UNIVERSIDADE FEDERAL DO PARANÁ

LEONARDO VICENZI

MAPEANDO “HYPES”: EXAGEROS E ESPERANÇAS NA MEDICINA

CURITIBA

2025

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Dissertação apresentada ao Programa de Pós-Graduação em Bioinformática, Setor de Educação Profissional e Tecnológica, Universidade Federal do Paraná, como requisito parcial à obtenção do título de Mestre em Bioinformática..

Orientador: Prof. Dr. Roberto Tadeu Raittz

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CURITIBA, 10 de Dezembro de 2025.

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TERMO DE APROVAÇÃO

Os membros da Banca Examinadora designada pelo Colegiado do Programa de Pós-Graduação BIOINFORMÁTICA da Universidade Federal do Paraná foram convocados para realizar a arguição da Dissertação de Mestrado de **LEONARDO VICENZI**, intitulada: **"Mapeando "Hypes": Exageros e Esperanças na Medicina"**, que após terem inquirido o aluno e realizada a avaliação do trabalho, são de parecer pela sua APROVAÇÃO no rito de defesa.

A outorga do título de mestre está sujeita à homologação pelo colegiado, ao atendimento de todas as indicações e correções solicitadas pela banca e ao pleno atendimento das demandas regimentais do Programa de Pós-Graduação.

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“spe gaudentes,
in tribulatione patientes,
orationi instantes
(Biblia Sacra, ad Romanos 12, 12)

RESUMO

A inovação médica é frequentemente acompanhada por ciclos de otimismo e ceticismo, comumente expressos em inglês através do par retórico “hype or hope”. Embora amplamente utilizado como marcador de hesitação científica, esse discurso ainda não havia sido examinado em larga escala. Analisamos 422 artigos indexados no PubMed que continham ambos os termos em seus títulos ou resumos, com o objetivo de mapear alegações médicas contestadas na literatura biomédica. Utilizando uma metodologia híbrida que combinou processamento de linguagem natural, agrupamento hierárquico de embeddings de texto, sumarização dialética baseada em grandes modelos de linguagem (LLM) e curadoria humana especializada, identificamos 23 tópicos principais abrangendo doenças e tratamentos. A prevalência dos tópicos no corpus do estudo foi então comparada à base de dados geral do PubMed usando análise de enriquecimento hipergeométrico. Os resultados revelaram diferenças marcantes entre os domínios biomédicos. Tópicos relacionados a tratamentos foram mais super-representados do que os relacionados a doenças, com biópsia líquida (enriquecimento de 22×) e terapias com células-tronco (13×) apresentando a maior super-representação; alto enriquecimento também foi observado para medicina de precisão, inteligência artificial, cannabis e intervenções baseadas no microbioma. Entre as doenças, o autismo apresentou o maior enriquecimento (4,8×), enquanto o câncer foi o contexto mais frequente para o enquadramento “hype or hope”. Em vez de resolver se inovações específicas constituem “hype” ou progresso genuíno, este estudo mapeia onde promessa e evidência divergem nos domínios biomédicos—demonstrando como a análise computacional de texto pode revelar padrões coletivos de incerteza científica.

Palavras-chaves: hype, inovação médica, processamento de linguagem natural, modelagem de tópicos, grandes modelos de linguagem

ABSTRACT

Medical innovation is often accompanied by cycles of optimism and skepticism, commonly expressed through the rhetorical pairing “hype or hope”. Although widely used as a marker of scientific hesitation, this discourse has not previously been examined at scale. We analyzed 422 PubMed-indexed articles that contained both terms in their titles or abstracts, aiming to map contested medical claims across the biomedical literature. Using a hybrid methodology that combined Natural Language Processing (NLP), hierarchical clustering of text embeddings, Large Language Model (LLM)–based dialectical summarization, and expert human curation, we identified 23 core topics spanning diseases and treatments. The prevalence of topics in the study corpus was then compared with that in the broader PubMed database using hypergeometric enrichment analysis. The results revealed marked differences across biomedical domains. Treatment-related topics were more over-represented than disease-related ones, with liquid biopsy (22× enrichment) and stem cell therapies (13×) showing the strongest over-representation; high enrichment was also observed for precision medicine, artificial intelligence, cannabis, and microbiome-based interventions. Among diseases, autism showed the highest enrichment (4.8×) while cancer was the most frequent context for “hype or hope” framing. Rather than resolving whether specific innovations constitute hype or genuine progress, this study maps where promise and evidence diverge across biomedical domains—demonstrating how computational text analysis can uncover collective patterns of scientific uncertainty.

Key-words: hype, medical innovation, natural language processing, topic modeling, large language models

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API	Application Programming Interface
BERT	“Bidirectional Encoder Representations from Transformers”
CBD	Cannabidiol
HTML-TM	Hyper Text Markup Language with Text Mining
ITOL	Interactive Tree Of Life
LDA	“latent Dirichlet allocation”
LLM	“Large Language Model”
MeSH	Medical Subject Headings
NCBI	National Center for Biotechnology Information
NLP	Natural Language Processing
SWeeP	Spaced Words Projection

SUMÁRIO

1 INTRODUÇÃO

O que um livro de medicina de 1742 pode nos ensinar à luz da era digital e da inteligência artificial na medicina? O mundo do médico que escreveu essa obra era o das sanguessugas e da teoria humoral, desprovido dos ensaios clínicos randomizados, do sequenciamento genético e da vasta base de conhecimento que hoje está a poucos cliques de distância em plataformas como o PubMed. No entanto, em seu livro “A Treatise of the Acute Diseases of Infants”, o autor faz uma crítica que ainda é válida hoje. Ele afirma: “Diferentes modos e costumes entram e saem de moda na medicina assim como no vestuário” (Harris, 1742).

Desde então, diversos autores chamaram a atenção para a recorrência do fenômeno dos modismos na medicina (Reynolds, 1871) (Hutchison, 1925) (NEJM, 1934) (Kelly, 1962) (Tindall, 1993). Essas observações revelam como a prática clínica pode ser influenciada por tendências passageiras, nos afastando do compromisso com a verdade, comprometendo assim o princípio que sustenta a Medicina Baseada em Evidências.

Um exemplo contemporâneo particularmente ilustrativo é o chamado *Angelina Jolie Effect* — termo cunhado pela revista Time para descrever o aumento significativo na procura por testes genéticos relacionados ao câncer de mama (Liede *et al.*, 2018). Esse aumento ocorreu após a atriz ter tornado pública, em 2013, a sua decisão de se submeter a uma dupla mastectomia preventiva devido à descoberta de que era portadora de uma mutação no gene BRCA1.

Outro estudo mostrou que a taxa de realização de mastectomias preventivas dobrou após o relato da atriz (Basu *et al.*, 2021). Independentemente do mérito clínico de tais decisões individuais, é inegável que a popularização desses testes e cirurgias decorreu não de uma nova evidência científica, mas de um evento midiático amplamente divulgado. Como já observava Hutchison 100 anos atrás, a imitação de figuras de prestígio — sejam celebridades ou autoridades médicas — é um potente vetor de modismos (Hutchison, 1925). Isso nos leva a questionar: quando isso acontece, estamos, de fato, praticando uma medicina baseada em evidências ou apenas reproduzindo padrões moldados pelas dinâmicas de influência social?

Ao longo da história, não faltam exemplos de práticas médicas que podem ser classificadas como modismos, terapias que ganharam popularidade rapidamente e que não tinham sustentação em evidências científicas. Talvez o mais trágico deles tenha sido a lobotomia, um procedimento que, durante algumas décadas do século XX, foi considerado uma solução inovadora para inúmeros distúrbios mentais(Kucharski, 1984).

Essa “onda terapêutica” varreu hospitais e clínicas, deixando um rastro de sofrimento e de famílias devastadas, inclusive entre figuras proeminentes, como os Kennedy.

A lobotomia foi inicialmente celebrada como uma inovação científica: seu criador, o neurologista português António Egas Moniz, recebeu o Prêmio Nobel de Medicina em 1949 pelo desenvolvimento do procedimento (Moniz, 1949). No entanto, os resultados foram trágicos — milhares de pacientes sofreram danos neurológicos irreversíveis, como ocorreu com Rosemary Kennedy, irmã do presidente John F. Kennedy, submetida à lobotomia aos 23 anos, o que resultou em sequelas que a deixaram permanentemente incapacitada (O’Brien, 2004). O caso exemplifica como a euforia da época pode transformar uma hipótese terapêutica em um modismo com consequências devastadoras.

Outro caso emblemático envolvendo um presidente americano, ocorrido em uma época anterior, foi o de George Washington. Seu caso está ligado à chamada “medicina heroica”, predominante nos séculos XVIII e XIX, cuja crença na eficácia da sangria e de outras intervenções drásticas possivelmente custou a sua vida (Chernow, 2010).

Em 1799, após desenvolver uma inflamação de garganta, Washington foi submetido, em poucas horas, a sucessivas sangrias que retiraram cerca de 40% de seu volume sanguíneo total — um procedimento considerado, à época, uma intervenção racional e vigorosa contra doenças agudas. O tratamento incluiu ainda a administração de calomelano (um composto de mercúrio tóxico) e de laxantes agressivos, práticas alinhadas ao ideal da “terapia ativa”, que caracterizava a medicina heroica, segundo a qual a recuperação do paciente dependia da intensidade da ação médica. O estado de debilidade extrema induzido por estes “tratamentos heroicos”, somado à doença original, é considerado por alguns historiadores da medicina como um fator decisivo que precipitou seu óbito (Barrett; Mingo, 2002).

Esses exemplos, separados por séculos, mas unidos pelo mesmo padrão de adesão precipitada, confirmam a advertência do autor daquele livro de 1742. Sua reflexão, ainda que distante no tempo, revela uma verdade persistente: a tendência da prática médica a aderir a modismos, sejam eles teóricos ou terapêuticos. Essa constatação reforça a necessidade de exercer a medicina com cautela, mantendo sempre uma atitude de dúvida e de autocrítica diante das nossas próprias convicções.

O reconhecimento de que muitas das práticas que antes eram consideradas padrão acabaram sendo revistas posteriormente nos convida a uma postura de humildade. O conhecimento científico está em permanente construção, e a história da medicina demonstra como teorias consolidadas podem ser substituídas à luz de novas evidências. Essa atitude de humildade não implica relativismo, mas expressa o compromisso com uma ciência que reconhece seus limites e se mantém aberta à revisão

constante.

Outro aspecto essencial dessa atitude é a disposição para escutar as vozes dissonantes. Em cada um dos casos históricos mencionados — da medicina heroica à lobotomia — houve críticas contemporâneas que foram muitas vezes marginalizadas (North, 2000) (Torkildsen, 2022). Podemos supor que, se essas vozes tivessem sido ouvidas com mais atenção, talvez tivéssemos abreviado capítulos particularmente sombrios da história médica.

Não sabemos quais das práticas hoje aceitas serão rejeitadas pelas gerações futuras, mas é pouco provável que todas elas resistam ao tempo sem revisão. A história da medicina é, em grande parte, uma história de mudanças e correções — e ignorar esse padrão seria um equívoco científico e até mesmo ético.

1.1 HYPE OR HOPE

O termo “modismo” parece ter caído em desuso na literatura médica recente, sendo, em certa medida, substituído por um conceito análogo: o “hype”. Derivado do inglês *hyperbole* — exagero — o termo remete à ideia de expectativas infladas, frequentemente acima do que as evidências sustentam. No contexto da literatura médica, uma expressão recorrente tem sido “hype or hope”, que funciona como uma espécie de fórmula retórica para expressar incerteza e cautela.

Pode-se hipotetizar que os conceitos “modismo” e “hype” tenham origem em fatores de ordem psicológica e social, talvez vieses cognitivos, o efeito de manada (*bandwagon effect*) ou questões de validação social. Porém, para além dessas questões de ordem subjetiva, surgiram iniciativas voltadas a traduzir o fenômeno “hype” em estruturas analíticas mais objetivas, capazes de delinear seus ciclos e regularidades.

O Ciclo de Hype da Gartner — um modelo conceitual originado no campo da gestão da inovação tecnológica (Linden; Fenn *et al.*, 2003) — oferece um vocabulário complementar, orientado por processos, para compreender esses padrões de otimismo e decepção. O modelo descreve a adoção de inovações em cinco fases: um gatilho da tecnologia inicial (Technology Trigger), seguido de um pico de expectativas infladas (Peak of Inflated Expectations), um vale da desilusão (Trough of Disillusionment), uma rampa de esclarecimento (Slope of Enlightenment) e, por fim, um platô de produtividade (Plateau of Productivity).

Aplicado à medicina, esse esquema pode ajudar a distinguir picos de otimismo transitório de processos de consolidação mais duradouros, baseados em evidências. Diversos autores têm utilizado esse modelo para analisar tecnologias biomédicas (Oosterhoff; Doornberg, 2020) (Stikov; Karakuzu, 2023) (Polyakov *et al.*, 2025), argumentando que o ritmo e a forma dessas fases variam conforme o campo e são

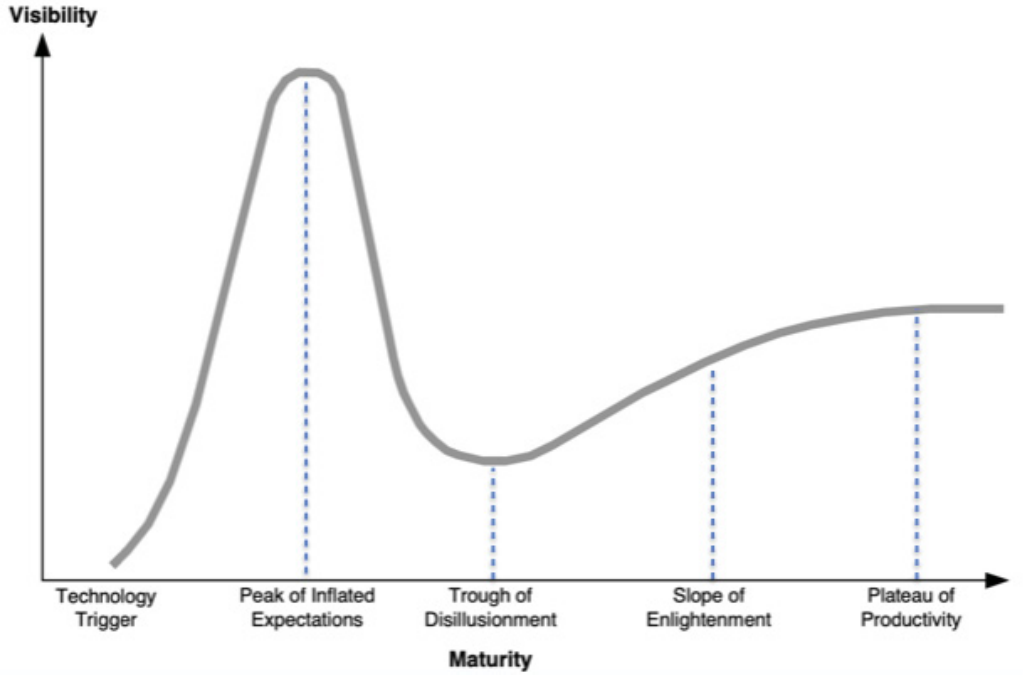

FIGURA 1 – Gartner Hype Cycle
Fonte: adaptado de Understanding Gartner's hype cycles - Linden, Fenn *et al.* (2003)

influenciados por diversos fatores.

Ao mesmo tempo, críticos do modelo alertam que o "ciclo de hype" deve ser entendido como uma heurística, não como uma lei preditiva: ele pode simplificar trajetórias heterogêneas, obscurecer assimetrias entre diferentes domínios terapêuticos e minimizar o papel de fatores políticos, econômicos e éticos na determinação de quais tecnologias avançam (Dedehayir; co-authors, 2016). Apesar do valor de se investigar as particularidades do fenômeno "hype" em si, torna-se igualmente relevante uma observação panorâmica de quais áreas da medicina vêm sendo questionadas por meio dessa fórmula de incerteza e cautela.

A maioria dos artigos científicos que utilizam a expressão "hype or hope" raramente oferece um veredito definitivo sobre se o objeto em questão deve ser entendido como uma esperança legítima "hope" ou como uma falsa esperança "hype". Essas publicações, em última análise, manifestam uma dúvida — uma espécie de reflexão sobre os limites entre o otimismo e o ceticismo. O número crescente de publicações que recorrem à expressão "hype or hope" revela que a própria comunidade científica reconhece esse dilema. São centenas de artigos que o utilizam, sob diferentes perspectivas, em doenças, terapias e tecnologias emergentes, refletindo a tensão da medicina diante de seus próprios limites e promessas.

Esse crescimento quantitativo, contudo, suscita uma pergunta ainda pouco explorada: quais áreas da medicina concentram mais o uso da fórmula "hype or hope"?

Observar a distribuição temática desses artigos pode revelar não apenas os campos onde a incerteza é mais explicitamente reconhecida, mas também aqueles em que a velocidade da inovação, a escassez de evidências ou a pressão por resultados favorecem a emergência desse enquadramento retórico.

Compreender como essa dinâmica se manifesta no discurso médico contemporâneo, porém, exige mais do que a leitura isolada de alguns exemplos. A análise manual de um volume de textos na casa das centenas é uma tarefa complexa e limitada, o que torna especialmente relevante o uso de métodos automatizados de análise textual, como os baseados em aprendizado de máquina. Tais métodos possibilitam uma visão mais sistemática do discurso médico contemporâneo, capturando suas recorrências e dinâmicas centrais.

1.2 MODELAGEM DE TÓPICOS

Ao longo da história, o avanço da ciência esteve frequentemente ligado à capacidade de observar fenômenos em novas escalas e sob novas perspectivas. O desenvolvimento de instrumentos e métodos — o telescópio e o microscópio, os grandes estudos epidemiológicos e o sequenciamento genético — permitiu revelar dimensões antes invisíveis da realidade. Hoje, um movimento análogo ocorre no campo da ciência de dados textuais: a possibilidade de analisar grandes coleções de textos como unidades coerentes de estudo.

Essa nova abordagem questiona a suposição de que um conjunto de textos representa uma multiplicidade de vozes, e não um objeto de estudo singular. Os avanços em representação textual e em aprendizado de máquina possibilitam descrever o discurso coletivo de um campo do conhecimento, revelando padrões que só emergem quando o conjunto é observado em sua totalidade.

Nesse contexto, a modelagem de tópicos (topic modeling) surge como uma técnica promissora para a análise de grandes volumes de texto. Essa abordagem permite identificar temas recorrentes em um conjunto documental. A primeira etapa consiste na vetorização dos textos. Na segunda etapa, com os textos transformados em vetores, ou *embeddings*, a modelagem de tópicos opera sobre o corpus como um todo, extraindo dele uma estrutura temática por meio da clusterização, ou agrupamento, de conceitos e documentos. Essa capacidade de representar uma coleção textual como um espaço estruturado torna possível investigar dimensões do discurso científico que antes dependiam exclusivamente de leitura e interpretação humanas, abrindo caminho para uma visão panorâmica de um determinado corpus.

No campo da medicina, outras possibilidades abertas pelo avanço da inteligência artificial, como os grandes modelos de linguagem - “Large Language Model” (LLM),

são particularmente relevantes. A literatura médica é caracterizada por uma linguagem altamente técnica, marcada pela presença de jargões, siglas e terminologia específica de subáreas. Essa complexidade torna desafiadora a tarefa de identificar, de forma automatizada, os temas que atravessam diferentes segmentos da pesquisa médica. Além disso, a velocidade com que novos conceitos e tecnologias são introduzidos gera um vocabulário em constante transformação, o que dificulta a identificação de regularidades semânticas. Para que esses modelos produzam resultados coerentes e interpretáveis, é necessário lidar cuidadosamente com as particularidades linguísticas desse domínio, ajustando as representações textuais de modo a torná-las mais informativas e comparáveis.

1.3 MAPEAMENTO

É nesse contexto que se insere o artigo “Mapping Medical Hypes and Hopes”. A investigação parte de um corpus composto por artigos científicos indexados na base PubMed que contêm as palavras “hype” e “hope” em títulos ou resumos. O objetivo é compreender como esses termos são empregados no discurso médico contemporâneo. A partir desse conjunto, aplicam-se técnicas de processamento de linguagem natural e de modelagem computacional de textos.

A primeira etapa da análise consistiu em transformar os dados textuais em representações numéricas adequadas para o processamento computacional, característica típica do processo de *text embedding*. Adotamos o pipeline descrito em nosso trabalho anterior (Ieger-Raittz *et al.*, 2025). Esse procedimento se baseia em uma vetorização inspirada na modelagem de sequências biológicas, utilizando o método SWeeP por meio da abordagem Biotext (Machado *et al.*, 2022). A essa etapa somamos uma mineração de texto baseada em HTML — Hyper Text Markup Language with Text Mining (HTML-TM) — que permitiu um exame interativo do corpus.

Paralelamente, aplicamos uma etapa de aumento de dados que gerou, para cada artigo, uma descrição das razões pelas quais o tratamento ou a tecnologia poderia ser visto como promissor e, ao mesmo tempo, como potencialmente superestimado. Essa expansão do conteúdo produziu textos mais uniformes e comparáveis, fortalecendo a base para as análises computacionais subsequentes.

Com base nessas representações vetoriais, foram conduzidas análises de agrupamento temático utilizando a clusterização hierárquica, seguidas de validação manual e de exame de palavras-chave, a fim de garantir a coerência e a relevância dos tópicos identificados. Os resultados foram então visualizados por meio de dendrogramas, o que permitiu identificar as áreas médicas e as tecnologias mais frequentemente associadas a discursos de esperança ou de exagero. Por fim, o estudo discute o significado dos padrões encontrados para a compreensão das tensões, expectativas e controvérsias

que caracterizam a medicina contemporânea.

2 JUSTIFICATIVA

Apesar da ampla difusão da expressão “hype or hope” na literatura médica, não temos conhecimento de estudos que buscam compreender, de forma sistemática, o que ela revela sobre o discurso científico contemporâneo. Faltam, em particular, esforços de síntese capazes de mapear, em larga escala, quais áreas da medicina têm sido mais frequentemente associadas a discursos de esperança ou de exagero — e, portanto, onde se concentram as maiores controvérsias, expectativas e incertezas.

Uma das razões para essa lacuna pode residir em limitações técnicas que, até recentemente, tornavam inviável a análise automatizada de grandes coleções de textos. Embora técnicas de modelagem de tópicos como “latent Dirichlet allocation” (LDA) tenham sido introduzidas em 2003 (Blei *et al.*, 2003), foi apenas com o avanço da vetorização de palavras — inaugurado por modelos como o word2vec em 2013 (Mikolov *et al.*, 2013) — que se tornou possível representar de forma mais precisa as relações semânticas entre textos, e apenas cerca de uma década depois surgiram as primeiras ferramentas de modelagem de tópicos que utilizavam essa tecnologia, como o BERTopic por exemplo (Grootendorst, 2022), baseado nos *embeddings* gerados pelo “Bidirectional Encoder Representations from Transformers” (BERT)(Devlin *et al.*, 2019).

Nesse percurso de evolução metodológica, nosso grupo de pesquisa tem desenvolvido e aplicado ferramentas computacionais que oferecem abordagens alternativas para a análise textual. O pipeline utilizado neste trabalho incorpora uma dessas soluções, que aplica conceitos da modelagem de sequências biológicas ao processamento de linguagem natural, combinada a um framework de mineração de texto baseada em HTML para análise interativa do corpus. A aplicação dessas ferramentas, validadas em nossos estudos anteriores (Ieger-Raittz *et al.*, 2025), demonstrou ser adequada para a representação semântica de textos especializados, criando, assim, as condições necessárias para implementar as análises que caracterizam esta investigação.

A popularização dos grandes modelos de linguagem (LLM) baseados na arquitetura transformer (Vaswani *et al.*, 2017) também permitiu o refinamento dos textos através de técnicas de text augmentation, capazes de lidar com a alta especificidade da linguagem médica. Esse recurso possibilitou, em certa medida, “traduzir” o vocabulário técnico e ampliar o contexto semântico dos artigos, favorecendo a identificação de padrões e melhorando a qualidade da clusterização dos temas. Assim, apenas muito recentemente as ferramentas computacionais alcançaram um nível de maturidade que tornou viável realizar análises como a proposta neste trabalho.

Em paralelo aos desenvolvimentos técnicos, há também uma dimensão clínica que reforça a pertinência desta pesquisa. Como discutido na introdução, a história da medicina é marcada por ciclos de esperança e desilusão, frequentemente impulsionados por terapias que despertam grande expectativa antes de passarem por uma revisão crítica. Mapear as áreas onde esses discursos de “hype or hope” emergem pode, portanto, contribuir para reconhecer onde mais pesquisas são mais necessárias.

Por fim, os resultados dessa análise podem oferecer subsídios valiosos não apenas para pesquisadores, mas também para formuladores de políticas públicas e gestores de saúde, ao indicar quais áreas concentram maior contestação ou incerteza. Um mapa desse tipo pode funcionar como um instrumento de reflexão e de monitoramento do discurso médico, favorecendo uma prática científica mais consciente.

3 OBJETIVOS

3.1 OBJETIVO GERAL

Identificar os principais tópicos presentes no conjunto de artigos científicos que utilizam a expressão “hype or hope” na literatura médica, com o propósito de mapear as áreas que concentram maior contestação ou debate dentro da medicina contemporânea.

3.2 OBJETIVOS ESPECÍFICOS

1. Construir um corpus de análise, composto por artigos indexados na base PubMed do National Center for Biotechnology Information (NCBI), que contêm as palavras “hype” e “hope”.
2. Representar os textos processados em um espaço vetorial por meio da geração de *embeddings* capazes de refletir a similaridade semântica entre os documentos.
3. Realizar análise de clusterização sobre as representações vetoriais, com o intuito de identificar agrupamentos temáticos presentes no corpus.
4. Validar os clusters identificados, empregando revisão manual e análise de frequência de palavras-chave para verificar a coerência e a relevância dos temas resultantes.
5. Visualizar e interpretar os resultados por meio de dendrogramas, destacando as áreas médicas e as tecnologias mais frequentemente associadas a discursos de exagero ou de esperança.
6. Discutir as implicações metodológicas dos achados, destacando as potencialidades e as limitações do uso da modelagem de tópicos e de outras técnicas computacionais na análise de coleções de textos científicos.
7. Refletir sobre o significado dos resultados no contexto da medicina contemporânea, considerando como as tendências identificadas podem contribuir para a interpretação das áreas de maior debate.
8. Mapear lacunas de evidência e oportunidades de pesquisa, diagnosticando áreas em que a predominância de discursos de expectativa (“hype”) em relação a resultados concretos sinaliza a necessidade prioritária de estudos empíricos mais rigorosos.

4 MAPPING MEDICAL HYPES AND HOPES

4.1 INTRODUCTION

Throughout medical history, waves of optimism have often preceded critical appraisal. Practices once hailed as revolutionary later became cautionary tales about the fragility of medical certainty. This oscillation between optimism and skepticism continues to shape how the medical community interprets innovation. The contemporary lexicon for this tension is captured by the pairing “hype or hope”, a phrase that frequently appears in biomedical papers as a marker of scientific hesitation (Moynihan, 2006)

The question “hype or hope?” appears to act as a rhetorical signal of the field’s self-reflective stance toward innovation. It suggests uncertainty about whether an emerging technology represents genuine therapeutic progress or merely inflated expectations. To our knowledge, no study has applied a large-scale topic modeling approach to a corpus containing the terms “hype” and “hope” across the medical literature. This study aims to map contested medical treatments using that approach. What topics most often trigger this skeptical formulation? Which diseases and therapeutic domains are most prone to cycles of excitement and doubt?

Addressing these questions requires moving beyond traditional narrative or systematic reviews toward computational methods that can handle large textual corpora. Advances in Natural Language Processing (NLP) and machine learning now make it possible to examine text through a data-driven lens (Mikolov *et al.*, 2013), revealing collective patterns that emerge only when the literature is treated as a unified semantic landscape. In particular, topic modeling using vector-based text representations—commonly referred to as embeddings—enables researchers to identify latent structures and semantic clusters within extensive document collections.

In this study, we mapped the landscape of “hype or hope” discourse in the medical literature. We analyzed 422 PubMed-indexed articles containing both terms, integrating artificial intelligence techniques with human validation. This hybrid approach, pairing NLP with expert curation, enabled us to identify the diseases and treatments most frequently associated with contested medical claims.

By investigating the targets of “hype or hope” discourse, we aimed to identify the fault lines in contemporary medical debate: the areas where innovation meets uncertainty and where optimism may outpace empirical evidence. In constructing this map, we offer both a methodological contribution to computational text analysis in biomedical research and empirical insights into how medicine navigates its ongoing oscillation between therapeutic promise and scientific caution.

4.2 METHODS

We performed a systematic search in the PubMed database using the query hype AND hope[title/abstract], executed on April 22, 2025. This query was designed to capture the full range of rhetorical formulations pairing these terms—while “hype or hope” was the most common expression, variations such as “hope or hype”, “hype and hope”, and constructions separating the two words across different phrases were also present in the literature. The query returned 787 records that contained both the terms “hype” and “hope” in their titles or abstracts. We then applied exclusion criteria to remove duplicate entries and articles without an abstract, resulting in a final corpus of 422 unique articles, published between 1988 and 2025. Each article was subsequently subjected to a multi-stage analysis that combined Natural Language Processing (NLP) techniques with expert manual review.

The topic modeling began with the creation of embeddings from the original corpus of 422 articles, meaning it generated 422 embeddings, one for each article. We encoded the textual data using an embedding model developed by our group, as described in our previous work (Ieger-Raittz *et al.*, 2025). We then performed hierarchical clustering of the data using the neighbor-joining (NJ) method (Saitou; Nei, 1987). That procedure generated a dendrogram, which we visualized using ITOL (Interactive Tree Of Life)(Letunic; Bork, 2007). That allowed us to see the relationships between articles based on their semantic similarity.

After applying this pipeline to the original corpus (titles and abstracts), one of the main challenges was identifying the overarching medical treatments represented in the dataset. For instance, the article titled “Cannabinoids in glioblastoma multiforme—hype or hope?” (Doherty; Paula, 2021) exemplifies this difficulty. While we can interpret the title as having a therapeutic focus—cannabinoids as a potential treatment—the hierarchical clustering results revealed that the article’s closest neighbors were primarily defined by disease categories rather than by therapeutic modalities. As shown in the resulting dendrogram (see Figure 2, corresponding to branch 244 of the ATitAbs.tree file) (The tree files are available in the Supplementary Material), the 3 nearest neighbors to this article referred respectively to “immunotherapy and glioblastoma”, “malignant glioma”, and “immunotherapy and gastrointestinal malignancies”, none mentioning cannabinoids or similar terms. This pattern indicates that the bias captured by the clustering was predominantly oncological—that is, structured around disease type rather than treatment strategy.

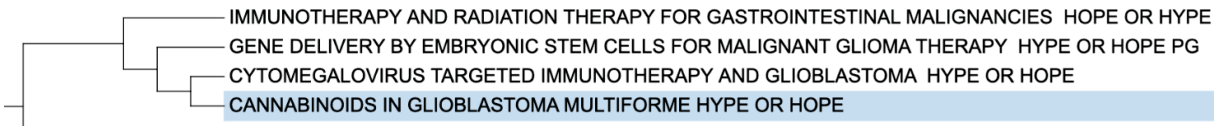

FIGURA 2 – Clustering on Original Corpus

4.2.1 LLM Dialectical Summarization

To address the disease-centric bias in the initial clustering, we implemented a dialectical summarization pipeline using an LLM. We processed each article through a four-stage pipeline (Figure 3). Stage 1 (hypothesis) presented the LLM with the original article and a prompt querying the specific treatment or technology described in hyperbolic or trending terms within the article. Stages 2 and 3 used the text that resulted from stage 1 and prompted the LLM to generate two complementary analytical perspectives: (2) a thesis articulating why the identified subject was believed to represent a promising or beneficial approach, and (3) an antithesis explaining why it might constitute mere hype or inflated expectations. Stage 4 (synthesis) presented the hypothesis and two opposing viewpoints to the LLM, prompting it to integrate them into a coherent summary.

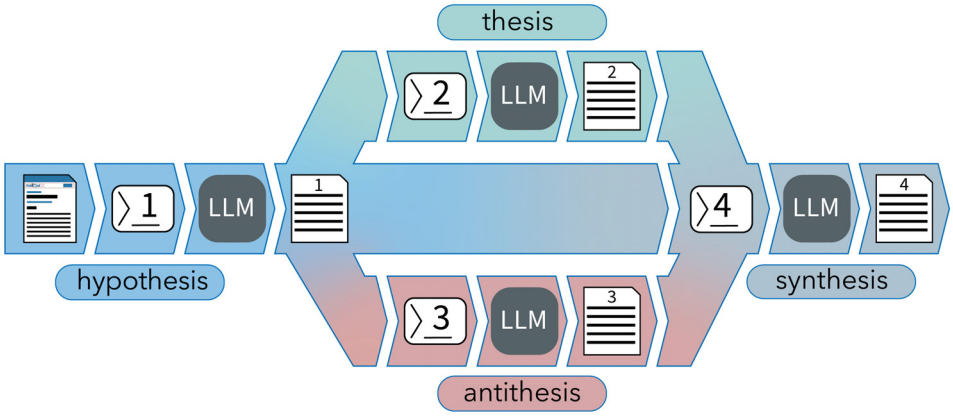

FIGURA 3 – LLM Dialectical Summarization Pipeline

This dialectical approach was applied to each one of the articles, resulting in 1,688 requests to the LLM, 4 prompts for each of 422 articles. The model we used was Google Gemini 2.5 [GeminiTeam2025], accessed via the API through our own script with our custom prompts.

After this Data Augmentation step, the clustering pattern shifted significantly. Looking back at our cannabinoid example, the nearest neighbors shifted toward cannabinoids or cannabidiol (CBD), as illustrated in Figure 4 (branch 107 of the AugTitAbs.tree file, available in the Supplementary Material), indicating a new focus on treatment rather than on the disease. This change exemplifies how the augmentation process enhanced

the treatment-focused semantic coherence of the clusters, aligning related concepts that had previously been dispersed across disease-based branches.

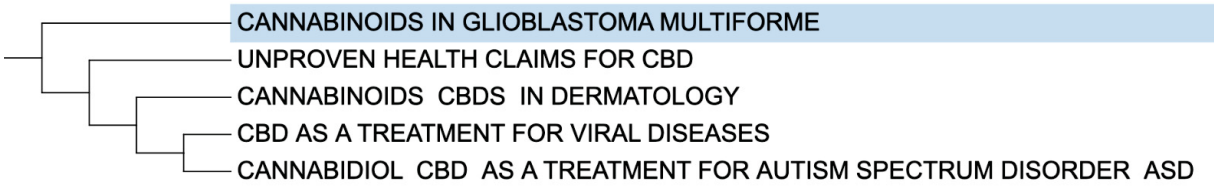

FIGURA 4 – Clustering After Text Augmentation

4.2.2 Topic Definition

The LLM dialectical summarization pipeline and the topic modeling approach provided a guide for human curation. Both dendrograms were manually analyzed. The one constructed from the original articles provided initial guidance for identifying disease topics, while the one constructed from the augmented texts informed the preliminary selection of treatment topics. To further support human-led exploration of the dataset, we employed the HTML-TM tool (HTML-based text mining) (Ieger-Raittz *et al.*, 2025), which provided an interactive environment for inspecting lexical patterns and document-level structures across the dataset. Based on these analyses, we curated 23 topics: 12 disease-related and 11 treatment-related. The full dendrograms and the HTML-TM files are available in the supplementary material.

While both the LLM pipeline and clustering analysis provided a valuable overview of the dataset, validation remained essential given the inherent limitations of both approaches. Large Language Models exhibit stochastic behavior, generating variable outputs even with identical inputs (Atil *et al.*, 2025), which affects reproducibility. Similarly, clustering algorithms pose interpretability challenges, as it may at times remain unclear which specific semantic features or linguistic patterns the algorithm prioritizes when grouping articles (Hu *et al.*, 2025). To address these limitations, we performed a traditional keyword search to validate and quantify the topics identified by the machine learning approach.

We used PubMed's MeSH (Medical Subject Headings) vocabulary as a guide to compile lists of representative keywords for each human-curated topic. We then used those keywords to search the original set of 422 abstracts to determine the frequency of each topic across the corpus. This keyword-driven approach allowed individual articles to be classified into multiple topic categories simultaneously, reflecting the fact that some articles may address more than one topic. Such multi-label classification would be difficult to achieve using clustering approaches exclusively, as hierarchical clustering assigns each article to a single branch of the dendrogram. Based on the frequency analyses, we generated two complementary sets of results: one focused on treatments

and the other on diseases. (The lists of keywords along with the script used to search the dataset are available in the supplementary material.)

4.2.3 Statistical Analysis

To evaluate whether topics in the “hype or hope” corpus were over- or under-represented relative to the broader biomedical literature, we conducted a hypergeometric enrichment analysis. Since the corpus was sampled from PubMed, this approach is well-suited for comparing topic prevalence in the study sample against the source database. The hypergeometric distribution estimates the probability of observing a given number of topic occurrences in a finite sample without replacement, allowing us to assess deviations from expected prevalence under random sampling.

For each topic, a compound Boolean query was constructed by combining all validated synonyms using the OR operator, with each term restricted to the title/abstract field. Queries were executed using the NCBI Entrez E-utilities API, and the total count of indexed articles matching each query was retrieved programmatically. The reference population consisted of the entire PubMed database, estimated at approximately 39,000,000 indexed articles at the time of analysis.

4.3 RESULTS

The analysis revealed substantial variation in the distribution of “hype or hope” articles across medical fields, with some showing markedly higher concentrations than others. This uneven pattern highlights areas where debates around innovation and therapeutic promise are more prevalent.

The two major categories of analysis, treatment-focused and disease-focused, capture distinct dimensions of the “hype or hope” discourse in medicine. The first encompasses debates surrounding specific therapeutic interventions, in which discussions assess the credibility, clinical impact, and potential overstatement of emerging treatments (TABELA 1). The second involves diseases that most frequently serve as contexts for contested innovations, highlighting areas where expectations for new therapies are especially concentrated (TABELA 2).

The keyword-based categorization successfully classified 69.7% of the corpus (294 of 422 articles) into treatment and disease categories. The categorized articles were distributed across three groups: treatment-only discussions (75 articles, 17.8%), disease-only discussions (115 articles, 27.3%), and articles covering both treatment and disease contexts (105 articles, 24.9%). The remaining 128 uncategorized articles (30.3%) represent discussions of broader medical topics—such as healthcare delivery systems and research methodologies—that did not fit the specific treatment or disease

framework used for categorization.

TABELA 1 – Treatment-Focused Results

Treatment	Enrichment	Corpus n (%)	PubMed n (%)	p-value
Liquid Biopsy	22.44×	7 (1.66%)	28,832 (0.07%)	4.15×10^{-8}
Stem Cell	12.96×	62 (14.69%)	442,029 (1.13%)	6.93×10^{-48}
Precision Medicine	9.16×	39 (9.24%)	393,462 (1.01%)	6.27×10^{-25}
Microbiome	7.73×	10 (2.37%)	119,542 (0.31%)	1.03×10^{-6}
Gene Therapy	6.66×	13 (3.08%)	180,441 (0.46%)	1.38×10^{-7}
Cannabis	5.95×	5 (1.18%)	77,674 (0.20%)	1.72×10^{-3}
Immunotherapy	5.57×	14 (3.32%)	232,425 (0.60%)	3.88×10^{-7}
Artificial Intelligence	4.31×	32 (7.58%)	686,780 (1.76%)	1.06×10^{-11}
Vitamins	4.16×	5 (1.18%)	111,170 (0.29%)	7.72×10^{-3}
Nanotechnology	3.68×	7 (1.66%)	175,994 (0.45%)	3.40×10^{-3}
Vaccines	1.21×	6 (1.42%)	458,872 (1.18%)	3.78×10^{-1}

TABELA 2 – Disease-Focused Results

Disease	Enrichment	Corpus n (%)	PubMed n (%)	p-value
Autism	4.76×	4 (0.95%)	77,713 (0.20%)	4.15×10^{-2}
Parkinson's disease	3.71×	16 (3.79%)	398,346 (1.02%)	1.04×10^{-5}
COVID-19	3.05×	19 (4.50%)	575,878 (1.48%)	2.41×10^{-5}
Schizophrenia	2.29×	5 (1.18%)	201,372 (0.52%)	6.97×10^{-2}
Hepatitis	2.27×	13 (3.08%)	528,881 (1.36%)	5.76×10^{-3}
Cardiovascular Disease	2.27×	48 (11.37%)	1,955,687 (5.01%)	1.54×10^{-7}
Epilepsy	2.24×	5 (1.18%)	206,445 (0.53%)	7.57×10^{-2}
Obesity	2.08×	12 (2.84%)	532,946 (1.37%)	1.47×10^{-2}
Alzheimer's disease	2.07×	10 (2.37%)	445,453 (1.14%)	2.50×10^{-2}
Cancer	2.05×	100 (23.70%)	4,514,904 (11.58%)	2.49×10^{-12}
Stroke	1.62×	9 (2.13%)	513,060 (1.32%)	1.09×10^{-1}
Diabetes	1.49×	24 (5.69%)	1,488,809 (3.82%)	3.61×10^{-2}

For each topic, we calculated: the expected count under the null hypothesis of no enrichment; fold enrichment, defined as the ratio of observed to expected counts, with values greater than 1 indicating overrepresentation; and a one-tailed p-value for enrichment using the hypergeometric survival function. With the exception of vaccines, schizophrenia, epilepsy, and stroke, which did not reach statistical significance ($p > 0.05$), all remaining topics demonstrated significant enrichment in the corpus relative to the broader PubMed literature.

Liquid biopsy exhibited the highest fold enrichment (22.44×), and stem cell therapies showed the second-highest (12.96×), in addition to being the most frequent topic by absolute count (62 articles). Among disease categories, autism had the highest fold enrichment (4.76×), and cancer, despite being the most frequent disease topic (100 articles, 23.7% of the corpus), showed only a modest fold enrichment of 2.05×.

4.4 DISCUSSION

The quantitative patterns observed in this study raise a fundamental interpretive question: what does it mean, in practical terms, for a medical topic to be overrepresented in the “hype or hope” literature? Measures such as frequency within the corpus and enrichment relative to the overall PubMed literature do not directly distinguish between justified optimism and exaggerated claims. Rather, they identify domains in which authors repeatedly feel compelled to qualify expectations, articulate uncertainty, or explicitly problematize emerging innovations. In this sense, the signals captured here reflect not a resolution of the “hype or hope” dichotomy, but its persistence across specific areas of biomedical research.

This interpretive challenge is compounded by the ambiguity of the term “hype” itself. In its colloquial usage, popularized by frameworks such as the Gartner Hype Cycle (Linden; Fenn *et al.*, 2003), hype denotes a phase of inflated attention—a surge of interest that may or may not correspond to substantive progress. Yet the etymological root of the word, derived from “hyperbole”, carries a stronger connotation: that of throwing beyond the mark and, by exceeding it, missing it altogether—of overstating what the evidence supports. Whether “hype” signals mere excitement or genuine exaggeration remains unresolved in most of the articles analyzed.

Recognizing these challenges, our methodological approach sought not to resolve the “hype or hope’ question for any given topic, but rather to map where these tensions concentrate most intensely. The LLM-based dialectical summarization pipeline proved essential to this endeavor. By altering the semantic organization of the corpus—shifting clustering patterns from disease-centered to treatment-centered groupings—the pipeline enabled us to identify the topics that proved most meaningful to the analysis we set out to do.

4.4.1 Over-represented Topics

The enrichment analysis revealed that treatment-related topics were substantially more overrepresented than disease-related topics. The mean fold enrichment for treatment categories (M = 9.07) was approximately 3.6 times greater than that observed for disease categories (M = 2.49), indicating that therapeutic and technological interventions receive disproportionate attention in the “hype or hope” corpus relative to their representation in the broader scientific literature. Furthermore, nearly all treatment topics (10/11, 91%) were statistically significant ($p < 0.05$), whereas only over half of disease topics (7/12, 58%) met this threshold.

Stem cell therapies showed a high enrichment (12.96×) and dominated in absolute volume, appearing in 62 articles (14.7% of the corpus). Further exploration

suggested possible reasons why stem cells might occupy such a central place in the "hype or hope" discourse. The term itself has come to signify two distinct realities: on one hand, established therapies such as hematopoietic stem cell transplants for blood cancers; on the other, the broad and largely unvalidated promise of regenerative medicine—regrowing organs, reversing neurodegeneration, curing chronic conditions. This semantic duality fuels confusion, and the term "stem cell tourism" encapsulates the dangers it entails. It refers to patients traveling abroad for unproven procedures, often marketed directly to vulnerable or desperate families.

Among other treatment topics, liquid biopsy, though appearing in only seven articles, exhibited the highest fold enrichment of any topic (22.44×), indicating that emerging technologies with transformative potential but limited clinical validation attract disproportionate scrutiny relative to their presence in the broader literature. Precision medicine and artificial intelligence reflect fields where expectations for transformative impact remain high, yet implementation is uneven—conditions that make them especially prone to "hype or hope" framings. Microbiome-based therapies, gene therapy, and immunotherapy similarly demonstrated substantial enrichment.

The disease-treatment co-occurrence matrix (Figure 5) reveals some interesting intersections between treatment and disease topics. Cannabis is particularly noteworthy, reflecting the convergence of scientific uncertainty, regulatory flux, and cultural controversy. Its presence in the corpus connects to cancer through the cannabinoid–glioblastoma example discussed in the Methods section, and to autism through the article "Cannabidiol for the treatment of autism spectrum disorder: hope or hype?" (Pedrazzi *et al.*, 2022).

Autism and cancer illustrate contrasting dynamics around the disease topics. Autism, despite appearing in relatively few articles, was the most enriched disease topic, the only one to exceed the 4× enrichment threshold. Cancer, by contrast, was the most frequent disease topic (100 articles, 23.7% of the corpus) but showed a modest 2.05× enrichment. This contrast may point to qualitatively different dynamics underlying their presence in the "hype or hope" discourse. While cancer's prominence appears driven by sheer volume and sustained research attention, autism's over-representation might stem partly from ongoing debates about the diagnostic category itself. Some researchers have questioned the neurobiological coherence of autism spectrum disorder, arguing that "ASD diagnosis lacks biological and construct validit" (Waterhouse *et al.*, 2016). This foundational uncertainty—about whether autism constitutes a unified clinical entity—could amplify the "hype or hope" framing around any proposed intervention.

Another notable data point present in the co-occurrence matrix was the intersection between autism and stem cell. Regarding the discussion above about stem cell tourism, it's worth noting that some clinics do indeed advertise stem cell therapy for

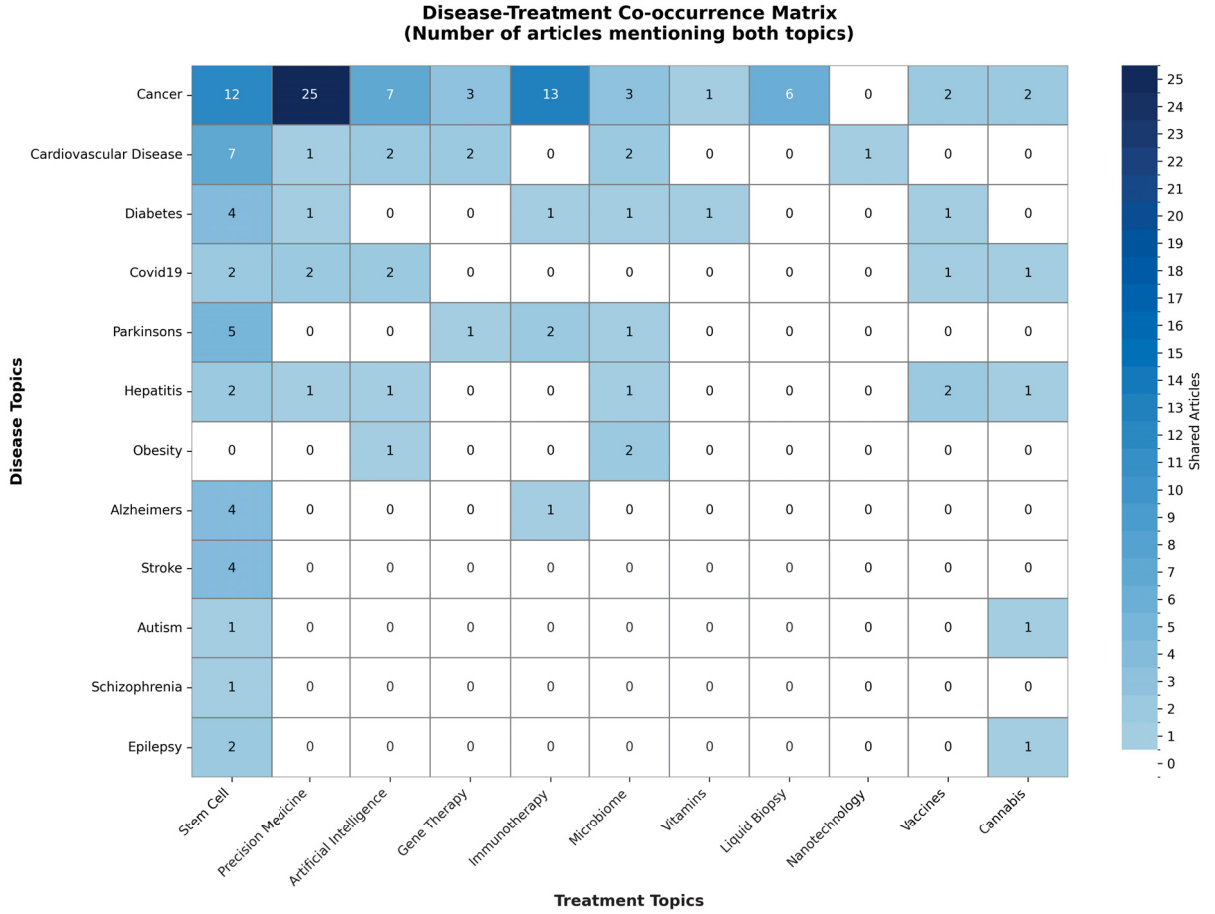

FIGURA 5 – Disease-Treatment Co-occurrence Matrix *Note:* The co-occurrence matrix illustrates the intersection between disease and treatment topics within the corpus. The matrix captures article-level co-occurrences rather than unique article counts, which may produce apparent discrepancies with total topic frequencies. A single article addressing multiple diseases will contribute multiple entries to the matrix, whereas articles discussing a disease without reference to any tracked treatment modality will not appear in the matrix at all.

autism. This pairing exemplifies how the “hype or hope” discourse can intensify when diagnostic uncertainty meets therapeutic speculation—each amplifying the other and potentially exposing patients to unproven interventions.

4.5 CONCLUSION

For researchers, the emergence of “hype or hope” rhetoric around a treatment signals the need for closer empirical scrutiny and methodological rigor. For clinicians, awareness of these rhetorical dynamics may support more transparent communication with patients about experimental therapies. For policymakers, understanding the mechanisms of hype can help balance optimism for innovation with the imperative to maintain safety, efficacy, and public trust.

Ultimately, the “hype or hope” discourse reflects not merely isolated cases of exaggeration but a structural tension within biomedicine—between aspiration and evidence, innovation and restraint. Recognizing these patterns demands intellectual humility: the acknowledgment that our methods, however rigorous, offer partial views rather than definitive answers.

4.5.1 Limitations and Future Research

These findings should be interpreted with caution. As indicated by Ioannidis (2005), biomedical research is particularly vulnerable to systematic distortions arising from methodological choices, selective emphasis, and interpretive flexibility, even when analyses are quantitatively rigorous. The present findings should not be read as definitive mappings but as reflections of how our analytical decisions—from corpus construction and topic definition to the choice of embedding model, clustering approach, and LLM—shaped the patterns that emerged. Each of these choices admits numerous viable alternatives, and different methodological paths might reasonably have led to different, yet internally consistent, representations of the same literature. Furthermore, our corpus, limited to PubMed abstracts containing both terms “hype” and “hope” and comprising 422 articles, captures only a fraction of the broader biomedical conversation, which may constrain the generalizability of our findings.

Future research could expand this approach by incorporating additional data, perhaps exploring other linguistic markers beyond the specific pairing “hype” and “hope”. Additionally, integrating real-time monitoring of media outlets and social media platforms could support the development of a “hypemetrics” tool: a system capable of tracking how emerging biomedical topics gain or lose momentum—functioning like a dashboard that displays the volume of media excitement alongside the accumulation of clinical trial data, flagging when the two diverge. Such a tool would not presume to deliver a final verdict on what constitutes hype or hope, but rather to help us map the uncertain terrain between expectation and evidence. If science is, at its core, the disciplined pursuit of truth, then tools that illuminate where evidence falters and speculation fills the gap serve not as judges but as guides—orienting us toward the questions that most urgently demand honest inquiry.

Finally, we’d like to stress that framing an area as “hype or hope” does not imply that it is dominated by ineffective or inappropriate solutions. Rather, it suggests that some recently introduced technologies or approaches in that field may not yet have accumulated sufficient evidence to establish their clinical utility, without calling into question the validity or effectiveness of existing, well-established treatments.

5 CONSIDERAÇÕES FINAIS

À luz desses resultados, torna-se claro que o discurso “hype or hope” funciona como uma janela privilegiada para compreender como expectativas, incertezas e controvérsias se organizam na ciência médica — sobretudo quando a esperança assume papel central na forma como tecnologias emergentes são percebidas, avaliadas e buscadas. Mais do que apontar casos isolados de otimismo excessivo ou ceticismo, o mapeamento realizado revela padrões estruturais que moldam a circulação de ideias, a distribuição de atenção científica e a maneira como determinadas tecnologias e doenças passam a ser enquadradas como promessas ou alertas. Assim, as considerações finais que seguem retomam alguns desses achados com o objetivo de discutir suas implicações para a pesquisa e para a prática clínica.

Entre os diversos relatos que ilustram o debate contemporâneo sobre terapias com células-tronco, destaca-se o caso apresentado por Charles E. Murdoch e Christopher Thomas Scott no artigo “Stem Cell Tourism and the Power of Hope”, publicado em The American Journal of Bioethics (2010)(Murdoch; Scott, 2010). O estudo discute o fenômeno denominado stem cell tourism, isto é, o deslocamento de pacientes para países onde terapias com células-tronco são oferecidas comercialmente, fora de protocolos clínicos regulados. Nesse contexto, a trajetória de Richard, um estudante universitário e engenheiro diagnosticado com Doença de Machado-Joseph (MJD), é descrita como um exemplo representativo das tensões éticas e científicas que caracterizam esse campo.

A MJD é uma ataxia hereditária e progressiva, marcada por deterioração motora e comprometimentos neurológicos cumulativos. No caso de Richard, a condição apresentava também um componente familiar: seu pai havia sido acometido pela mesma enfermidade, e o paciente era pai de uma criança pequena, o que conferia à doença uma dimensão intergeracional. Esse aspecto ampliava o sentido de urgência associado à busca por terapias emergentes, na medida em que envolvia não apenas a expectativa de benefício individual, mas também preocupações com o futuro familiar.

Diante da inexistência de terapias comprovadas, Richard recorreu a fóruns e comunidades virtuais de pacientes, onde obteve informações sobre clínicas estrangeiras que ofereciam procedimentos com células-tronco mediante pagamento. Após consulta com familiares e profissionais de saúde, optou por viajar para a China, onde se submeteu a três injeções de células-tronco derivadas de cordão umbilical na medula espinhal, complementadas por sessões de fisioterapia e acupuntura.

Segundo o relato documentado por Murdoch e Scott (2010)(Murdoch; Scott,

2010), o hospital que o recebeu oferecia um protocolo padronizado, aplicável a múltiplas condições clínicas, caracterizado pelo próprio paciente como um modelo "*one size fits all*" - "abordagem que serve para todos". Antes da viagem, Richard solicitou a seu neurologista que realizasse avaliações motoras pré e pós-tratamento, com o objetivo de estabelecer um parâmetro comparativo mínimo. Após dois anos, não foram observadas melhoras clínicas mensuráveis, tampouco efeitos adversos relevantes. Ainda assim, Richard declarou não se arrepender da decisão, justificando-a como uma tentativa legítima diante da ausência de alternativas terapêuticas e da incerteza quanto à progressão da doença.

Para os autores, o caso de Richard evidencia a complexa interseção entre a prudência metodológica da medicina baseada em evidências e as dinâmicas psicossociais que orientam o comportamento do paciente em situações de vulnerabilidade. A decisão de buscar tratamento fora dos canais científicos convencionais não se reduz a um ato de desinformação, mas reflete a influência de fatores como a esperança e necessidade de agência diante da limitação terapêutica. Essa interpretação converge com a análise de Jerome Groopman em The Anatomy of Hope: How People Prevail in the Face of Illness (2004)(Groopman, 2004), para quem a esperança exerce um papel fisiológico e psicológico mensurável no enfrentamento da doença.

Nessa perspectiva, a experiência de Richard ilustra o que Groopman denomina "the vital role of hope" - "o papel vital da esperança", isto é, o papel funcional da esperança como elemento modulador da resposta clínica e emocional. Ainda que o tratamento não tenha produzido benefícios objetivos, a decisão de agir constituiu, segundo essa leitura, uma forma de manutenção da agência e de enfrentamento racional da incerteza.

Diante da inexistência de terapias comprovadas e da impossibilidade de participação em ensaios clínicos, a decisão de Richard adquire um caráter emblemático da condição em que se encontram inúmeros pacientes afetados por doenças raras e degenerativas: situados entre a urgência da progressão da doença e os limites temporais da validação científica. Essa lacuna ressoa com a expressão frequentemente reiterada nos textos biomédicos: "more research is needed" - "mais pesquisas são necessárias", que funciona como um marcador discursivo de suspensão — um modo de afirmar o potencial da inovação enquanto se adia a consolidação do conhecimento científico.

Nesse contexto, a presente pesquisa visa contribuir para o mapeamento das áreas da medicina em que a demanda por mais pesquisas é mais recorrente, revelando onde a distância entre promessa e evidência se mostra particularmente significativa.

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APÊNDICE 1 – KEYWORDS

TABELA 3 – Keywords used for treatment categorization

Treatment Category	**Keywords**
Stem Cell	stem cell, stem cells, embryonic stem, mesenchymal stem, induced pluripotent, iPSC, hematopoietic stem, regenerative medicine, cellular therapy, cell therapy, stem cell therapy, stem cell treatment
Precision Medicine	precision medicine, personalized medicine, individualized medicine, pharmacogenomics, biomarker, genomic medicine, targeted therapy, companion diagnostics, molecular profiling
Artificial Intelligence	artificial intelligence, machine learning, deep learning, AI, neural network, algorithm, automated diagnosis, computer-aided, digital health, health informatics
Immunotherapy	immunotherapy, checkpoint inhibitor, CAR-T, monoclonal antibody, immune checkpoint, PD-1, PD-L1, CTLA-4, cancer immunotherapy, adoptive cell therapy
Microbiome	microbiome, microbiota, probiotics, gut bacteria, fecal transplant, dysbiosis, microbial, bacterial therapy, microflora
Gene Therapy	gene therapy, genetic therapy, gene editing, CRISPR, gene transfer, viral vector, adeno-associated virus, lentivirus, genetic modification, transgene
Liquid Biopsy	liquid biopsy, liquid biopsies, circulating DNA, cell-free DNA, ctDNA, circulating tumor cells, CTC, blood-based biomarker
Nanotechnology	nanotechnology, nanoparticle, nanomedicine, nanocarrier, targeted nanoparticles, drug delivery system, nano-drug delivery
Vaccines	vaccine, vaccination, immunization, prophylactic vaccine, therapeutic vaccine, mRNA vaccine, viral vector vaccine
Vitamins	vitamin D, vitamin C, vitamin supplementation, antioxidant, nutraceutical, dietary supplement, multivitamin, micronutrient
Cannabis	cannabis, marijuana, CBD, cannabidiol, THC, medical marijuana, cannabinoid, hemp, cannabis therapy
Complementary and Alternative Medicine	complementary medicine, alternative medicine, CAM, integrative medicine, herbal medicine, traditional medicine, naturopathic, homeopathy, acupuncture

TABELA 4 – Keywords used for disease categorization

Disease Category	**Keywords**
Cancer	cancer, tumor, tumour, oncology, malignancy, carcinoma, sarcoma, leukemia, lymphoma, metastasis, chemotherapy, radiation therapy, neoplasm, glioblastoma
Cardiovascular Disease	cardiovascular disease, heart disease, cardiac, heart failure, myocardial infarction, coronary artery disease, atherosclerosis, hypertension, arrhythmia
Diabetes	diabetes, diabetic, insulin, glucose, glycemic, hyperglycemia, type 1 diabetes, type 2 diabetes, diabetic complications
COVID-19	COVID-19, SARS-CoV-2, coronavirus, pandemic, COVID, viral infection, respiratory illness
Parkinson's Disease	Parkinson, Parkinson's disease, dopamine, movement disorder, neurodegenerative, bradykinesia, tremor
Hepatitis	hepatitis, liver disease, hepatitis B, hepatitis C, hepatocellular carcinoma, cirrhosis, liver fibrosis
Obesity	obesity, overweight, bariatric, weight loss, metabolic syndrome, BMI, body mass index, adiposity
Alzheimer's Disease	Alzheimer, Alzheimer's disease, dementia, cognitive decline, amyloid, tau protein, neurodegeneration
Stroke	stroke, cerebrovascular, ischemic stroke, hemorrhagic stroke, brain injury, cerebral infarction
Autism	autism, autistic, ASD, autism spectrum disorder, neurodevelopmental, social communication
Schizophrenia	schizophrenia, psychosis, antipsychotic, psychiatric disorder, mental illness, dopamine receptor
Epilepsy	epilepsy, seizure, convulsion, anticonvulsant, antiepileptic, status epilepticus, refractory epilepsy

APÊNDICE 2 – DENDROGRAMAS

2.1 TITLES + ABSTRACTS


PSYCHIATRIC DIAGNOSIS AND TREATMENT IN THE 21ST CENTURY PARADIGM SHIFTS VERSUS INCREMENTAL INTEGRATION
INTERNET AND MEDIA ASSISTED THERAPY
CREATING CRITICAL CONSUMERS OF HEALTH AND SCIENCE NEWS TEACHING SCIENCE TO THE NON SCIENTIST USING NEWSWORTHY TOPICS IN THE LIFE SCIENCES
AN ANALYSIS OF NEWSPAPER REPORTS OF CANCER BREAKTHROUGHS HOPE OR HYPE
GENETIC OPTIMISM FRAMING GENES AND MENTAL ILLNESS IN THE NEWS
VOXEL BASED MORPHOMETRY FROM HYPE TO HOPE A STUDY ON HIPPOCAMPAL ATROPHY IN MESIAL TEMPORAL LOBE EPILEPSY
ADULT NEUROGENESIS MENTAL HEALTH AND MENTAL ILLNESS HOPE OR HYPE
THE REALITY OF DENTAL CAD CAM HYPE OR HOPE
HOW SHOULD PHYSICIANS HELP PATIENTS UNDERSTAND UNKNOWNS OF NANOPARTICLE BASED MEDICINES
ZERO PARTY DATA BETWEEN HYPE AND HOPE
MANAGING CANCER PATIENTS EXPECTATIONS AMID HOPE AND HYPE
HOPE OR HYPE IN THE TREATMENT OF SCHIZOPHRENIA WHAT S THE ROLE OF THE PHYSICIAN
HOPE VERSUS HYPE WHAT CAN ADDITIVE MANUFACTURING REALISTICALLY OFFER TRAUMA ANDORTHOPEDIC SURGERY
THE MARCH COMING TOGETHER TO CONQUER CANCERTRADE MARK
MUSINGS ON MANAGEMENT TEN IDEAS DESIGNED TO RILE EVERYONE WHO CARES ABOUT MANAGEMENT
THE IMPACT AND INFLUENCE OF HOPE AND HYPE IN DECISION MAKING ABOUT HEALTH TECHNOLOGIES
BETWEEN HYPE AND HOPE WHAT IS REALLY AT STAKE WITH PERSONALIZED MEDICINE
THE ROLE OF PHILOSOPHY AND ETHICS AT THE EDGES OF MEDICINE
GREAT FUTURE OR GREEDY VENTURE PRECISION MEDICINE NEEDS PHILOSOPHY
THE MIND AND THE MACHINE ON THE CONCEPTUAL AND MORAL IMPLICATIONS OF BRAIN MACHINE INTERACTION
NEUROSCIENCE AND NANOTECHNOLOGIES IN JAPAN BEYOND THE HOPE AND HYPE OF CONVERGING TECHNOLOGIES
NEUROFEEDBACK IN THE WORKPLACE FROM NEUROREHABILITATION HOPE TO NEUROLEADERSHIPHYPE
NAMING IT NANO EXPERT VIEWS ON NANO TERMINOLOGY IN INFORMED CONSENT FORMS OFFIRST IN HUMAN NANOMEDICINE TRIALS
A CONSUMER PERSPECTIVE ON INFORMED CONSENT AND THIRD PARTY ISSUES
THE HOPE AND THE HYPE OF ORGANOID RESEARCH
PUBLIC PERCEPTIONS AND EXPECTATIONS DISENTANGLING THE HOPE AND HYPE OF ORGANOID RESEARCH
IN DEFENCE OF MACHINE LEARNING DEBUNKING THE MYTHS OF ARTIFICIAL INTELLIGENCE PG 734 747
MISINFORMATION IN AND ABOUT SCIENCE
HUMAN MICROBIOME MYTHS AND MISCONCEPTIONS
HOPE AND HYPERBOLE THE RHETORIC AND REALITY OF MANAGERIAL REFORM IN HEALTH CARE PG 62 4
FORECASTING SCIENCE FUTURES LEGITIMISING HOPE AND CALMING FEARS IN THE EMBRYOSTEM CELL DEBATE
THE BIO FICTION FILM FESTIVAL SENSING HOW A DEBATE ABOUT SYNTHETIC BIOLOGY MIGHTEVOLVE
THE DAO OF HUMAN CLONING UTOPIAN DYSTOPIAN HYPE IN THE BRITISH PRESS AND POPULARFILMS
CROOK PIPETTES EMBRYONIC EMIGRATIONS FROM AGRICULTURE TO REPRODUCTIVE BIOMEDICINE
CONSIDERATIONS INTO PHARMACOGENOMICS OF COVID 19 PHARMACOTHERAPY HOPE HYPE AND REALITY
DRUG DESIGN FOR EVER FROM HYPE TO HOPE
FALLING GIANTS AND THE RISE OF GENE EDITING ETHICS PRIVATE INTERESTS AND THE PUBLIC GOOD
NEUROMARKETING THE HOPE AND HYPE OF NEUROIMAGING IN BUSINESS
GUIDELINES EDITORS PHARMA AND THE BIOLOGICAL PARADIGM SHIFT
CORPORATE SOCIAL RESPONSIBILITY AND THE TOBACCO INDUSTRY HOPE OR HYPE
INFORMATION AND COMMUNICATION TECHNOLOGY IN CARDIOVASCULAR DISEASE PREVENTION IN DEVELOPING COUNTRIES HYPE AND HOPE REPORT OF THE INTERNATIONAL COLLABORATION ON INFORMATION USE IN CARDIOVASCULAR HEALTH PROMOTION IN DEVELOPING COUNTRIES
VIRTUAL REALITY IN PEDIATRIC CARDIOLOGY HYPE OR HOPE FOR THE FUTURE
PRECISION MEDICINE HYPE OR HOPE
ADVANCED THERAPIES AND REGULATORY FRAMEWORK IN DIFFERENT AREAS OF THE GLOBE PAST PRESENT AND FUTURE
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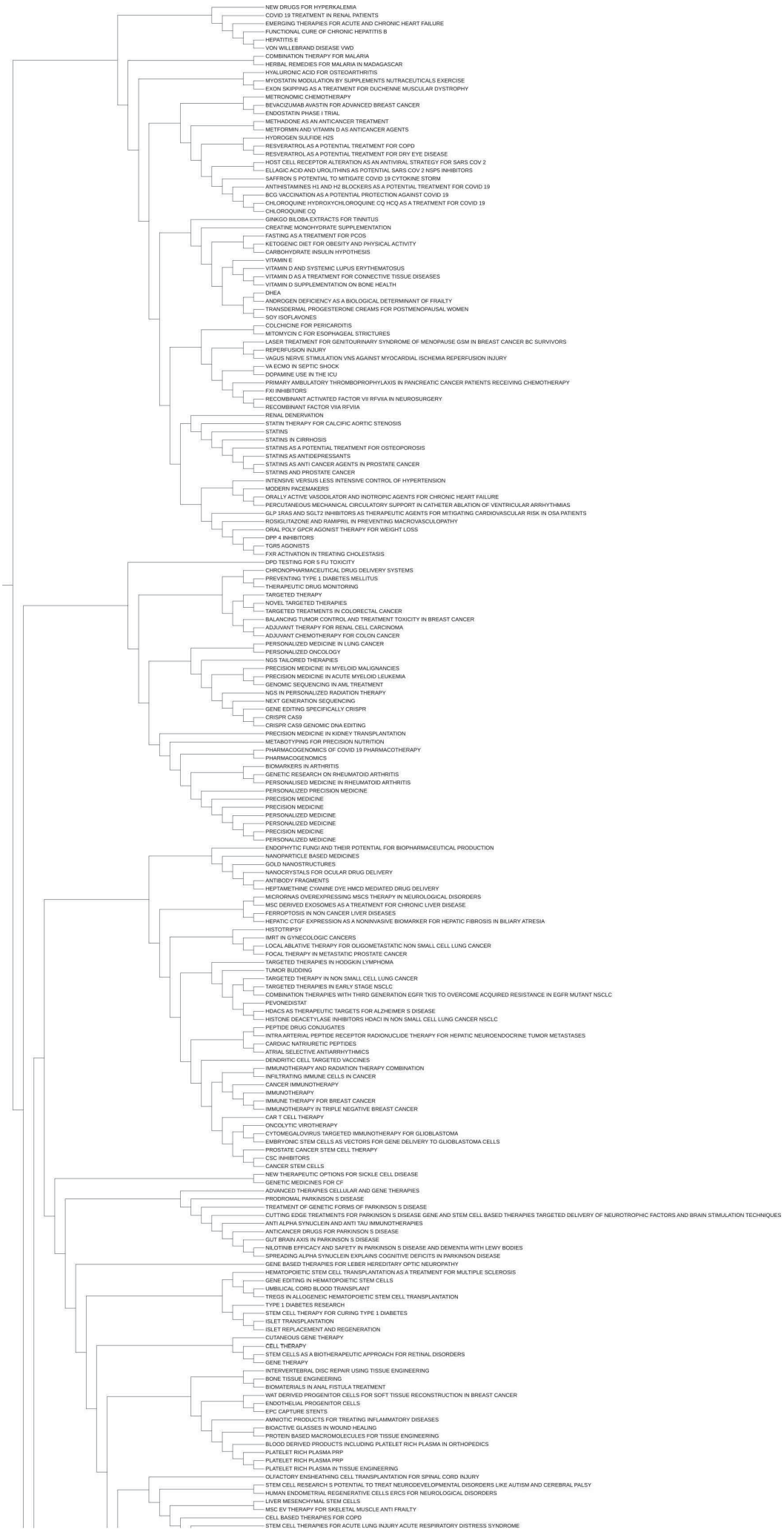
2.2 AUGMENTED TEXTS


NEW DRUGS FOR HYPERKALEMIA
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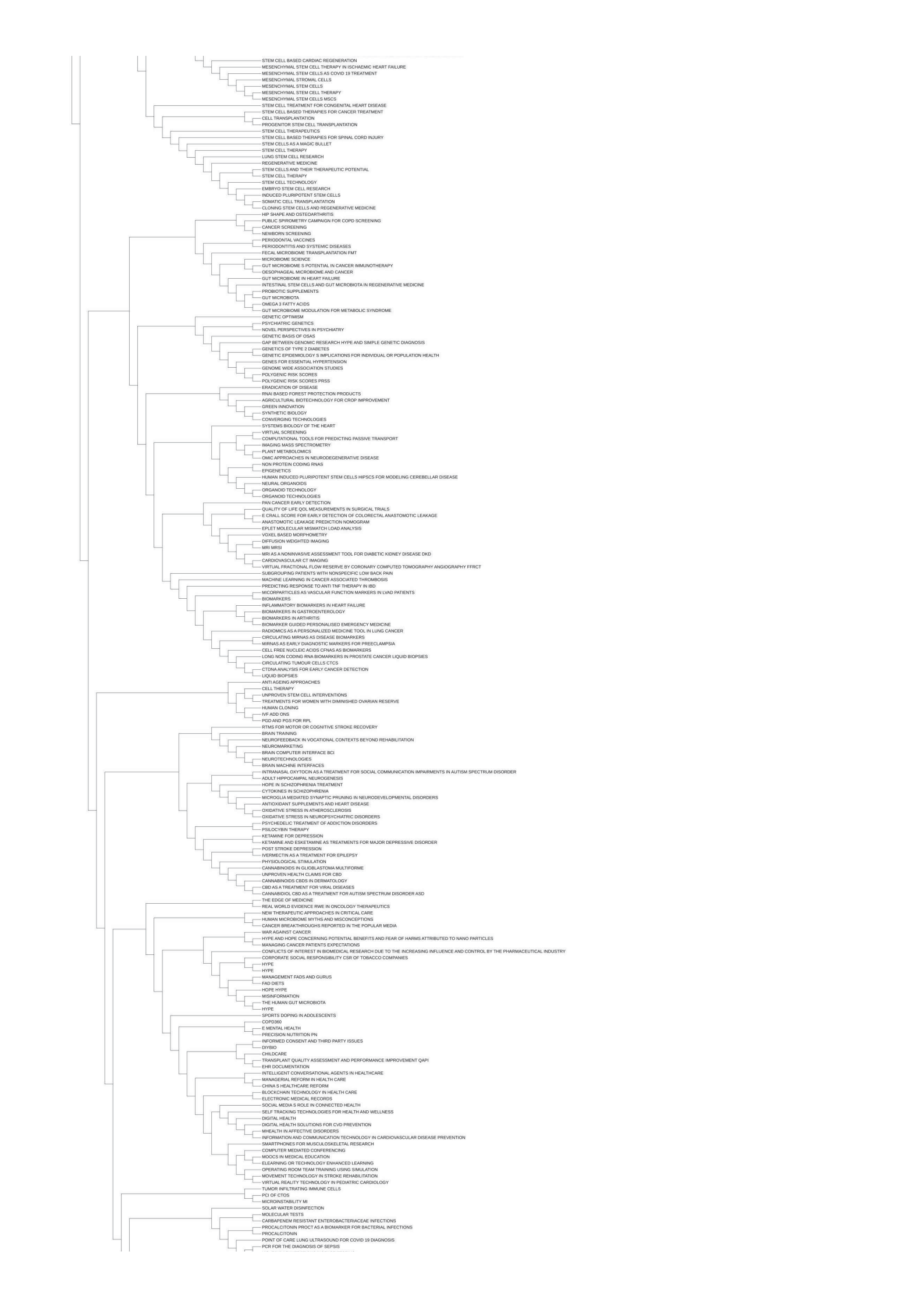
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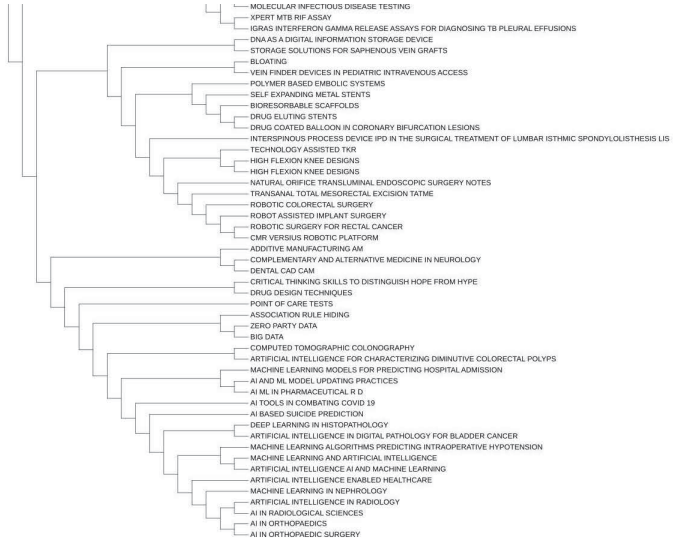
MOLECULAR INFECTIOUS DISEASE TESTING
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HIGH FLEXION KNEE DESIGNS
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MACHINE LEARNING IN NEPHROLOGY
ARTIFICIAL INTELLIGENCE IN RADIOLOGY
AI IN RADIOLOGICAL SCIENCES
AI IN ORTHOPAEDICS
AI IN ORTHOPAEDIC SURGERY