dongling et al., 2016). Adolescents with PTSD may have a reduction in the size of the hippocampus, a brain region that is essential for memory and emotion regulation. This reduction in the hippocampal volume has been associated with intrusive memories and flashbacks, which are common symptoms of PTSD. Not only is the hippocampus affected as an outcome of earthquake exposure, but individuals with PTSD may also have increased activity in the amygdala, a brain region involved in processing fear and emotion. This increased activity in the amygdala can contribute to hypervigilance, avoidance behaviors, and an exaggerated startle response. In this stage of adolescence, the prefrontal cortex is still rapidly developing, and the amygdala and hippocampus are heavily relied on in this developmental stage. Studies have shown that adolescents with PTSD have reduced connectivity between the

prefrontal cortex, which is involved in executive function and decision-making, and the amygdala. This reduced connectivity can contribute to difficulties with emotion regulation and impulse control. Teenagers might rely more on the amygdala to make decisions and solve problems than adults. An impact on the hippocampus causes an obstacle in a child's learning and memory.

EDUCATIONAL CHALLENGES AND GENDER DISPARITIES

Roughly half of the schoolchildren in the Yushu earthquake-affected area attend boarding schools. For these students, the school serves as more than just an educational institution; it also functions as a place where they eat, sleep, interact with friends, and, thus, contribute to their overall well-being. An interruption in their learning would have represented a significant setback for their education and lives. A report posted by UNICEF found that in the aftermath of the Yushu earthquake, 80% of primary and 50% of secondary schools in the Yushu Country had been severely damaged, causing a severe disturbance to over 200,000 students and around 1000 teachers (UNICEF, 2020). Studies have shown that 30.7% of adolescents adapt poorly to school five years after the earthquake (Liu et al., 2019). This finding was crucial as it shows the necessity of government intervention and support towards long-term support programs for school-aged populations who have experienced traumatic events in China (Liu et al., 2019).

In a 2014 study that surveyed 1000 students aged between 11-20, girls were found to have a higher rate (9.6%) of PTSD than boys (8.1%) (Jin et al., 2014). This result is supported by a later study performed in 2019, where female adolescents were found to have higher average PTSD scores than males (Xie et al., 2019). Xie and her team suggest that this is because women have a stronger tendency to engage in contemplative rumination (repetitive thinking or dwelling on negative feelings) as they tend to be more religious (Xie et al., 2019). This is further supported by the hypothesis that females at puberty tend to have a heightened

susceptibility to duel about negative life events (Xie et al., 2019). On the contrary, according to another study performed in 2016, scores of PTSD severity was equally the same between boys and girls, showing participants of both genders face similar conditions (Dongling et al., 2016). This is consistent with the findings in Jin's study in 2014, where gender and PTSD scores had no significant differences. due to similar responsibilities and obligations of girls and boys under the Buddhist religion (Jin et al., 2014). An explanation for this is that the participants being surveyed in this study has influences of Buddhism in all aspects of their life, and the effects of the Buddhist belief were the same regardless of gender, resulting in a similar result of PTSD severity for both. According to Liu's study in 2019, male students were more likely to experience poor school adaptation after the earthquake over the long term. Lu's study in 2020 discovered that being female was a negative factor for resilience (Lu et al., 2020). According to Lu and his team, girls are more sensitive to stress responses than boys, which can lead to impaired resilience (Lu et al., 2020).

RECOVERY EFFORTS

A total of 29,218 new houses were constructed by the Chinese government and delivered to earthquake survivors (Jin et al., 2015). The government also sent out over 5000 foundations, charity associations, and Red Cross organizations involving the general public (Liu et al., 2011). One year post-disaster, 11,665 houses were built in 19 towns within Yushu (Liu et al., 2011). Despite all this support, it was not enough to support the Yushu population. An earthquake survivor mentioned that Yushu was highly isolated from other cities in China. He said, "The most important thing now is that this place is far from everything, with few accessible rescue troops available…I feel like the number of dead and injured will keep going up." (Jacobs, 2010). The words of the earthquake survivors show the extreme difficulty in providing prompt and adequate assistance to the are, especially faced with isolation and limited resources.

Furthermore, these words revealed the complexities of disaster relief and the difficulties in reaching and assisting all affected survivors. The Chinese government's assistance also fell short in addressing the psychological aspects of the disaster's aftermath. Researchers suggest that interventions for post-traumatic stress must be carried out in adolescents 2–6 months after the traumatic events (Lie et al., 2019). According to the Health Status of Adolescents of Yushu study, only 53.81% of adolescents had received psychological escape training and counseling (Liu et al., 2017). In Liu's study in 2017, researchers stressed the importance of Earthquake-related health education, suggesting that it can bring positive changes to the population, especially as Yushu is prone to and at high risk of earthquakes (Liu et al., 2017).

CONCLUSION

Due to their less mature cognitive capacities and lower adaptability, adolescents are more vulnerable to psychological distress in the aftermath of traumatic events such as earthquakes. The devastating impact of the Yushu earthquake, alongside the isolation of the region and limited resources, led to significant psychological challenges among the affected population. The analysis of PTSD, anxiety, and emotional challenges from numerous studies shows the severity of the trauma. At the same time, the insights into the biological impact added a scientific layer to the comprehension of the adolescent psychological state. Despite the numerous efforts made by the Chinese government to provide physical reconstruction and assistance, the psychological toll on survivors, especially adolescents, remained a constant concern. The emotional and psychological needs of the Yushu earthquake survivors are often overlooked. The Yushu earthquake serves as a reminder that addressing trauma and promoting resilience among adolescent victims is crucial for their long-term well-being and future physical and psychological success.

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Antibacterial Properties of Manuka Honey and the Role of Methylglyoxal

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AUTHOR BIO

Youlin is a high school student in Auckland, New Zealand. One of his main hobbies includes playing lawn bowls at his local club. It was there that he met someone that introduced him to beekeeping. From then on, he always tried to do some beekeeping in his spare time, and it was this interest that led him to become curious about honey's chemical properties. He is an avid chemist and hopes to pursue research in university to discover new molecules that may have special traits that could be applicable in medicine or industrially. Aside from bowls, beekeeping, and chemistry, he also strives to help out the community during school. He's established his own non-profit which performs chemistry experiments for children around South Auckland.

ABSTRACT

The unique ecosystems of New Zealand have produced a diverse range of honey over the years, with Manuka honey being one of the most renowned. Produced by Western honeybees extracting nectar from Manuka flowers, this monofloral honey has become known for its distinct antibacterial and anti-inflammatory properties. Whilst antibacterial activity in other honey tend to stem from factors such as hydrogen peroxide content, high viscosity, osmotic effect, and acidic pH, the antibacterial activity of Manuka honey is mainly attributed to methylglyoxal (MGO), a dicarbonyl compound which is found in high concentrations in Manuka honey. This review paper will focus on the antibacterial properties of Manuka honey and the role that MGO plays. Understanding the specific chemical mechanisms of attack on different strains of bacteria by Manuka honey and the role of MGO is crucial to potentially understanding how new drugs or medicines can combat antibacterial resistance to antibiotics.

Keywords: *methylglyoxal, antibacterial, Manuka, honey, antibiotics, dihydroxyacetone, bacteria, mechanism, non peroxide.*

THE ORIGIN OF MANUKA HONEY

The ecosystems of the North and South Islands of New Zealand (NZ) have naturally developed a large variety of unique honey samples (1). Among the diverse variety of honey in NZ is Manuka (*Leptospermum scoparium*), known for its antibacterial activity and the ability to repair wounds (2). Manuka honey is a monofloral honey which is produced by Western honeybees (*Apis mellifera*) through extracting nectar from Manuka flowers (3). Peter Molan and his team at University of Waikato showed that Manuka honey can resist bacterial *Staphylococcus aureus (S.aureus)* on a culture plate. It is much more potent than any other honey samples. Remarkably, Manuka honey even retained its antibacterial properties at low concentration and high temperatures (95 °C) (1). Some published research papers report tests of Manuka honey on other strains of bacteria such as *Pseudomonas aeruginosa (P.aeruginosa)* and *Escherichia coli* (*E. coli*) and proposed that the suppression of the growth of different species of bacteria by Manuka honey utilizes different mechanisms (4).

UNIQUE PROPERTIES OF MANUKA HONEY

For many honeys, antibacterial activity stems from hydrogen peroxide content. However, Manuka honey exhibits a significant amount of non-peroxide antibacterial activity which is largely due to the presence of MGO (5,6). MGO itself is a molecule that is found in a range of other foodstuffs and beverages, such as wine, bread, and dairy products (7-9). However, Manuka honey is unique in that upon testing samples of Manuka honey, researchers have reported the presence of large amounts of methylglyoxal in each sample which correlated with its non-peroxide activity (6). It is also well known among NZ beekeepers that MGO content and hence non-peroxide antibacterial activity increase over time with storage (10)

Manuka honey can also be used to treat wounds. Manuka honey creates a high viscosity protective barrier on the wound and prevents bacterial infection (1). Manuka honey's hygroscopicity also contributes to wound healing as it absorbs and holds the moisture around the wound area, decreasing the chance of bacterial survival (11). In addition, it also has the potential to minimize hypertrophic scarring. The pH of Manuka Honey generally ranges from 3.5 to 4.5 which can increase the oxygen release from haemoglobin around the wound area. This excess oxygen activates fibroblasts which help to further stimulate wound healing (12).

One of the key issues in wound healing recovery is bacterial infection and subsequently inflammation occurred (13). Manuka honey has been shown to be beneficial in wound healing, primarily due to its antibacterial activity. In addition, it is also known to have Leptosperin which is an anti-inflammatory agent that enables it to decrease wound inflammation effectively (14). Manuka honey can also stimulate angiogenesis, epithelialization, and granulation to speed up the rate of healing and proliferate fibroblasts. A combination of Manuka honey's anti-inflammatory process and stimulatory effects on epithelialization and granulation help to rapidly reduce pain and edema (12).

Interestingly, Manuka honey failed to gain notoriety early on due to harvesting issues; Manuka honey was much more difficult to extract than other alternatives. Additionally, Manuka honey did not seem to have any outstanding properties that made it worth extracting (1). However, this changed when Molan published a paper confirming the unique antibacterial effects of Manuka honey, specifically emphasizing the use of honey as a wound dressing which attracted huge media attention across the world (15). Since then, the demand for Manuka honey increased significantly, and eventually led to the creation of the Unique Manuka Factor (UMF), which reflects the level of MGO concentration in a sample of honey (16) and sets apart authentic Manuka honey from other blended, multifloral honeys (1). Grades of UMF 24+ are classified as Superior Rare High Grade, UMF 15+ to 20+ Ultra Premium Grade, UMF 10+ to 15+ Premium Grade, UMF 5+ to 9+ Certified Authentic. The higher the grade, the greater the antibacterial activity and the more severe a wound the honey can treat (17). Manuka honey

can easily be distinguished since it contains MGO, a natural molecule responsible for the antibacterial properties of the honey, and DHA (dihydroxyacetone), the precursor of MGO that slowly converts to MGO over time and hence dictates the amount of MGO content in a jar of honey and its shelf life (18).

WHERE MGO IN MANUKA HONEY COMES FROM

MGO is derived from its parent molecule dihydroxyacetone (DHA) and is converted from DHA to MGO through non-enzymatic Maillard reactions (4). The conversion from DHA to MGO is essentially a non-reversible dehydration reaction which requires both acidic and basic conditions (19). If conditions are only acidic aqueous, then only dehydration of DHA to MGO occurs. On the other hand, basic conditions would result in isomerization from DHA to glyceraldehyde. Thus, both isomerization and dehydration would occur under a buffer solution such as phosphate or acetate, which contain both acid-base catalysts (20) (Figure 1).

However, another study suggests that both DHA and Glyceraldehyde form a common intermediate enediol compound first, with the enediol compound being dehydrated instead of the DHA or Glyceraldehyde (21) (Figure 2). This mechanism is significant during the storage of Manuka honey since MGO levels within the honey tend to rise over time due to conversion from DHA to MGO (4).
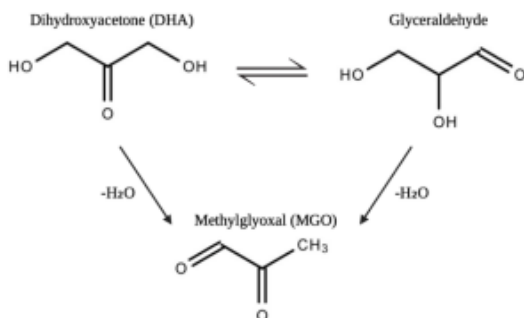
Figure 1. Conversion of DHA to Glyceraldehyde and MGO.
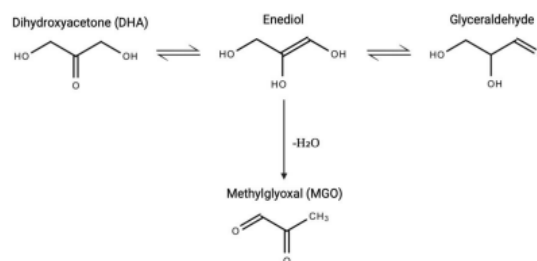
Figure 2. Conversion of DHA to Glyceraldehyde and MGO with Enediol intermediate.

Upon adding MGO to a sample of clover honey, Adams et al. (10) found that there was little change in concentration of MGO and practically no formation of DHA, which further suggested the irreversibility of the proposed mechanism of the conversion from DHA to MGO by dehydration mechanism. However, addition of DHA to clover honey stored at 37 degrees Celsius showed the formation of MGO and decrease in DHA over time. Particularly, the higher the concentration of DHA, the higher the rate of formation of MGO. They also demonstrated that the conversion from DHA to MGO did not produce a 1:1 ratio and hence was not balanced in terms of stoichiometry (22), suggesting that DHA and MGO also took part in side-reactions with other components in Manuka honey (23).

The presence of amino acids in Manuka honey such as lysine and arginine also catalyze the conversion of DHA to MGO (10). Other studies suggest that DHA potentially undergoes reactions with amino acids, since DHA is more reactive than glucose on reaction with amino acids and has been found to be especially reactive with amino acids of relatively higher pH such as lysine and proline. (24).

MGO IN MANUKA HONEY PLAYS A CRITICAL ROLE IN ANTIBACTERIAL ACTIVITY

Manuka honey's non-peroxide antibacterial activity can be mainly attributed to MGO. The antibacterial activity of MGO is mainly due to its ability to inactivate proteins through cross-linking them (25). Hydrogen

peroxide is also present in Manuka honey, although in relatively lower concentrations compared with non-Manuka honeys.

Nevertheless, hydrogen peroxide still plays a role in Manuka honey through interacting with other components in Manuka honey and producing hydroxyl radicals to increase overall antibacterial activity (26). A study by Weigel et al. (27) showed evidence of 1,2-dicarbonyl compounds in honey, specifically 3-deoxyglucosulose (3-DG), methylglyoxal (MGO), and glyoxal (GO). Mavric et al. (6) tested the inhibiting effects of these three 1,2-dicarbonyl compounds found in Manuka Honey on two different strains of bacteria, *E. coli* and *S. aureus*, finding that MGO had the most pronounced antibacterial effect out of all three compounds at a minimum inhibitory concentration (MIC) of 1.1mM for both strains of bacteria (Table 1). The researchers were also able to verify that MGO was the main contributor to antibacterial activity using an Agar well diffusion assay with S. aureus as the bacteria. Testing equally concentrated samples of forest honey and Manuka honey, the sample of Manuka honey showed a clear inhibition zone while the sample of forest honey did not. MGO was confirmed to be the key contributor of antibacterial activity when it was found that the inhibition zone of the MGO-supplemented forest honey was similar to that of the original Manuka honey sample when an equivalent amount of MGO found in the sample of Manuka honey was added to another sample of forest honey.

Table 1. Minimum inhibitory concentration (MIC) of solutions of 1,2-dicarbonyl compounds adapted from Mavric et al (6)

Sample	MIC for *E. coli* (mM)	MIC for *S. aureus* (mM)
3-DG	No inhibition	No inhibition
GO	6.9	4.3
MGO	1.1	1.1

CHANGES TO ANTIBACTERIAL ACTIVITY DUE TO MGO-INFUSION INTO HONEY

Jervis et al. (28) wanted to establish the effects of adding additional amounts of MGO to Manuka and non-Manuka honey on biofilms containing *S. aureus* bacterial strains. Addition of Manuka Honey to biofilms showed biocidal activity at higher concentrations of 66.00% and 33.00% w/v (Table 2), and when only MGO was added to biofilms, biocidality was present at concentrations of 1.05 mg/ml and higher, while any concentration lower showed lack of biocidality (Table 3). On the other hand, non-MGO honeys did not demonstrate any form of biocidal activity at any concentration, yet when non-MGO honey was infused with MGO, the infused samples showed almost equivalent biocidal activity as Manuka honey with 790mg/kg MGO (Table 2). This not only proved that antibacterial activity could be increased through infusion of MGO, but it also further reinforced the significant role of MGO in Manuka honey (6).

Table 2. Biocidality of various honeys at differing concentrations adapted from Jervis et al. (28)

% Honey Concentration (w/v)	CH only	MH (790 mg/kg MGO) only	CH = 790 mg/kg MGO	MH + 2370mg/kg MGO	CH + 3160mg/kg MGO
66.00	NB	B	B	B	B
33.00	NB	B	B	B	B
16.50	NB	NB	NB	B	B
8.25	NB	NB	NB	NB	NB

Cell color in this table corresponds to equivalent MGO-only concentration in Table 3.

Key: CH = capilano/non-MGO honey; MH = Manuka honey; MGO = methylglyoxal; NB = not biocidal; B = biocidal

Table 3. Biocidality of MGO-only Solutions adapted from Jervis et al. (28)

MGO Concentration (mg/ml)	Biocidality
2.11	B
1.05	B
0.53	NB
0.26	NB
0.13	NB
0.06	NB
<0.01	NB

Key: NB = not biocidal; B = biocidal

THE DIFFERENT MECHANISMS OF THE ANTIBACTERIAL ACTIVITY OF MGO AGAINST BACTERIA

Manuka honey has been shown to be effective against biofilm forms of *P. aeruginosa* and *S. aureus*. (29). One study (30) tested MGO against these two strains of bacteria, finding that MGO was an effective agent against *S. aureus* and *P. aeruginosa*. However, they were unable to identify the mechanisms of actions of MGO against *S. aureus* and *P. aeruginosa*. Jenkins et al. (4) have suggested that MGO inhibits different bacteria strains via different mechanisms. This view was supported by other studies that proposed that MGO inhibited *P. aeruginosa* via cell lysis while *S. aureus* was inhibited through cell division. (31,32)

PROPOSED MECHANISM OF MGO ON *S. AUREUS*

S. aureus typically duplicates its cells through segregating its chromosome to form two daughter cells that are still connected. The daughter cells are fully separated when murein hydrolase degrades the cell wall between the two cells (33). The mechanism proposed below shows how the *S. aureus* cell can achieve all the steps including septa completion. Yet, MGO prevents the final step of two daughter cells separating by inhibiting the activity of murein hydrolase and hence causing the formation of many septated but non-dividing *S. aureus* cells. It's interesting to note that many papers classify this mechanism against *S. aureus* as bactericidal (32, 34, 35), yet the proposed mechanism by Jenkins et al. (4) leans more towards bacteriostatic activity.
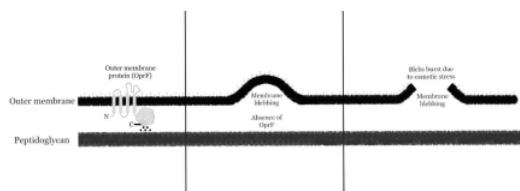

Figure 3. Representation of the mechanism by which MGO inhibits a S. *aureus* cell adapted from Jenkins et al. (4)

PROPOSED MECHANISM OF MGO ON *P. AERUGINOSA*

On the other hand, the mechanism by which MGO attacks *P. aeruginosa* cells is completely different to *S. aureus*, with *P. aeruginosa* cells undergoing cell lysis and losing their structural integrity when inhibitory concentrations of Manuka Honey and MGO are present (31). The structural integrity of *P. aeruginosa* cells is dependent on protein F (OprF) (36), which ensures that there is a link between the outer membrane layer and the peptidoglycan layer underneath to keep a regular cell shape (37). However, when MGO is added, a decrease in OprF leads to the loss of covalent cross links between the membrane and peptidoglycan layer, causing the membrane to become subject to osmotic stress, and eventually leading to membrane blebbing and cell lysis (4).

Roberts et al. (38) suggests that MGO reduces the expression for four of the flagellum-associated genes (fliA, fliC, fleN and

fleR) and hence decreases the number of flagellated cells. Reduced flagellation means reduced motility and increased retarded movement of the *P. aeruginosa* cells, meaning that *P. aeruginosa* cells are less likely to disseminate into the bloodstream (4).

Figure 4. Representation of the mechanism by which MGO inhibits a *P. aeruginosa* cell adapted from Jenkins et al. (4)

PROPOSED MECHANISM OF MGO ON *E. COLI*

Aside from *S. aureus* and *P. aeruginosa*, Manuka honey and MGO could also affect *e. coli's* cellular membrane permeability, which is closely linked with the ability of a cell to control its metabolism and energy (39). After application of MGO to a biofilm of *E. coli*, the quantities of potassium ions and proteins leaked from these cells increased over time, showing how MGO disrupted the cell membrane and suggesting that *E. coli* cells had undergone cell lysis and ultimately died (40).

## OTHER FACTORS IN MANUKA HONEY THAT CONTRIBUTE TO ANTIBACTERIAL ACTIVITY

Osmotic effect:

Manuka honey is essentially a super-saturated solution containing monosaccharides glucose and fructose, with water content making up only a small proportion of its weight (41). Since these monosaccharides interact with most water molecules through hydrogen bonding, there are very few free water molecules left for bacteria to thrive in (42). In other words, the level of *Water activity (a_w)* is too low to support the growth of many different strains of bacteria. Yet there are still some bacteria which can withstand low a_w. For example, s.aureus is very osmotolerant due

to its ability to accumulate glycine, betaine and proline, (43), meaning that Manuka honey can't inhibit its bacterial growth.

Hydrogen peroxide:

Another contributing factor to Manuka Honey's antibacterial activity is H_2O_2, which produces hydroxyl free radicals that can cause cell death, tissue injury, and damage DNA (44, 45). The mechanism below (Figure 5) shows how glucose, on reaction with oxygen, water, and glucose oxidase enzymes, produces gluconic acid and H_2O_2. Thus, the amount of H_2O_2 content in a sample of Manuka Honey is closely related to the acidic pH of the honey, which is primarily attributed to the presence of gluconic acid (42). The production of gluconic acid lowers the pH to levels that cause the enzyme activity of glucose oxidase to drop to almost zero, making glucose oxidase enzymes rather inactive and the level of H_2O_2 to be almost negligible in Manuka honey (46). Nevertheless, H_2O_2 still contributes to the antibacterial activity of Manuka Honey since H_2O_2 is produced at a continuous rate, which is more effective than when added in bulk as a bolus (47).
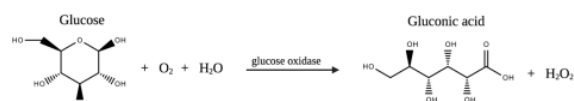
Figure 5. The glucose oxidase reaction that produces H_2O_2.

MANUKA HONEY AND ANTIBIOTICS

There is also clinical evidence to show that Manuka honey can augment the action of modern antibiotics. Some of these antibiotics include Rifampicin, which is a clinically used antibiotic for treatment of tuberculosis (48), while Oxacillin is often used to treat staphylococcal infections. (49) On the other hand, Tetracycline is an effective antibiotic for the treatment of acne (50), and Imipenem can be used to treat other severe skin infections (51). Jenkins et al. (52) provided evidence for a few of these antibiotics being synergistic with Manuka honey. The two different strains of bacteria tested, *P. aeruginosa*

and methicillin resistant *S. aureus* (MRSA), showed higher susceptibility to a combination of Tetracycline and Manuka honey, than just Tetracycline itself. Other antibiotics were also tested as well: Rifampicin and Imipenem. Imipenem and Manuka honey were found to be synergistic towards MRSA but not *P.aeruginosa*, while Rifampicin and Manuka honey were synergistic towards *P. aeruginosa*. Manuka honey also did not enhance the activity of Rifampicin against MRSA.

However, Liu et al. (53) had contradictory results, finding that MRSA strains became more sensitive to a combination of Rifampicin and Manuka honey. This nuance in results may be potentially attributed to the Manuka honey sources used by the two different studies, with Liu et al. (53) using unprocessed Manuka honey from Hokianga, NZ, while Jenkins et al. (52) using Manuka honey purchased from Oxoid in Cambridge, United Kingdom. Nevertheless, Liu et al. stated that Rifampicin and Manuka honey showed additive effects, further reinforcing the conclusion made by Jenkins et al. (52) that this combination was not synergistic towards *S. aureus*.

MGO and Rifampicin:

Muller et al. (54) also examined the synergistic effects of MGO and Rifampicin to see if MGO was solely responsible for the Manuka honey-Rifampicin synergistic effect. They found that MGO was not completely synergistic with Rifampicin (unlike the Manuka honey and Rifampicin combination), since growth of *S. aureus* strains weren't completely inhibited. The reason for this was that MGO with Rifampicin was only an additive and not synergistic combination.

However, when Mukherjee et al. (55) tested a similar combination of MGO and Rifampicin on *P. aeruginosa* strains instead of *S.aureus* strains, MGO was found to be synergistic with Rifampicin. These two different studies potentially suggest that MGO becomes synergistic with Rifampicin depending on the bacteria strain, however, further research and experiments would be needed to verify this.

LIMITATIONS

Risks of antibacterial resistance associated with Manuka honey:

Jervis et al. (28) suggest that for clinical purposes, a combination of MGO and honey solution would yield stronger biocidality than that of an MGO-only solution, since the antibacterial activity of MGO is enhanced when it is in the presence of other components found in Manuka honey. Cooper et al. (56) also suggest that extracting specific active components of honey such as MGO and using it alone on bacteria would only increase the chances of bacteria developing resistance to the antibacterial effects of Manuka honey.

Camplin et al. (57) reported that isolates of *P. aeruginosa* from Manuka honey treated biofilms exhibited greater minimum inhibitory concentrations (MICs) than their progenitor strains, whose biofilms weren't treated with Manuka honey, when antibiotics Rifampicin and Imipenem were added separately. Even after repetition of the experiment, the Manuka honey treated isolates still exhibited increased resistance.

Relationship of concentration levels of Manuka honey to bacterial susceptibility to honey: Cooper et al. (56) showed that increasing the concentration of Manuka honey stepwise over long-term would decrease the abilities of *S. aureus* and *P. aeruginosa* strains to develop Manuka honey resistance. Nevertheless, the acquisition of antibacterial resistance still couldn't be prevented through this method. Additionally, Liu et al. (53) also tested a combination of Oxacillin and Manuka honey, finding that the combination helped to restore oxacillin susceptibility to a MRSA strain, which was similar to the conclusion drawn by Jenkins et al. (58). Muller et al. (54) also showed that Medihoney (a medical product containing very high concentrations of Manuka honey) combined with Rifampicin was unable to restore susceptibility to Rifampicin for Rifampicin resistant *S. aureus* strains, illustrating that Manuka honey doesn't necessarily restore

antibiotic susceptibility for all different species of bacteria.

The possible side effects of Manuka honey:

Aron et al. (59) tested the effects of Manuka honey on treating ear infections of chinchillas. On analysis of the cochleae applied with Manuka honey, they found that the honey had bactericidal properties on biofilms of *P. aeruginosa* and *S. aureus* but the concentration used also led to facial paralysis and hearing loss for the chinchilla.

In the treatment of diabetic ulcers, MGO reacts with protein residues such as lysine and arginine, leading to the formation of advanced glycation end products (AGEs) (60). Increased AGEs accumulation is often associated with diabetic lesions and enhances the activity of neutrophils which leads to long term chronic inflammation (61,62).

CONCLUSION

Although much is already known about the antibacterial properties of Manuka honey, there still needs to be further research to solidify the mechanisms by which MGO and other compounds in Manuka honey exert on different species of bacteria. Additionally, more research on different strains of bacteria is needed, as a large majority of published research has mainly focused on only three strains: *S. aureus, P. aeruginosa*, and *E. coli*. As researchers gain a greater understanding of how the components in Manuka honey work together, there is also a need for investigating the effects of combining the use of Manuka honey with conventional antibiotics to combat the inevitable development of antibacterial resistance.

ACKNOWLEDGEMENTS

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