Berkeley Pharma Tech
Journal of Medicine

Exploring Ethical Frontiers: A Content Analysis of Perceptions Surrounding Genetic Editing in Mental Health Treatments Over Time

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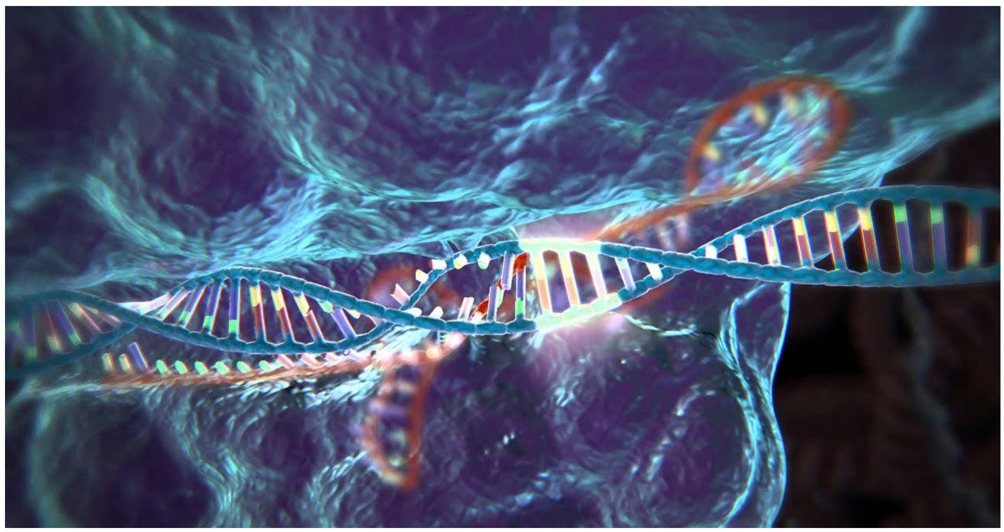
Keywords:
Genetic Editing
CRISPR-Cas9
Ethical Considerations
Mental Health Treatments
Public Medical Influences

Submitted July 14, 2024
Accepted August 19, 2024
Published December 27, 2024

Full Open Access



Abstract

Genetic editing has become a pivotal biotechnology tool in healthcare, enabling precise manipulation of DNA through insertions, deletions, modifications, or replacements. Its applications have expanded from treating monogenic diseases to addressing polygenic conditions, including potential mental health therapies. This study examines public sentiment and ethical considerations surrounding genetic editing systems like CRISPR-Cas9, zinc-finger nucleases (ZFNs), and transcription activator-like effector nucleases (TALENs). Analyzing a decade of medical literature, the research highlights a growing public acceptance of these technologies despite ethical concerns, such as off-target effects and unintended consequences. Positive sentiment trends indicate that social acceptance may support the integration of genetic editing in mental health treatments, driving advancements in healthcare. Addressing risks, including long-term impacts and ethical dilemmas, remains critical for responsible implementation. As public attitudes continue to improve, genetic editing may become a widely accepted therapeutic approach, fostering innovation in healthcare. Future research should focus on mitigating risks and enhancing the safety and efficacy of genetic editing to ensure its sustainable development and adoption.

1. Introduction

Genetic, or genome, editing is reshaping modern medicine as one of the latest advancements in the field, where improvements in genetic modification technology are now being applied to polygenic disorders rather than just monogenic disorders. Genome editing uses genetic engineering to manipulate DNA sequences from one nucleotide in length to large fragments, allowing the modeling for individual cells to complete organisms.[1] Genome editing tools are molecular strategies for modeling and correcting errors in mutated genes; thus, genome editing could change the human genome to treat or develop gene-based diagnoses and therapeutics for a number of diseases and disorders.[2] Bioengineering is a constantly progressing field, with genetic editing as a relatively new development in healthcare and medicine as a tool for treatment. Nevertheless, genetic editing has little insight into the progress of genome editing and its application to the polygenic nature of psychiatric disorders is still in its infancy.[3] With this remarkable progress in biotechnology, genetic editing presents promising applications for mental illness treatments in healthcare.

The rapid advancement of genetic editing technology engenders the question: What are the potential ethical considerations and public perceptions that arise from the implementation of genetic editing technology in healthcare as a treatment for polygenic diseases and mental health? Exploring the ethical frontiers of genetic editing is pivotal for scientists and medical professionals to understand its transformative potential and limits in medicine. The insights gained from examining this field of inquiry will play a vital role in defining the ethical framework and societal acceptance of this new advancing technology. In order to establish a connection between the perceptions and patterns in attitudes supporting or against the application of genetic editing technologies and the ethical considerations of this form of healthcare treatment, it is appropriate to hypothesize that the overall trend will exhibit a positive correlation in sentiments of various polygenic diseases as time progresses over the last decade.

2. Literature Review

2.1 Current Landscape of Mental Health Treatments

Mental health poses a significant challenge in contemporary society and continues to steadily escalate as a prevalent issue. A study found that "approximately half the population can expect to develop one or more mental disorders by age 75."[4] According to the National Institutes of Health, a mental illness is "a health condition that changes a person's thinking, feelings, or behavior (or all three) and that causes the person distress and difficulty in functioning."[5] Presently, the main traditional forms of treatments for mental health include psychotherapy, which encompasses counseling and cognitive-behavioral therapy, and pharmacotherapy, involving the administration of medications like antidepressants or antipsychotics. Psychotherapy has been defined as an effective psychological intervention for a multitude of psychological, behavioral, and somatic problems, symptoms, and disorders and thus rightfully considered as a main approach in mental and somatic health care management.[6] Yet, a study by Sarah Cook and her team challenge this idea, suggesting that psychotherapy to be difficult to apply to individuals of complex multimorbidities, specific socio-—demographic groups, and minority populations.[7] This study highlights that psychotherapy often overlooks individual factors influencing a patient's health, potentially leading to reduced efficacy and negative outcome.[8] Another form of mental health treatment is pharmacotherapy, the use of medicines for combating a disease or its symptoms that allow for the alleviation of symptoms and improvements in the health and quality of life of patients.[9] Nonetheless, Witczak and her team reveal that the frequent errors in prescription of medicine and medicine administration due to the complex and multifaceted nature of the pharmacotherapy process present alarming risks.[10]

Brucker and Faucher complement this finding, as they argue that pharmacotherapy introduces several disadvantages, such as drug resistance that makes pharmacotherapy inefficient as a long-term treatment option, adverse drug reactions, and drug-to-drug interactions that can cause further negative side effects that may be unpredictable and be more damaging than beneficial.[11] These studies ultimately imply that traditional approaches may present challenges and limitations such as partial efficacy, side effects, and variability in individual responses. This growing understanding of the biological basis of mental disorders emphasize the importance of considering biological interventions in mental health treatments. For instance, "scientists have identified genes as a factor that plays a role in determining whether someone develops a mental illness, specifically illnesses that are most likely to have a genetic component such as autism, bipolar disorder, schizophrenia, and ADHD, where the interaction of several genes may trigger mental illness in contrast to a change in a single gene"[12] This further highlights the concept of precision medicine in mental health, as "precision medicine is an approach for clinical treatment that uses genomic, lifestyle, and environmental information to provide targeted, individualized care that is tailored to patients' specific needs."[13] These studies insinuate and introduce the need for new innovative forms of mental health treatment, such as gene therapy. As a potential approach for more precise mental health intervention, gene therapy addresses genetic components associated with mental disorders and illnesses to affect the overall treatment efficacy for individuals.

2.2 Genetic Editing Technology

Gene therapy, defined by Sherkow is "the intentional, expected permanent, and specific alteration of the DNA sequence of the cellular genome, for a clinical purpose."[14] This signifies the potential of gene therapy to cure hereditary diseases like mental illnesses by manipulating gene sequences. "This therapy became possible through the advances of genetics and bioengineering that enabled manipulating vectors for delivery of extrachromosomal material to target cells."[15] Within these advances include some of the most prominent approaches to genetic editing, which include the Clustered Regulatory Interspaced Short Palindromic Repeats (CRISPR) / Cas9 (CRISPR-associated protein 9) system, zinc-finger nucleases (ZFNs), and transcription activator-like effector nucleases (TALENs).

The CRISPR/Cas9 system, one of the most significant gene editing technologies in the development of gene therapies, consists of "two essential components: a guide RNA [ribonucleic acid] to match a desired target gene, and Cas9—an endonuclease which causes a double-stranded DNA [deoxyribonucleic acid] break, allowing modifications to the genome."[16] The CRISPR/Cas system "affords the requisite recognition selectivity necessary to ensure single-site specificity in complex genomes, allowing the CRISPR system to provide acquired immunity against invading foreign DNA through RNA-guided DNA cleavage.[17] This insight implies how this form of technology holds the ability to address complexity in gene sequences and proposes this genome editing tool as a treatment approach for polygenic diseases. This development contrasts with earlier genetic editing technologies, such as ZFNs and TALENs, which relied on specially coded proteins to recognize key DNA sequences.[18]

This process required "complex, labor-intensive development processes that limited their practicality and efficiency in terms of time, cost, and efficiency (e.g., limited specificity and target recognition, off-target effects)."[19] This denotes how these developing technologies present several barriers in their application to medicine, suggesting how these advanced tools still hold disadvantages and restrictions that depict possible ethical considerations to take notice of. TALENs is an earlier genetic editing technology that comprises of a "non-specific DNA-cleaving nuclease fused to a DNA-binding domain that can be easily engineered so that TALENs can target essentially any sequence."[20] "TALENs are similar to ZFNs in that they can generate DSBs [double-strand breaks] at a desired target site in the genome and so can be used to knock out genes or knock in mutations in the same way."[21] Zinc-finger nucleases are more specifically defined as targetable DNA cleavage reagents, in which ZFN-induced double-strand breaks are subject to cellular DNA repair processes that lead to both targeted mutagenesis and targeted gene replacement at remarkably high frequencies."[22] This further signifies the capabilities of these gene editing tools, revealing the numerous methods and approaches available to potentially act as an effective mental health treatment. Hence, these new advancements in genetic editing technology found by recent medical experiments and studies portray the possibilities of this biotechnology and how it may revolutionize healthcare.

2.3 Research Gap

As I examine the notable gene editing technologies and their applications in healthcare, it becomes evident that the use of genome editing for mental illnesses is still a treatment in its infancy. Despite the recent advancements in genetic editing technologies, there is a notable lack of research that discusses the ethical considerations and perceptions associated with the use of genome editing for mental health treatments. Since the introduction of gene editing in the 1970's, much research has focused on the application of genetic editing technologies toward preventing and treating certain inherited disorders or monogenic diseases.[23] However, as the capabilities of these technologies advance and expand to the domain of polygenic diseases, such as mental illnesses, it remains unclear what the ethical implications and surrounding perceptions are in using genome editing technology as a form of treatment for mental illnesses in healthcare. Therefore, the purpose of this study was to predict the potential ethical considerations and public perceptions towards the use of genetic editing for mental disorders through analysis of public sentiment and add to the conversation of existing literature on the function and perceptions of genetic editing in the medical field.

3. Methods

3.1 Introduction

Over the course of 120 days, I conducted a study to construe trends of the sentiment expressed from ethical considerations towards gene editing as a medical treatment to interpret the possible implications and perceptions of genetic editing utilized for a mental health treatment. To achieve this objective, a content analysis was necessary to streamline the principal ethical considerations associated with the implementation of genetic editing in healthcare and facilitate the range of sentiments within significant academic, medical publications. This was essential to create a generalized comprehension of the ethical implications in contemporary society towards genetic editing and clarify an existence of a trend within the attitudes correlated with the implementation of this technology in healthcare, whether it is positive, negative or neutral, to predict the perceptions of genetic editing technology for mental health treatments. A correlational analysis was also conducted based on the time intervals and the sentiment scores connected with the attitudes toward the implementation of genetic editing as a medical treatment, as well as with the ethical implications and perceptions towards the application of gene editing technology for mental health treatments to ascertain the most prevalent ethical considerations.

3.2 Instrumentation

This study employed a content analysis to deduce the major considerations of genetic editing in healthcare and utilized a sentiment analysis to discover the perceptions that will develop from these implications. In order to conduct this method of study, a semantic differential scale was used, shown in Table 1. The semantic differential scale is a 7-point rating scale that presents pairs of bipolar adjectives at the endpoints of the scale. This scale was processed with opposite adjectives that indicate extremely strong negative sentiment, very strong negative sentiment, moderate negative sentiment, neutral sentiment, moderate positive sentiment, very strong sentiment, and extremely strong positive sentiment. With a set of bipolar adjectives on the endpoints, each of these codes were assigned a value to measure the attitude toward a specific negative or positive sentiment, ranging from the sentiments of extremely strong negative sentiment at -3, very strong negative sentiment at -2, moderate negative sentiment at -1, neutral sentiment at 0, moderate positive sentiment at +1, very strong positive sentiment at +2, and extremely strong positive sentiment at +3. This study underscores the notable distinction between negative and positive sentiments to facilitate easier differentiation of the perceptions towards genetic editing for healthcare treatments. A statement within academic articles or journals will be categorized as moderate sentiment if stance is primarily neutral with a slightly skewed viewpoint, regardless of denunciation or commendation. For a classification of very strong on the scale required such intense words like damaging, great, bad or beneficial. For a classification of extremely strong on the scale required such extreme words like extraordinary, catastrophic, remarkable or disastrous. These words emphasize and reflect the pronounced opinions and attitudes of genetic editing in healthcare. For this study, statements or paragraph fragments from medical papers were analyzed and applied to the semantic differential scale. The primary data sources used for my method of study were medical journals and studies retrieved from credible databases, such as PubMed or ScienceDirect.

This study utilized the Delve Tool website to administer this process for qualitative analysis and coding these medical journals. This website contains coding software that generates transcripts of the medical journals and the code of sentiment applied.

Consequently, the paper is averaged across the various sentiment scores, charted in Table 2 below. Table 2 reflects the averages of the sentiment analysis, employing a given range of values. The table comprises of a 7-point scale, where within each is a range of assigned values with an extremely strong negative at the spectrum of any value less than -2.0, to very strong negative at a range of -2.0 to -1.0, to moderate negative at a range of -1.0 to less than 0, neutral at 0, to moderate positive being between 0 and 1.0, to very strong positive being between 1.0 and 2.0, and extremely strong positive at any value more than 2.0. As qualitative research, this study utilized the collected data along with a TI-84 calculator to compute the correlation coefficient and values.

3.3 Content Analysis

I performed a content analysis, a detailed and systematic examination of the contents of a particular body of material for the purpose of identifying patterns, themes, and biases.[24] The content analysis classified thirty medical journals and studies, concluding the paper's data to express the article's general sentiment. Using medical journals and studies, I conducted a comprehensive analysis of the perceptions concerning the implementation of genome editing in healthcare, followed by an examination of the attitudes towards various polygenic diseases, to determine the potential ethical considerations and perceptions regarding the use of genetic editing technology as a viable mental health treatment.

In order to ensure that the medical journals and studies would be relevant and representative of how gene editing technology is presently used as a treatment for polygenic disorders, criteria were established for the medical journals and studies analyzed. The medical journals and studies were chosen due to their relevance in healthcare as each indicate the use of one of the foundational gene editing technologies, including the CRISPR/Cas9 system, TALENs, or ZFNs.[25] Furthermore, due to the rapidly evolving aspect of the medical field, all medical studies utilized have been conducted in the past decade. I analyzed medical journals across various polygenic diseases in order to gain a deeper comprehension on the extensive perceptions that exist with gene editing as a healthcare treatment overall, especially for more complex diseases. To analyze sentiment, this study used a consistent search engine within medical journal databases PubMed and ScienceDirect.

Once the study found all suitable medical journals and studies, the study applied the qualitative code to words, adjectives, and paragraph fragments in the medical journals that correlate to positive, neutral, or negative sentiment. These sentiments were evaluated on the 7-point Semantic Differential Scale to deduce a more comprehensive range of sentiment. The thirty medical journals this study analyzed and fit the criteria were transcribed into the Delve Tool website, where a trend became prevalent. After all the papers were coded through Delve Tool, the study calculated the sentiment score and how the sentiment varied across different types of polygenic diseases. The polygenic diseases were separated into three categories: neurological diseases, cancer, and other polygenic diseases. These categories will help highlight and clarify any significant variance in attitudes towards a specific type of polygenic disease to address if the perceptions towards all types of polygenic diseases can be used to predict the attitudes of genetic editing for mental health treatments.

Since this study is only utilizing medical journals and studies published in the last decade due the rapid nature of the medical field and its advancements, separate sentiment scores were also averaged for articles published in the first five years compared to the last five years in the last decade to denote if attitudes have increasingly become more positive, negative, or neutral towards genetic editing technology.

3.4 Correlational Analysis

Using a sentiment analysis to discover the current attitudes towards genetic editing, I used a correlational analysis in order to determine which considerations were most prevalent for medical professionals in their studies. Therefore, this study used the Pearson correlation coefficient, or "r," to establish the existence of an association between the number of ethical considerations and the sentiment score of genetic editing technology as a healthcare treatment. The Pearson correlation coefficient was used to determine the strength of the correlation and to accept or reject the null hypothesis that a relationship does not exist between sentiment towards genetic editing and polygenic diseases.

4. Findings

After the study averaged the sentiment scores, general sentiment scores were evaluated for the different types of polygenic diseases that have been tested with genetic editing technology as a healthcare treatment. For neurological diseases, the attitudes toward genetic editing technology treatment were characterized with a positive sentiment at 0.295 for the first five years of the last decade and a positive sentiment of 0.507 for the last five years. This revealed an increase in positive sentiment over time, with a change of 0.212 in positive sentiment, and a total sentiment score resulting in a positive sentiment of 0.4234. For types of cancer, the attitudes toward genetic editing technology treatment were also characterized with a positive sentiment starting at 0.350, compared to the concluding sentiment of 0.950 with a change of 0.60, and total sentiment score of 0.900, which can be seen on Table 2. For other types of polygenic diseases, the perceptions also started with a moderately positive sentiment of 0.518, however experienced a slight decrease of 0.09 in positive sentiment, producing a moderately positive final sentiment score of 0.428 and total sentiment of 0.4574. This trend displays how the average sentiments over time had an increase in positive sentiment for cancer and neurological diseases, as genetic editing

technology strengthened as viable treatments for these polygenic diseases over time. In contrast, for medical journals concerning other polygenic diseases, the average sentiment score had encountered a small decline in positive sentiment over time, yet the total average sentiment still remained moderately positive which portrays that there was an increase of negative sentiment. This implied that more concerns emerged as perceptions toward the application of gene editing treatment became more negative.
After this study marked a trend of increased positive sentiment in the attitudes towards genetic editing technology, the study utilized the sentiment score and the number of ethical implications that were considered and reflected in the perceptions of the medical journals to establish if there is a relationship between the ethical implications most prevalent and what implications signify advantages or disadvantages of genetic editing. Although the study could not establish an accurate correlation between all ethical implications across all polygenic diseases that have a form of genetic editing treatment, the two quantitative variables of sentiment score and number of ethical considerations could be utilized to represent a correlation for each type of polygenic disease. For this study, the Pearson correlation coefficient used the number of ethical considerations as the X values, or independent variable, and the sentiment score as the Y values, or dependent variable, in order to convey if the prevalence of ethical implications has a true influence on the sentiment of attitudes towards genetic editing technology as a healthcare treatment for polygenic diseases.

The study analyzed the perceptions across the past ten years to indicate if the sentiment and number of ethical implications affected any correlation or trend of positive, negative, or neutral sentiment. The Pearson correlation coefficient or "r" had resulted with r=0.4673, which expresses that there is a moderately strong relationship between the number of ethical implications and the sentiment score reflecting the public's attitudes, as seen on Table 3.

Table 1 depicts the 7-point semantic differential scale that this study utilized to calculate the sentiment scores, in which each scale value number is assigned to how strong a statement or paragraph fragment found in the medical paper is, in order to average the sentiment score on a scale of negative to positive.

Scale Value Number	Sentiment
-3	Extremely Strong Negative Sentiment
-2	Very Strong Negative Sentiment
-1	Moderate Negative Sentiment
0	Neutral Sentiment
+1	Moderate Positive Sentiment
+2	Very Strong Positive Sentiment
+3	Extremely Strong Positive Sentiment

Table 1. Semantic Differential Scale for Sentiment Analysis. This table defines the 7-point semantic differential scale used in the study. It outlines how statements from medical journals were rated based on sentiment polarity, ranging from extremely negative to extremely positive, for precise sentiment classification.

Figures 1, 2, and 3 represent the number of phrases or paragraph fragments observed for each level of sentiment for genetic editing technology in healthcare treatments across each category of polygenic diseases in the past decade. These polygenic diseases, labeled Figures 1, 2, and 3, were respectively categorized as neurological diseases, cancer, and other polygenic diseases to highlight the three main categories of polygenic diseases that have used genetic editing technology as a form of treatment. Each of these three figures are also separated into two 5-year time periods, 2016-2020 and 2021-2024, to differentiate changes in the observed sentiment polarity over time, as healthcare treatments experience rapid changes in its evolving field with new advancements daily.

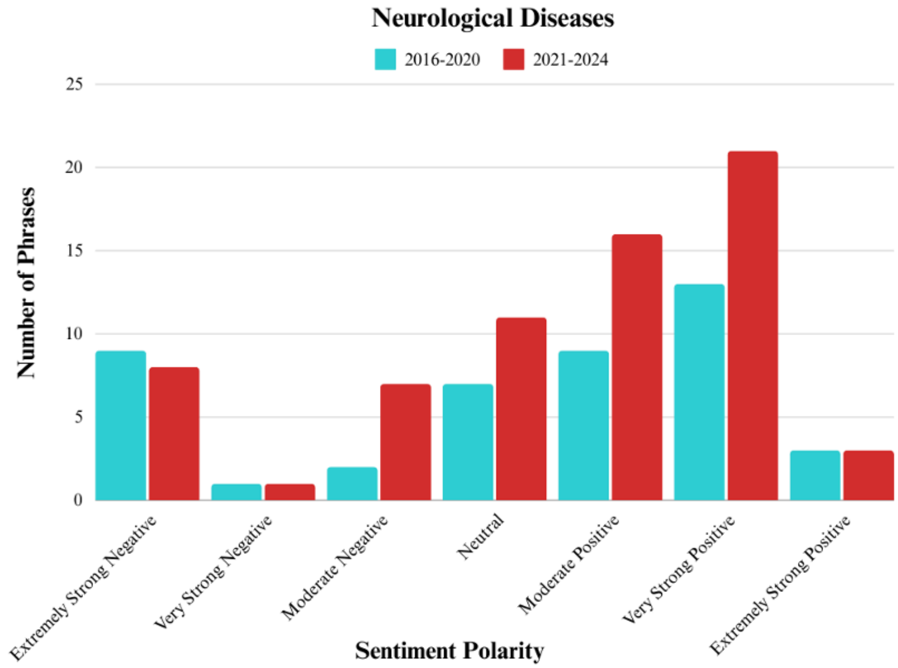


Figure 1. Sentiment of Genetic Editing Treatments in Healthcare across Neurological Diseases. This graph illustrates the changes in sentiment regarding genetic editing treatments for neurological diseases over the past decade. The data shows a notable increase in positive sentiment from 2016 to 2024, reflecting growing acceptance of this technology in treating neurological conditions.

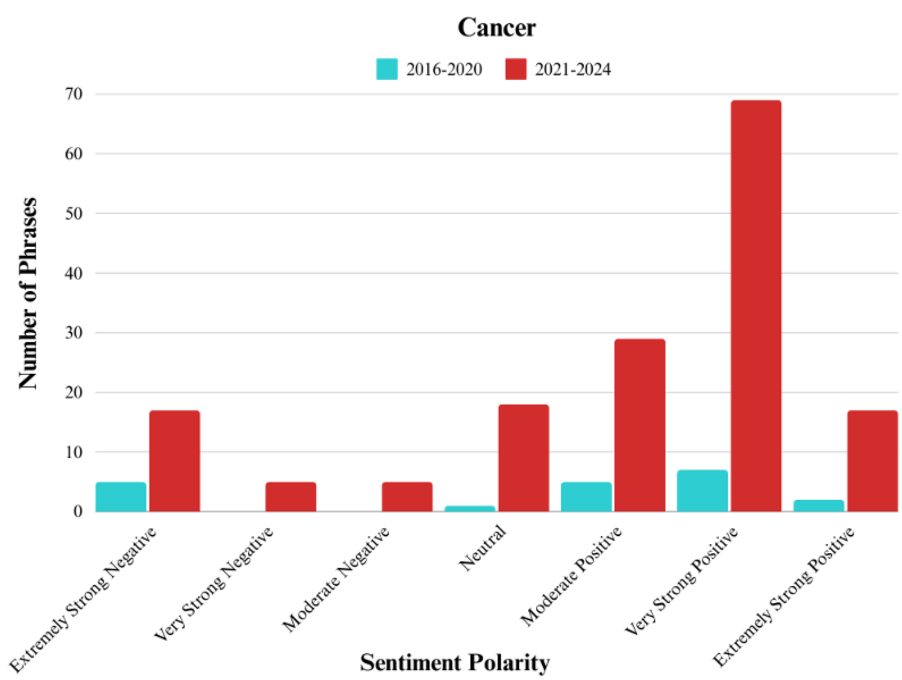


Figure 2. Sentiment of Genetic Editing Treatments in Healthcare across Cancer. This graph highlights the increasing positive sentiment toward genetic editing technologies

in cancer treatment from 2016 to 2024. The sharp rise in sentiment demonstrates growing confidence and optimism in using genetic editing as a therapeutic approach for oncology.

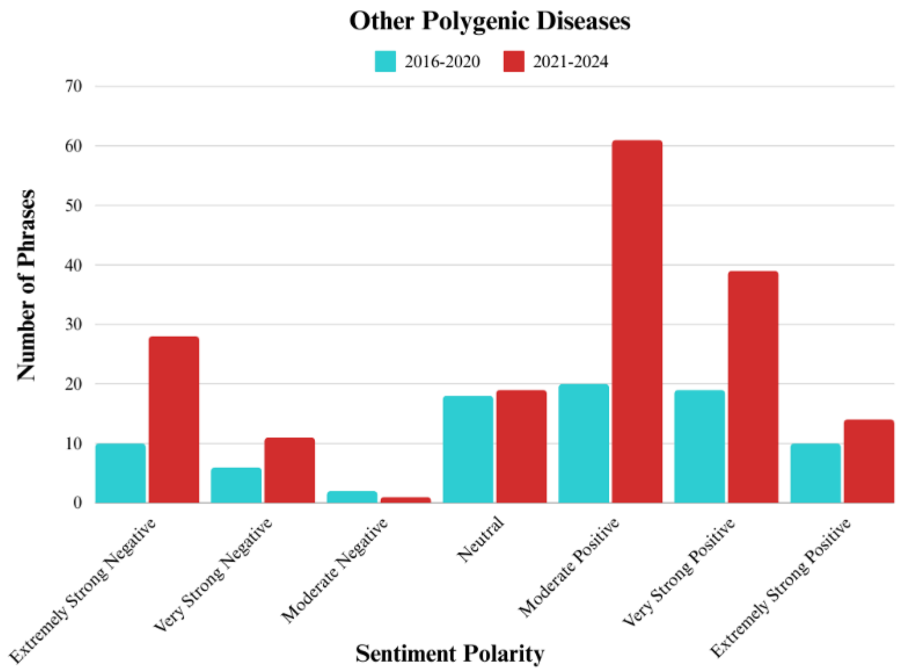


Figure 3. Sentiment of Genetic Editing Treatments in Healthcare across Other Polygenic Diseases. This graph shows sentiment trends for genetic editing technologies in polygenic diseases other than cancer and neurological conditions. While sentiment remains moderately positive overall, the slight decline in positivity over time suggests increasing ethical and practical concerns.

Table 2 portrays the average sentiment scores and the various interval scales that classifies a score as extremely negative, very strong negative, or moderately negative, neutral, moderately positive, very strong positive, or extremely strong positive. These scores are calculated using the number of phrases or paragraph fragments sorted as negative, neutral, or positive with the scale value numbers outlined in the semantic differential scale, shown by Table 1. The table conveys the average sentiment score for each category and each 5-year time period to express any relevant changes in public sentiment observed over time. A total sentiment score is also calculated for each category of neurological, cancer, or other polygenic diseases, so the average value of sentiment overall can compare against the different categories.

Extremely Strong Negative	Very Strong Negative	Moderate Negative	Neutral	Moderate Positive	Very Strong Positive	Extremely Strong Positive
X≤-2.0	-2.0<X≤-1.0	-1.0<X<0	X=0	0<X<1.0	1.0≤X<2.0	X≥2.0

	Neurological Diseases	Cancer	Other Polygenic Diseases
2016-2020	Mod positive 0.295	Mod positive 0.350	Mod positive 0.518
2021-2024	Mod positive 0.507	Mod positive 0.950	Mod positive 0.428
Total	0.4234*	0.9000*	0.4574*

Table 2. Average Sentiment Score. This table presents the calculated average sentiment scores for each polygenic disease category over two time periods, 2016–2020 and 2021–2024. The data highlights an overall positive trend in sentiment, with significant growth in cancer and neurological disease treatments. Note: values are averages.

Table 3 illustrates the correlational data between the number of ethical considerations and sentiment score. The number of ethical considerations is the ethical implications observed when coding the medical journal's words and phrases with negative sentiment. This is compared to the sentiment score of each category of polygenic diseases, neurological, cancer, and other, to establish how strong the existing relationship between the number of ethical considerations and the sentiment score is.

	Neurological Diseases 2016-2020	Neurological Diseases 2021-2024	Cancer 2016-2020	Cancer 2021-2024	Other Polygenic Diseases 2016-2020	Other Polygenic Diseases 2021-2024
Number of Ethical Considerations	2	4	3	13	7	18
Sentiment Score	0.295	0.507	0.350	0.950	0.518	0.428

Table 3. Ethical Considerations Correlation Data. This table shows the correlation between the number of ethical considerations and sentiment scores for genetic editing technologies. It provides insights into how ethical implications influence public attitudes across different categories of polygenic diseases.

Figure 4 illustrates how the average sentiment of genetic editing technology changes over the past decade. The sentiment score was calculated for 5-year periods, between 2016-2020 and between 2021-2024, to determine the difference of sentiment score over the past decade. Figure 4 illustrates the increase in positive sentiment, indicating how attitudes towards the implementation of genetic editing technology significantly becomes more positive as the technology continues to advance over the years.

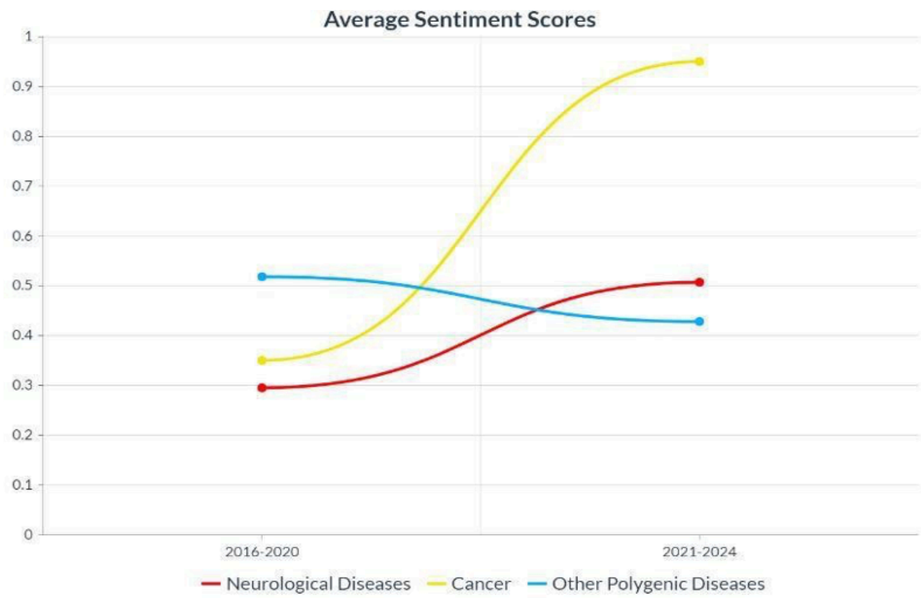


Figure 4. Average Sentiment over the Past Decade. This chart compares the average sentiment scores for genetic editing technologies across different categories—neurological diseases, cancer, and other polygenic diseases—over two five-year intervals. It underscores a consistent rise in positive sentiment, particularly in cancer and neurological applications, reflecting advancements in genetic editing technology.

4. Analysis

Thirty medical journals extending across the last decade were annotated and analyzed for their sentiment, exemplifying the existence of a positive trend of sentiment over time for the application of genetic editing technologies for polygenic diseases in healthcare. Since the correlation coefficient between sentiment scores and ethical implications was r=0.4673, it concluded that a moderately strong relationship was present between sentiment and the number of ethical implications presented. In similar regards with other polygenic diseases, the results demonstrated a moderately positive correlation with the total sentiment of genetic editing technology as a healthcare treatment overall, yet a minor negative trend did occur over time on contrary to the positive trend that arose for cancer and neurological diseases. Therefore, the polygenic diseases reject the null hypothesis because there is an existence of a trend between time and sentiment across all three categories of polygenic diseases. This study can conclude that there is a

positive correlation between the implementation of genetic editing technology as a treatment for polygenic diseases within the domain of cancer and neurological diseases and their sentiment over time in the past decade but a slight negative correlation under other polygenic diseases.
In addition, this study identified a pattern of which positive sentiment was often associated, behind context, that the specific benefits of genetic editing technology include its efficiency and effectiveness in modifying specific genes. 38 percent of the coding in positive sentiment was correlated with how effective and precise genetic editing technology is for polygenic diseases. In contrast, this study observed a pattern of negative sentiment that was frequently connected to the ethical consideration that genetic editing technology has the significant risk of negative unpredictable effects and off-target effects, which entails genome editing affecting other parts of the target DNA that were unintentional. 36 percent of the coding in negative sentiment was related to this risk, and thus indicates the distinct danger and ethical consideration that genetic editing presents.

This overall portrays how the attitudes towards the use of genetic editing technology as a form of treatment for polygenic diseases has increasingly become more positive over time as more advancements are being made in this type of treatment. This indicates that as genetic editing is presently used for mental health disease and psychiatric treatment, it will be met with a more positive response according to the trend of positive sentiment reflecting public attitudes and perceptions of the use of genetic editing technology as a healthcare treatment. This study found a consistent positive correlation of positive sentiment over time in polygenic diseases such as cancer and neurological diseases, reflecting how attitudes and perceptions towards the use of this technology in healthcare will likely follow this positive trend. Although other polygenic diseases experienced a slight decrease in positive sentiment within its perceptions, it concluded with a moderately positive sentiment, indicating that genetic editing for mental health diseases will be received with positive attitudes. This is significant because the public acceptance of the new medical technology can substantially affect the ability of genetic editing technology developing further. Opposition against the development of genetic editing technology to be implemented into healthcare as a treatment would reflect that the perceptions of gene editing focus on negative ethical considerations and concerns. If negative sentiment prevailed to be most prominent, it would conclude that relevant perceptions reject the proposition of gene editing based treatment for polygenic diseases in healthcare. Nevertheless, across the various polygenic diseases, the total sentiment concluded as moderately positive, suggesting acceptance of the application of genetic editing technology in healthcare.

Hence, this reinforces my initial assumptions that attitudes toward genetic editing technology in polygenic diseases will increasingly become positive, as a positive correlation indicates a growth in positive perceptions and establishes a total moderately positive sentiment across all polygenic diseases in the past decade. This shows how polygenic diseases are met with moderately positive attitudes and regarded with positive perceptions, further supporting the advancement of genetic editing technology to be utilized in polygenic diseases' treatments. Although a moderately positive sentiment is reflected throughout the last decade, the correlation between the sentiment over time and relevant ethical considerations cannot be concretely proven, even though a general trend of sentiment is apparent. There is no definite methodology to confidently prove the correlation of data across time, as the patterns of sentiment are not a clear catalyst due to existing external variables. Therefore, this study can only absolutely establish that there is a possible larger trend that exists.

4. Conclusion

4.1 Implications

The trend of total sentiment resulting in moderately positive across the polygenic diseases disclose how genetic editing technology-based treatments are often met with positive perceptions and attitudes. This implies that the public will hold similar sentiments toward the application of genetic editing for other complex polygenic diseases, specifically mental health diseases. "In psychiatry, GWAS [Genome-wide association studies] have uncovered a high degree of polygenicity underlying mental illnesses and related complex phenotypes."[26] This indicates how mental health diseases are very complex polygenic diseases, as multiple genes must be considered in the treatment of mental health illnesses. Hence, the positive sentiment observed over time towards the application of genetic editing technology for the treatment of various polygenic diseases signifies how public perceptions and attitudes will likely follow a similar trend of positive sentiment. With a trend of positive sentiment, it insinuates that public attitudes and perceptions will likely be supportive of the implementation of genetic editing in mental health treatments over time, and this social acceptance will empower the advancement of genetic editing technology in healthcare treatments.

4.2 Limitations

This study utilized a coding process in order to rate the sentiment of words, phrases, and paragraph fragments in the medical journals analyzed; nonetheless, the subjective aspect of coding the sentiment is a crucial consideration as a limitation. In this particular study, the content analysis consisted of identifying words that are associated with a positive or negative connotation and the extremity of the connotation, where the scale values were rated from extremely strong, very strong, moderately strong, and neutral. This can cause varying results of the content analysis in replicability because it is subjective in what the coder defines a word or phrase with regards to how extreme of a positive or negative connotation exists. To maintain as much objectivity as possible, the study ensured to emphasize the English language's definitions and connotations. Additionally, this study analyzes and codes thirty medical journals, which is a small sample in total; therefore, this limited sample size can restrict the study's total reflection on the perceptions towards genetic editing technology for polygenic diseases. Due to the small sample size, this study will conclude general data for the trend of sentiment that is insufficient to be utilized as a measure for how other trends will appear for genetic editing technology in healthcare.

Moreover, it is necessary to acknowledge that since genetic editing technology is encompassed within the rapidly evolving medical field, time brings forth change in how people perceive the information presented in medical journals and studies. Significant events that have occurred in the past decade, such as the coronavirus pandemic, can incite bias towards how the medical journals' information and studies are received or accepted by the public. The lack of focus on analyzing the trend of sentiment for only one specific polygenic disease also presents as a limitation since it is difficult to accurately identify if a certain sentiment is only present for a specific disease. However, this study examines various polygenic diseases, categorized as neurological, cancer, and other, in order to efficiently conclude a general trend of data for the sentiment that reflects the public's attitudes and perceptions towards the implementation of this technology in healthcare overall.

In addition, the 7-point semantic scale is a limitation, as the scale restricts the ability to rate the public perceptions present in the medical journals past the sentiment extremity of positive, neutral, and negative. Yet, the scale is optimized as an efficient method to classify the general data of public attitudes and perceptions towards genetic editing. This is a prime research method to identify any existing trends of sentiment towards genetic editing over time due to the lack of direct public surveys that analyze the perceptions and ethical considerations of the public. This is the best methodology to predict the sentiments of the public's perceptions towards the implementation of genetic editing technology in mental health diseases and treatments due to the absence of medical studies with a focus on genetic editing technologies utilized as a mental health treatment.

4.3 Future Directions

The genetic editing technologies of ZFNs, TALENs, and the CRISPR/Cas9 system present a new revolution in the healthcare field as it reflects the significant advancements developed in technology and medical devices. Nonetheless, this widely-used genetic editing tool still has rising concerns associated with its ethical implications, demonstrated by the slight decrease in positive sentiment analyzed under other polygenic diseases, but specifically shown by this correlational analysis that negative off-target effects are the most relevant ethical implication. Hence, future research should draw a focus on how to prevent these negative off-target effects associated with the application of genetic editing technology. The accuracy and precision of this technology was notably recognized throughout the medical journals, contributing to a significant percentage of the positive sentiment coded; therefore, it is imperative that additional research addressing this concern is investigated in order to maintain the observed trend of positive sentiment which insinuates that public sentiment and perceptions support the implementation of genetic editing technology in mental health illness treatments and other healthcare applications.

Another concern that arises when analyzing the negative sentiment of medical journals is the challenge of unpredictable long-term effects and consequences caused by genetic editing technology. To address this issue, future research should analyze the long-term effects of genetic editing technology for polygenic diseases, as this study only examined medical journals regarding the last decade. Thus, these guiding topics can help further the discourse about the implementation and advancements of genetic editing technology as viable treatments in healthcare for various diseases, with the consideration of the ethical implications and public perceptions surrounding the subject, and this research can serve to enable and revolutionize the efficiency of mental health treatments through this biotechnology.

5. Appendix A: Sentiment Code Ratings

Each number indicates the number of words or phrases that were coded and correlated with that sentiment extremity of positive, neutral, or negative within the medical journal.

NEUROLOGICAL DISEASES	Extremely Strong Negative	Very Strong Negative	Moderately Negative	Neutral	Moderately Positive	Very Strong Positive	Extremely Strong Positive
Application of gene editing in neurodegenerative diseases, volume II	0	0	0	0	2	2	1
CRISPR for Neuromuscular Disorders: Gene Editing and Beyond	4	1	0	2	5	3	0
Potential disease modifying therapies for Huntington's disease, lessons learned and future opportunities	0	0	0	1	2	2	1
CRISPR-based functional genomics for neurological disease	1	1	0	7	3	5	1
CRISPR/Cas9 gene editing: New hope for Alzheimer's disease therapeutics	4	0	2	0	9	8	0
Gene Editing and Modulation: the Holy Grail for the Genetic Epilepsies emerging treatment for Scn2a mutation-induced autism spectrum disorders	2	0	2	1	0	3	0
Gene Therapy for Parkinson's Disease, An Update	0	0	0	2	1	3	1
Huntingtin Lowering Strategies for Disease Modification	3	0	2	3	1	3	0
Neuro-Immuno-Gene- and Genome-Editing: Therapy for Alzheimer's Disease: Are We There Yet?	2	0	0	0	2	4	2

CANCER	Extremely Strong Negative	Very Strong Negative	Moderately Negative	Neutral	Moderately Positive	Very Strong Positive	Extremely Strong Positive
CRISPR/Cas9 and next generation sequencing in the personalized treatment of Cancer	6	0	0	3	3	4	1
CRISPR/Cas9 gene editing: a new approach for overcoming drug resistance in cancer	2	0	3	0	0	9	2
CRISPR/Cas9 therapeutics: a cure for cancer and other genetic diseases	5	0	0	1	5	7	2
CRISPR/Cas9-Mediated Genome Editing in Cancer Therapy	1	1	1	1	5	4	3
CRISPR/Cas9: Role of genome editing in cancer immunotherapy	0	1	0	1	1	4	1
Current applications and future perspective of CRISPR/Cas9 gene editing in cancer	3	1	1	1	7	20	5
Gene editing to enhance the efficacy of cancer cell therapies	0	1	0	3	0	2	0
Genome editing and cancer: how far has research moved forward on CRISPR/Cas9?	2	0	0	1	8	12	1
Genome editing: an essential technology for cancer treatment	0	0	0	5	1	4	0
Recent advances and applications of CRISPR-Cas9 in cancer immunotherapy	3	1	0	3	4	10	4

OTHER POLYGENIC DISEASES	Extremely Strong Negative	Very Strong Negative	Moderately Negative	Neutral	Moderately Positive	Very Strong Positive	Extremely Strong Positive
Applications of genome editing technology in the targeted therapy of human diseases: mechanisms, advances, and prospects	3	3	0	6	9	8	6
Challenges and progress relate to gene editing in rare skin diseases	1	0	1	2	1	1	0
Challenges of Gene Editing Therapies for Genodermatoses	7	5	0	5	8	6	2
Clinical applications of the CRISPR/Cas9 genome editing system: Delivery options and challenges in precision medicine	9	4	0	2	9	10	3
CRISPR Modeling and Correction of Cardiovascular Disease	1	2	0	4	9	3	0
Gene editing and its applications in biomedicine	2	0	0	3	9	7	0
Gene editing in dermatology: Harnessing CRISPR for the treatment of cutaneous disease	1	2	2	7	4	9	4
Principles of CRISPR-Cas9 technology: Advancements in genome editing	7	0	0	0	25	8	9
Ready for Repair? Gene Editing Enters the Clinic for the Treatment of Human Disease	6	1	0	5	7	2	0
Therapeutic applications of gene editing in chronic liver diseases: an update	1	0	0	3	0	4	0

5. Appendix B: Representative Quotations of Sentiment Score

Polygenic Disease	Year	Title of Medical Journal or Study	Quotation	Average Sentiment Score
Cancer	2022	CRISPR/Cas9 and next generation sequencing in the personalized treatment of Cancer	"Continued genomic modification increases the likelihood of off-target cleavage and reduces editing selectivity, potentially leading to undesired mutations and toxicity."	-0.235 Moderate Negative
Cancer	2022	CRISPR/Cas9 gene editing: a new approach for overcoming drug resistance in cancer	"Targeting some of these genes using CRISPR/Cas9 technology has yielded promising results in weakening drug resistance and increasing the effectiveness of anticancer drugs."	0.938 Moderate Positive
Cancer	2016	CRISPR/Cas9 therapeutics: a cure for cancer and other genetic diseases	"The CRISPR/Cas9 technology has presently been shown to correct the mutations causing those diseases and has a potential to be developed as a promising therapy at genetic level to protect patients at risk."	0.500 Moderate Positive
Cancer	2023	CRISPR/Cas9-Mediated Genome Editing in Cancer Therapy	"Among these, the CRISPR/Cas9 system, as a third-generation gene editing tool, exhibits several advantages with ZFN and TALEN, such as high efficiency, simple design, rapid operation, and low cost."	1.000 Very Strong Positive
Cancer	2024	CRISPR/Cas9: Role of genome editing in cancer immunotherapy	"This novel method allows for precise alterations in the genome and the correction or removal of mutations that promote cancer initiation and development."	1.250 Very Strong Positive
Cancer	2022	Current applications and future perspective of CRISPR/Cas9 gene editing in cancer	"Due to its high efficiency and precision, the CRISPR/Cas9 technique has been employed to explore the functions of cancer-related genes… and probe drug targets, vastly increasing our understanding of cancer genomics."	1.316 Very Strong Positive
Cancer	2021	Gene editing to enhance the efficacy of cancer cell therapies	"CRISPRi can efficiently repress expression of single or multiple genes in mammalian cells, and its effects are reversible."	0.333 Moderate Positive

Cancer	2022	Genome editing and cancer: how far has research moved forward on CRISPR/Cas9?	"This method is being utilized to efficiently replace the altered sequence's hot spot area,, resulting in the inhibition of tumor development, elimination of drug resistance, and enhancement of medication efficacy."	1.208 Very Strong Positive
Cancer	2022	Genome editing: an essential technology for cancer treatment	"The CRISPR/Cas9 system may target oncogenic changes in cancer cell lines with precision and efficiency."	0.900 Moderate Positive
Cancer	2023	Recent advances and applications of CRISPR-Cas9 in cancer immunotherapy	"Although CRISPR-Cas9, with its remarkable scalability, flexibility, and operability, provides a powerful technical enablement for achieving the highest target gene editing goal, many obstacles remain."	0.760 Moderate Positive
Neurological Disease	2023	Application of gene editing in neurodegenerative diseases, volume II	"Therefore, CRISPR Cas9 and related gene editing technology have enabled humans to explore the relationship between genes and diseases more precisely."	1.800 Very Strong Positive
Neurological Disease	2019	CRISPR for Neuromuscular Disorders: Gene Editing and Beyond	"Although the promise of therapeutic gene editing is high for monogenic diseases, there are still many obstacles that need to be addressed before CRISPR therapies can be translated to NMD patients."	-0.200 Moderate Negative
Neurological Disease	2022	Potential disease modifying therapies for Huntington's disease, lessons learned and future opportunities	"CRISPR (clustered regularly interspaced short palindromic repeats)-based systems have emerged as potentially versatile, specific, and efficient gene-editing technologies with potential to treat HD and other neurodegenerative disorders."	1.500 Very Strong Positive
Neurological Disease	2020	CRISPR-based functional genomics for neurological disease	"More recently, precise genome editing techniques based on zinc finger nucleases, transcription activator-like endonucleases (TALENs) or CRISPR were successfully implemented… and used to generate models of neurological and related diseases…"	0.611 Moderate Positive
Neurological Disease	2021	CRISPR/Cas9 gene editing: New hope for Alzheimer's disease therapeutics	"This emerging technology is relatively straightforward, inexpensive, and precise, which has led to an increased interest in this technique for neurodegenerative diseases (NDDs)."	0.478 Moderate Positive
Neurological Disease	2021	Gene Editing and Modulation: the Holy Grail for the Genetic Epilepsies	"Although CRISPR/Cas has advantages over classical gene therapy approaches, limitations involving CNS delivery, low editing efficiency, and off-target effects may hinder its rapid adoption into the clinic."	-0.250 Moderate Negative
Neurological Disease	2023	Gene therapy as an emerging treatment for Scn2a	"With its limitations, the prospect of gene therapy as a	-0.571 Moderate

		mutation-induced autism spectrum disorders	viable treatment option for patients with ASD must ultimately be considered."	Negative
Neurological Disease	2018	Gene Therapy for Parkinson's Disease, An Update	"Gene therapy offers a promising potential treatment avenue for PD with the theoretical possibility of targeting both non-disease and disease modifying targets."	1.429 Very Strong Positive
Neurological Disease	2019	Huntingtin Lowering Strategies for Disease Modification	"Although TALEN-based nucleases theoretically have higher efficiency and more specificity than ZFN-based approaches, TALENs require a specific nucleotide at the end of the DNA sequence that can limit potential targets."	-0.333 Moderate Negative
Neurological Disease	2018	Neuro-Immuno-Gene- and Genome-Editing: Therapy for Alzheimer's Disease: Are We There Yet?	"Clustered regularly interspaced short palindromic repeat (CRISPR)-Cas nucleases have revolutionized the field of gene editing and have tremendous application in the field of molecular medicine."	1.000 Very Strong Positive
Other Polygenic Diseases	2020	Applications of genome editing technology in the targeted therapy of human diseases: mechanisms, advances, and prospects	"Genome editing has extended our ability to elucidate the contribution of genetic to disease by promoting the creation of more accurate cellular and animal models of pathological processes and has begun to show extraordinary potential in a variety of fields, ranging from basic research to applied biotechnology and biomedical research	0.800 Moderate Positive
Other Polygenic Diseases	2024	Challenges and progress relate to gene editing in rare skin diseases	"A main limitation in gene therapy applications has been the efficient isolation of patient epidermal stem cells (holoclones) - the intended target cell population for treatment…"	-0.167 Moderate Negative
Other Polygenic Diseases	2023	Challenges of Gene Editing Therapies for Genodermatoses	"However, there are still many challenges to consider before gene editing therapies can be applied to genodermatoses in the clinical setting. These include gene editing efficiency, reducing off-target effects, effective delivery…"	-0.152 Moderate Negative

Other Polygenic Diseases	2023	Clinical applications of the CRISPR/Cas9 genome editing system: Delivery options and challenges in precision medicine	"In this system, the Cas9 protein can target the desired sequence using an engineered guide RNA (gRNA) which makes a smooth double-stranded cut in three nucleotides sequence upstream at the target site which is called Proteospacer-Adjacent Motif (PAM)."	0.081 Moderate Positive
Other Polygenic Diseases	2023	CRISPR Modeling and Correction of Cardiovascular Disease	"Among the four major classes of nucleases, the RNA-guided CRISPR-Cas system (clustered regularly interspaced short palindromic repeats and CRISPR-associated proteins) simplifies genome editing and has made genome engineering more accessible than ever before."	0.316 Moderate Positive
Other Polygenic Diseases	2022	Gene editing and its applications in biomedicine	"More recently, under the direction of a guide RNA (gRNA), clustered regularly interspaced short palindromic repeats (CRISPR)/CRISPR-associated protein (Cas) nuclease can cleave the DNA double-strand at target sites with great convenience, efficiency, and precision."	0.810 Moderate Positive
Other Polygenic Diseases	2020	Gene editing in dermatology: Harnessing CRISPR for the treatment of cutaneous disease	"The success of this approach demonstrated the potential for CRISPR-Cas9-induced gene correction of epidermal stem cells in vivo without the cost and technical challenge of ex vivo cell modification."	0.793 Moderate Positive
Other Polygenic Diseases	2024	Principles of CRISPR-Cas9 technology: Advancements in genome editing	"The extensive utilization of CRISPR-Cas9 technology has unquestionably brought about a revolutionary transformation in the field of genome editing."	0.776 Moderate Positive
Other Polygenic Diseases	2020	Ready for Repair? Gene Editing Enters the Clinic for the Treatment of Human Disease	"A drawback for clinical implementation of such strategy is the long-term presence of active gene editing components in the liver of patients and the associated risk of damaging the genome by introducing double-stranded breaks at off-target loci."	-0.429 Moderate Negative
Other Polygenic Diseases	2022	Therapeutic applications of gene editing in chronic liver diseases: an update	"Further, the efficacy of mRNA vaccines during the COVID-19 pandemic indicated that the safety and accuracy of gene therapy can be further improved using Cas mRNA instead of Cas gene or Cas protein."	0.625 Moderate Positive

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