Original Article

Natural language processing in Mining Electronic Health records for Cancer insights

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Abstract

A data-driven revolution has been made possible by the digitization of healthcare through the use of Electronic Health Records (EHRs), which provide a comprehensive database of patient information. Natural language processing (NLP) has the potential to completely transform cancer treatment through this treasure trove of data. The significant influence of NLP on EHR mining for cancer insights is examined in this abstract. NLP is the connecting thread between machine comprehension and the unstructured narratives found in EHRs. NLP serves as a catalyst for converting qualitative data into useful insights, from automating data extraction to revealing hidden patterns in clinical records. By using an iterative process, the standard of cancer care is continuously improved by taking into account practical observations. But there are issues that need to be resolved, like data privacy, medical terminology standardization, and the requirement for big, varied datasets. To overcome these obstacles and realize the full promise of natural language processing (NLP) in cancer treatment, cooperation between stakeholders including data scientists, medical experts, and policymakers is essential. Research found that there is a plethora of opportunities ahead for the integration of NLP and EHRs in the search for cancer insights. NLP's incorporation into cancer care represents a promising new chapter in the history of healthcare as we find ourselves at the crossroads of technology and medicine. a day when each cancer patient receives timely, tailored interventions that are based on knowledge gained from the massive quantity of electronic health data. NLP has the potential to be a revolutionary force that changes the oncology landscape and enhances the lives of cancer patients by ongoing cooperation, innovation, and a dedication to moral data practices.

Keywords:

Natural Language Processing (NLP), Mining Electronic Health records (MEHR), Cancer Insights (CI).

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Introduction

The terms "Natural language processing" can be explained in these words "It is a kind of technology advancement in which a computer program can understand the language of human as it is in vocal or written form". This natural language processing technology is also abbreviated as NLP.

This has become a main component of artificial intelligence [1]. The electronic health data record, also abbreviated EHR, is mainly the electronic version of the medical history of patients, which is managed and maintained by the physician at the time of treatment, and it contains all the important data and information related to that person, including medication, administration, demographics, and others [2]. The advent of electronic health records (EHRs) has brought about a transformation in the healthcare industry, leading to the digital storage of massive volumes of patient data. In addition to streamlining administrative procedures, this digital revolution creates previously unheard-of potential for gaining insightful data that will enhance patient care. The use of natural language processing (NLP) to mine electronic health records (EHRs) for insights about cancer, a disease that still presents enormous problems to the worldwide healthcare community, is one of this field's most promising areas. A paradigm change from traditional paper-based record-keeping to extensive, digital warehouses of patient data was brought about by the introduction of EHRs [3].

Numerous pieces of information are contained in these records, such as clinical notes, diagnosis results, demographics of the patient, and medical history. However, utilizing this data to the fullest extent possible for clinical decision-making and research is extremely difficult due to its unstructured nature and massive volume [4].

There are many benefits of electronic health records such as improved quality of care by physicians, improved efficiency of treatment, boosted engagement of patients during treatment, reduced chances of medication errors, enhanced security of data, increased chances for data accessibility, it saving money for treatment. The technology of natural language processing can be used in Healthcare departments in different ways[5]. It will help physicians to identify the presence or absence of specific types of medical conditions or symptoms. This technology helps to recognize different negated words such as likely, and unlikely. These negated words can help to understand the condition or symptoms of diseases. Some advancements in natural language processing will help to promote the use of electronic data records for better treatment of cancer. The mining of electronic data records can be more helpful than other means of records because these electronic data records contain legal health information, it also contains prescriptions, and it also contains details of office visits of patients for treatment by physicians[6]. When these types of records are maintained by electronic data management, these data can be retrieved by using natural language processing. It can help the computer to visualize and analyze data from electronic data records for better treatment of patients. The common data mining techniques that are used mainly are sentiment analysis, named entity recognition, text summary, topic modeling, keyword extraction, and others. For example, sentimental analysis is related to the analysis of emotions with the help of analyzing data to know whether emotion is related to positive conditions or negative conditions[7].

The goal of the artificial intelligence (AI) field of natural language processing is to enable machines to comprehend and interpret human language. NLP is a potent tool in the setting of EHRs, helping to extract the nuances from textual data and turn it into organized, useful insights. NLP has the potential to reveal hidden trends, patterns, and correlations in the massive body of electronic health data related to cancer. The basic tenet of the journey is that language is a vehicle for complex, nuanced information. Numerous sources, including clinical notes, pathology reports, radiological findings, and physician narratives, contain important information regarding a patient's cancer journey. But significant information extraction from these unstructured tales demands a comprehension level above the capabilities of conventional computer systems. NLP fills in this gap by bridging the understanding gap between machine

learning and human language. This sentimental analysis can be effectively used in Healthcare centers to know about the feelings and perceptions of patients concerning physicians that can help in the effective treatment of cancer. This sentimental analysis can be based on feedback, too. For example, if a patient says that he is feeling less pain as compared to before, it shows that treatment is effective for the patient[8]. This sentimental analysis can help determine the nature of emotion, whether it is positive, negative, or neutral. The other technique of natural language processing is named entity recognition which is abbreviated as NER which can be used to detect important components and elements from interested texts, given documents, mentioned slides, and videos [9]. As regards cancer treatment, proper data on patients is very necessary to understand the mental and physical condition of that patient[10]. Financial and demographic conditions should also be known. These electronic data records are developed for these reasons to maintain all the health records of that patient during and after treatment. Moreover, a single electronic data record can be used in multiple hospitals so there is no need for extra tests or initiation of procedures for treatment. The mining from electronic data records is also mandatory many times in Healthcare centers for records of specific patients during treatment[11]. Natural language processing is helpful for mining electronic data records for Cancer insights. Sometimes, the treatment of cancer is prolonged and painful. During this duration of treatment, sometimes a patient would not be able to describe his condition verbally in the form of words. At that point, natural language processing is helpful to convert the negated words into proper text that can help to understand the mental condition of patients that will in return help in the effective treatment of cancer[12]. The important technique used in natural language processing is keyword extraction, which helps physicians to understand the words from verbally ill patients. Although electronic data records have many benefits, as described before. However, there are some challenges for electronic data records; for example, some patients feel reluctant to provide information because of widespread insecurity related to data loss. The use of social media has tremendously increased day by day but the trust of people in social media has been lost because of many factors such as leakage of sensitive data, data loss, hacking of data, misuse of data, blackmailing of patients, and others[13]. When it comes to cancer and EHRs, data extraction is the main goal of natural language processing. Envision the clinical history of a patient integrated into an EHR narrative, complete with information on the development of symptoms, course of the disease, reaction to therapy, and unsatisfactory outcomes. With a degree of efficiency that outperforms manual techniques, NLP algorithms may be trained to sort through this textual treasure trove, finding and extracting pertinent information. Healthcare providers

can save a lot of time and money by automating this procedure, which frees them up to concentrate more on patient care and less on data entry. An extension of NLP is text mining, which is a subset of the analysis. It entails going through unstructured text and looking for hidden trends, correlations, and patterns. Text mining can be used in the context of cancer insights to analyze clinical notes and find patterns in symptom descriptions, themes that repeat in treatment outcomes, and even minute details in doctor observations that could be diagnostically significant [14].

The capacity to convert qualitative data into quantitative data allows for the exploration of new areas of cancer knowledge. The other challenge related to electronic data recording is that it needs proper skill for maintaining and mining of data records, and this skill learning takes time and effort. Although it is an achievement of artificial intelligence, it is decreasing reliance on human beings and increasing reliance on computers that can be harmful shortly because of the dominance of artificial intelligence. If all these challenges related to electronic data records are coped up6, then electronic data records can be proved helpful as compared to paperwork because they can store data for a long time without fear of data loss if properly managed. Along this, natural language processing can be proven effective shortly to understanding negated words, to understand mental health issues, and the emotional level of patients, these aspects will help physicians related to patients for effective treatment of cancer. This study has effectively described the natural language processing role in the Mining of electronic data records for the treatment of cancer [15].

There are many benefits of artificial intelligence in our life and natural language processing is one of these benefits[16]. NLP's expertise is also evident in the field of predictive analytics. NLP algorithms can find patterns and correlations in past EHR data analysis that could pass the human eye by. These systems have the ability to evaluate incoming patient data, match it with the most recent research results, and promptly offer recommendations to medical practitioners. For example, the clinical decision support system can notify physicians immediately if a new study indicates a better course of treatment for a particular subtype of cancer, ensuring that the most recent information is incorporated into patient care plans.

This flexible and adaptable method has the power to greatly improve the standard of cancer treatment. Furthermore, building strong NLP models requires a vast and diverse dataset. To address these obstacles, cooperation between data scientists, regulatory agencies, and healthcare organizations is crucial. Creating a collaborative culture, adhering to privacy laws, and standardizing data sharing protocols are essential to maximizing the application of natural language

processing in the field of oncology.

Research objective

The main objective of this study is to understand natural language processing and the role of natural language processing in Mining Electronic Health records for Cancer insights. This study gave us an idea about natural language processing which can help in Mining Electronic Health records for the treatment of cancer that can be proven effective in the near future if properly managed for the time being. Natural language processing has been proven an important achievement of artificial intelligence.

Literature Review

Natural Language Processing in Mining Electronic Health Records for Cancer Insights

Cancer is one of the chronic diseases that leads to the people's death if not detected at early age. For this purpose, the clinicians have used the various types of the screenings which best settle to the health of the patients. Screening tests are recommended for patients who have high risks. Natural Language processing (NLP) is used to extract clinical insights from the Electronic Health Record (EHR). Natural Language processing is the computer's ability to understand the human language as it is being spoken and written. It is the part of the Artificial Intelligence (AI) working as the smart devices[17].It deepened its roots in linguistics, and it has existed for more than 50 years. Natural Language Processing (NLP) helps the computers to understand the human language as other people's do. It may be in the form of spoken or written language, it uses the Artificial Intelligence (AI) in order to take the notes of the real-life input[18].For the detection of the urinary tract infection, the Natural Processing language (NLP) acts as the surveillance for data analyses. It helps in collecting the data in the form of the clinical notes, for that purpose manual notes and scripts are not required[19].

In the past decades, the storage of the medical information in digital form created a boom in the medical industry. It was mainly developed to maintain the billing processes of the patients, but with time, it was converted for applications in various medical information[20].The natural processing language is the other form of the Artificial Intelligence for efficiently storing the medical history for the clinicians to fetch it at any stage of the Patient's Medical treatment. It is contingent to develop the data mining and data warehouses that stores a lot of data in systematic form[21]. Another significant achievement is the incorporation of NLP into clinical trials and cancer research. Finding qualified candidates for clinical trials has always required a lot of effort and resources. NLP can speed up this process by comparing patient profiles to the requirements for trial eligibility. This improves the

generalizability of research findings by expediting participant recruiting and guaranteeing a representative and varied sample in clinical trials [22]. The goal of improving the quality of cancer care is a continuous process, and NLP is essential to this effort. Healthcare organizations can find chances to improve patient outcomes, areas for improvement, and adherence to guidelines by doing a more thorough analysis of EHRs. Because of this data-driven approach, clinical practices may be continuously improved, giving healthcare providers the knowledge and tools they need to give the best possible treatment. However, there are obstacles in the way of using NLP to mine EHRs in the context of cancer. Concerns about data security and privacy are significant, requiring strict precautions to safeguard private patient data. Another challenge is standardizing medical terminology, as differences in language and vocabulary between various healthcare systems might make it difficult to apply NLP algorithms effectively. Since 1995, the information extraction from the electronic health record has been highly increased. The processes start from the preprocessing, leading it to the detection and analysis and developed a decision making in the useful form[23].Computations techniques have been employed by the Natural language processing for learning and understanding the human language content. It was basically developed for linguistics as a structure of language, but with time, it has been inculcated in the medical fields. In today's world, such system has been refined and has created new contents and tools in real life applications, Peech to speech translation system, spoken dialogue and data mining for information in the health and finance sectors[24]. As the humans have sensors, same as the computer have developed programs to read and audio through microphones. Humans have brain for the processing of the inputs, computers have the programs for processing the respective inputs. The input has been converted into the codes which computer can understand. There is abundant of knowledge available for the natural language processing but the presence of the wisdom in the computer is the basic hurdle in implementation[25]. Natural Processing language is the approach to analyze the computations and text based on the set of theories and technologies. It was basically developed to fetch the human like decision from the data set for making it useful for the clinicians. Naturally occurring text may be of many kinds and in any language etc. It may be used to communicate to one another whether it is in any type of the language[26]. The technology brings in the human like features in the computer for making it intelligent. Artificial Intelligence helps in creating and developing the computer software's that are helpful in generating the subset of the human like intelligence. It cultivates a lot of fruits if the computers are made able to understand the human languages[27]. Natural Processing languages has enabled the computer to understand one of the major languages of the humans such as English, Russian and Chinese. The input may be in the form of text or spoken language. The process of imputing the data may be classified and changed into learning and understanding the human language[28]. There are two phases of natural language processing: one is data preprocessing, and the second one is Algorithm development. In the data preprocessing, data has been cleaned to make it able to analyze the data. It helps in putting the data in meaningful form and highlight the features in the text[29]. For the patients of the Cancers, there is the need to develop the proper planning and coordinating the patterns in the treatments with desired results to be attained in the future [30].

The Natural language processing has developed the defined electronic records and maintain the structured clinical notes to identify the treatments of the cancer patients[31]. With the increasing information on the internet and in real world, it is difficult for the researchers to extract and find the useful information for the best use. For providing the solutions, the machine learning based natural Processing language has been developed. The treatment of breast cancer has been highly focused on as it has become the main stream disease for women in the world. High level of mortalities has been observed due to the breast cancer or lack of the ability to learn and predict the cause of cancer[32]. The convergence in the data is due to the data mining in Natural Language Processing (NLP). It helps in extracting the data for the cancer initiation points, its progression, and treatment responses. These phenotypes have been extracted from the Natural Language Processing (NLP) source. There is increase at an exponential rate in oncology. In the United States, electronic medical records have increased significantly in the past few years[33]. The precise form of the phenotype information is needed to develop the genetics and the epigenetics changes on the cancer tumors and responsiveness. Extractions of the cancer phenotypes are mainly performed manually; genomic data has been made to correlate the data mining[34]. Natural Language Processing (NLP) uses the detailed form of the textual data to maintain the electronic medical records to help maintain the patient's care[35]. That's a really interesting point where technology and healthcare meet! When searching for cancer-related insights in electronic health records (EHRs), natural language processing (NLP) might be extremely important. To enable computers to extract useful information from the massive amount of unstructured data in EHRs, it entails educating them to comprehend and analyze human language [36].

NLP is beneficial in various ways

1. Data Extraction: NLP algorithms are capable of navigating EHRs and extracting pertinent data, including treatment specifics, medical history, and patient demographics.

2.Text mining: By using natural language processing

(NLP) to analyze unstructured clinical notes, pathology reports, and radiology reports, important information regarding cancer types, stages, and treatment outcomes can be gleaned.

3. Predictive Analytics: NLP can help forecast patient outcomes by examining past EHR data. This can be useful in seeing trends and determining which medicines could work better for certain kinds of cancer.

4. Clinical Decision Support: By supplying up-to-date information and suggestions based on patient data and the most recent research, NLP integration into clinical decision support systems can help medical personnel.

5.Research and Clinical Trials: By comparing patient profiles to trial eligibility requirements, natural language processing (NLP) helps expedite identifying potential participants for clinical trials.

6.Quality Improvement: NLP analysis of EHRs can be used to pinpoint areas where cancer care can be made better, including patient follow-up, early detection procedures, and adherence to guidelines.

Table 1: Correlations

		Natural language processing 1	Natural Language Processing 2	Natural language processing 3	Mining Electronic Health 1	Mining Electronic Health 2	Mining Electronic Health 3
Natural Language Processing 1	Pearson Correlation	1	-.444[**]	-.112	-.150	.065	-.231
	Sig. (2-tailed)		.001	.439	.300	.656	.107
	N	50	50	50	50	50	50
Natural Language Processing 2	Pearson Correlation	-.444[**]	1	.413[**]	.348[*]	-.195	-.113
	Sig. (2-tailed)	.001		.003	.013	.174	.434
	N	50	50	50	50	50	50
Natural language processing 3	Pearson Correlation	-.112	.413[**]	1	.115	-.219	-.308[*]
	Sig. (2-tailed)	.439	.003		.428	.127	.029
	N	50	50	50	50	50	50
Mining Electronic Health 1	Pearson Correlation	-.150	.348[*]	.115	1	-.050	-.356[*]
	Sig. (2-tailed)	.300	.013	.428		.733	.011
	N	50	50	50	50	50	50
Mining Electronic Health 2	Pearson Correlation	.065	-.195	-.219	-.050	1	.101
	Sig. (2-tailed)	.656	.174	.127	.733		.487
	N	50	50	50	50	50	50
Mining Electronic Health 3	Pearson Correlation	-.231	-.113	-.308[*]	-.356[*]	.101	1
	Sig. (2-tailed)	.107	.434	.029	.011	.487	
	N	50	50	50	50	50	50

**. Correlation is significant at the 0.01 level (2-tailed)

*. Correlation is significant at the 0.05 level (2-tailed)

The above result describes that the correlation coefficient results present Pearson correlation values, the significant value, and the number of observation of each indicator. The mining electronic health 1,2 shows that 0.065, -0.050, and 0.101 show some negative and positive correlation between them. the overall significant value is 10%, 11% indicates a significant relation between the mining electronic health and natural language processing.

Clustered 3-D Bar of Mining Electronic Health 1 by Natural language processing 1 by Mining Electronic Health 3...
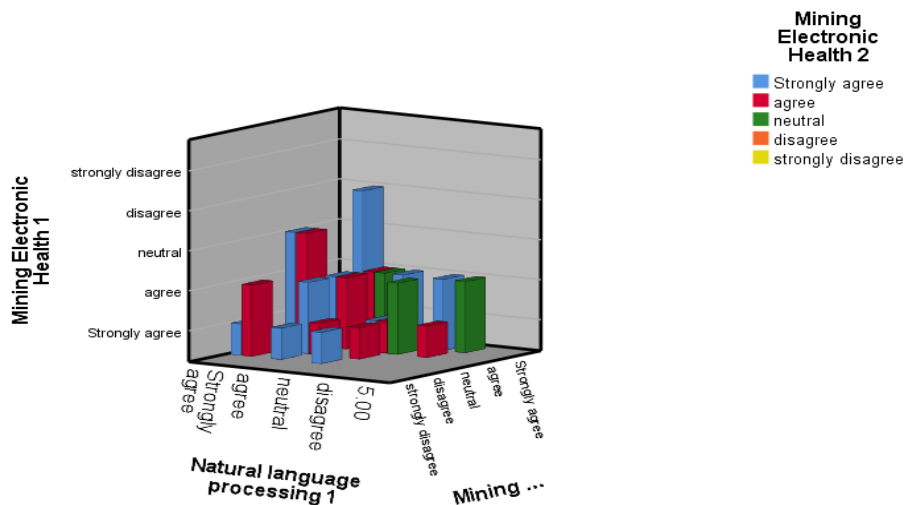

Figure 1

The above graph present that clustered 3-D bar related to the mining electronic health one by natural language. The blue bar line current that they strongly agree, the red line shows that decide level, the yellow bar line present that strongly disagree between them. A specialized area of natural language processing called text mining digs into unstructured clinical narratives to reveal subtle information about the course of cancer, the effectiveness of treatment, and doctor observations. NLP-enabled predictive analytics adds a future-focused aspect to cancer treatment. NLP algorithms can forecast patient outcomes by identifying trends and correlations in past data, which enables individualized treatment strategies and raises prognostic accuracy overall. This prediction power could change the way oncologists handle treating unique patient cases.

Clinical decision support systems incorporating natural language processing (NLP) provide cancer care with real-time response. These systems provide timely and pertinent information to healthcare providers by continuously comparing incoming data to the most recent study findings. This guarantees that treatment plans are regularly updated with the most recent information, promoting a flexible and dynamic approach to patient care. NLP plays a critical part in clinical trials and cancer research. NLP guarantees the inclusion of various patient populations in clinical trials and speeds up identifying qualified patients. This promotes the inclusivity and generalizability of research findings in addition to hastening the creation of novel treatments. Cancer care quality improvement is continuous, and NLP offers a data-driven navigational tool for this voyage. Healthcare organizations can find areas for improvement, chances to improve patient outcomes, and adherence to guidelines by doing a more thorough analysis of EHRs.

Conclusion

In summary, the combination of NLP with EHRs in the search for cancer insights is a frontier full of opportunities. NLP provides a comprehensive method for resolving the complexity of cancer care, ranging from data extraction and text mining to predictive analytics and clinical decision support. The integration of natural language processing (NLP) into healthcare ecosystems can usher in a new era of personalized, data-driven cancer, where every patient receives the correct care at the right time as technology continues to develop and collaboration deepens. In conclusion, a revolutionary route in the field of cancer care has been shown by integrating Natural Language Processing (NLP) with Electronic Health Records (EHRs). By utilizing the rich information contained within the enormous databases of patient information, this dynamic synergy can completely transform our understanding, diagnosis, and treatment of cancer. The first step in the trip is realizing that language is a powerful tool for profound understanding. NLP acts as a link between machine

comprehension and the complex stories found in EHRs. NLP frees medical personnel from the arduous tasks of manual information retrieval by automating data extraction, freeing them up to concentrate on delivering the best possible care for their patients. NLP's specialized field of text mining advances the study by revealing hidden links and patterns in unstructured clinical notes. This capacity provides a deeper understanding of cancer progression, treatment outcomes, and clinician observations by converting qualitative data into quantitative insights that may be put into action. NLP-enabled predictive analytics adds a future-focused aspect to cancer treatment. NLP algorithms can forecast patient outcomes by identifying trends and correlations in past data, which enables individualized treatment strategies and raises predictive accuracy overall. This prediction power could change the way oncologists handle treating unique patient cases. Clinical decision support systems that incorporate natural language processing (NLP) provide cancer care with real-time response. These systems provide timely and pertinent information to healthcare providers by continuously comparing incoming data to the most recent study findings. This guarantees that treatment plans are updated with the most recent information on a regular basis, promoting a flexible and dynamic approach to patient care. NLP plays a critical part in clinical trials and cancer research. NLP guarantees the inclusion of various patient populations in clinical trials and speeds up identifying qualified patients. This promotes the inclusivity and generalizability of research findings and hastening the creation of novel treatments.

Cancer care quality improvement is continuous, and NLP offers a data-driven navigational tool for this voyage. Healthcare organizations can find areas for improvement, chances to improve patient outcomes, and adherence to guidelines by doing a more thorough analysis of EHRs. Using an iterative process, the standard of cancer care is continuously improved by considering practical observations. This promising environment is with difficulties, though. Stakeholders in the healthcare, technological, and regulatory spheres must work together in response to privacy issues, the need for huge, diverse datasets, and the standardization of medical language.

To overcome these obstacles and realize the full potential of natural language processing (NLP) in cancer care, cooperation and developing strong standards for data sharing and privacy protection are essential. NLP's incorporation into cancer care represents a promising new chapter in the history of healthcare as we find ourselves at the crossroads of technology and medicine. a day when each cancer patient receives timely, tailored interventions that are based on knowledge gained from the enormous amount of electronic health data. NLP has the potential to be a revolutionary force that changes the oncology landscape and enhances the lives of cancer patients through ongoing cooperation, innovation, and a

dedication to moral data practices.

Recommendations and future research

Building on the revolutionary potential of Natural Language Processing (NLP) in extracting cancer insights from Electronic Health Records (EHRs), several suggestions are made to advance this junction towards real-world application and broad influence:

- Encourage cooperation between legislators, healthcare providers, and data scientists. Understanding the complexities of healthcare practices, ethical issues, and technological breakthroughs requires an interdisciplinary approach.

- Push for uniformity in medical language used in all healthcare systems. Uniformity and precision in data extraction are ensured by the smooth application of NLP algorithms made possible by consistent language and coding systems.

- Create strong mechanisms for data governance and privacy protection. It is crucial to protect patient information's privacy and security. Respect for moral principles and observance of data privacy laws are unavoidable.

- Set aside funds for the improvement and expansion of the technology infrastructure. This entails making computing resource investments, upgrading EHR systems to be NLP-friendly, and assisting with the integration of NLP into already-existing healthcare IT frameworks.

- Establish training and education initiatives for medical staff. Give them the information and abilities necessary to comprehend, interpret, and work together with NLP technologies efficiently. This determination makes the shift to incorporating NLP into routine clinical workflows easier.

- Give patient involvement top priority and acquire informed consent before using EHR data for NLP applications. Building trust and maintaining ethical data practices require open communication with patients about the reason for and possible advantages of using their data.

- Push for legislative measures that protect patient rights and promote innovation. Work with regulatory organizations to create precise guidelines for the moral and appropriate application of NLP in healthcare, ensuring that developments comply with accepted norms.

- Encourage the gathering of long-term data. Cancer is a dynamic illness with a wide range of course options. A more thorough understanding of the course of the disease, the effectiveness of treatment, and the long-term results is made possible by the collection of longitudinal data.

- Establish methods for ongoing assessment for NLP applications in the medical field. Create feedback loops involving data scientists, end users, and healthcare professionals to address biases, improve algorithms, and guarantee that NLP models continue to improve.

Promote international cooperation and information exchange. NLP in healthcare offers both opportunities and challenges that are universal. Global collaboration can accelerate development, encourage creativity, and guarantee that knowledge is not restricted to specific geographical areas. Stakeholders can navigate the complexities of this transformative journey by incorporating these recommendations into the strategic roadmap for integrating NLP into mining EHRs for cancer insights. To make NLP a potent ally in the fight against cancer and benefit patients, healthcare providers, and the larger healthcare ecosystem, the ultimate goal is to ethically and responsibly use technology.

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