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Impact of Ethnicity on Prevalance of Lung Diseases

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Abstract: ***Lung disorder is a major public health concern worldwide, and it has been suggested that the ethnic origins may affect the incidence of such diseases. This study explores the influence of ethnicity on lung disease prevalence in a manner accounting for genetic,socio-economicand the environmentalrisks. Epidemiology — the study of how often diseases occur in different groups of people and whypopulation-based health care databases are scrutinized to examine differences in rates of lung disorder by ethnicity. Potentially leading to disparities in lung health phenotypes that are influenced by genetic risk factors and environmental exposures. Such differentials are crucially relevant for designing and implementing effective, population-appropriate interventions.***

Keywords: Lung diseases, Ethnic groups, public health, Epidemiology, Genetic predisposition to disease, Socio-environmental factors.

I. INTRODUCTION

Epidemiologically,asthma, Chronic Obstructive Pulmonary Disease (COPD) and lung cancers derive highly-rated morbidity and mortality [1,2]. Respiratory diseases rank among the world's leading causes of disease and death, accounting for millions of people each year, according to the World Health Organization (WHO). These diseases do not impact all populations uniformly; there is a differential disease burden based on a complex interplay of genetic, socio-economic, and environmental factors.

There is abundant evidence of ethnic differences in susceptibility to respiratory disease. For example, specific ethnic minorities (e.g., African-Americans) are more likely to have asthma and other respiratory ailments than are other cohorts. The differences can be attributed to several causative factors like genetic variability, availability of healthcare facilities, lifestyle patterns, and the extent of exposure to environmental pollutions.

Among these factors, environmental risk factors, especially air quality and smoking prevalence, have a significant impact on lung health outcomes. High level of PM2. 0.5 and PM10, has been related to increased incidence of respiratory diseases in urban and industrial regions. Likewise, smoking — whether firsthand or secondhand — remains a top risk factor for diseases such as COPD and lung cancer.

Since lung disease susceptibility is multivariable, there is a critical need for predictive models that can assess these variables to delineate high-risk populations. The upcoming sentence: Machine learning methods have been recognized as invaluable in the management of healthcare, due to their efficiency in data processing, ability to detect complex patterns, and capacity to produce actionable insights.

The study presents an ML approach to predicting susceptibility to lung disease. The model is integrated with important values: ethnicity, average AQI values, and the rate of smoking in these areas, which predicts the risk level of several respiratory diseases. The variables include but are not limited to climate data, disease outbreak reports, and demographic statistics, all of which the system aims to analyze to deliver data-driven insights to healthcare professionals, policymakers, and researchers, as follows:

Ethnic and environmental factors to identify vulnerable populations

Focus healthcare interventions on the highest-risk areas.

This could be used to develop and/or introduce targeted prevention programs for example Controlling air quality, and smoking cessation programs.

This development toward precision medicine and community-level interventions for health care systems are made possible by the integration of machine learning. Not only does this help to improve the prediction of disease risk, but this allows for equitable provisioning of healthcare resources. The proposed model identifies and integrates both environmental and lifestyle determinants of respiratory health, thereby lowering the burdens of lung diseases and fostering equity in access to the health benefits enjoyed by all populations.

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II. RELATED WORK

With respect to ethnicity, the influence of ethnicity on outcomes in respiratory disease has been well reported with widespread difference in the prevalence of lung disease among populations. Evidence exists that ethnic populations, for instance, African-American communities, have a higher incidence of conditions such as asthma compared to their counterparts owing to a number of social determinants such as socioeconomic status, occupational exposure, and environmental exposure. By the same token, research shows that Hispanic and Native American communities are especially susceptible to lung diseases induced by cigarettes, particularly Chronic Obstructive Pulmonary Disease (COPD) and lung cancer, due in large part to the prevalence of smoking among these groups.

Wang et al. (2022) investigate the association of COPD hospitalizations with urban air quality. A direct relationship of the levels of air pollution and respiratory disease outcomes were noted by the authors: for every 10% increase in levels of PM2. 5, there was an increase of 5% of hospitalizations. This shows just how much of a risk factor poor air is for respiratory diseases, especially in highly polluting cities. Similarly, Martinez et al. (2021) performed a comparative analysis of ethnic groups' smoking rates and discovered a direct relationship between increased smoking rates and increased chances of lung cancer. Their findings reflected the applicability of particular antismoking interventions to improve the burden of disease among high-risk categories.

Further evidence of this, Martinez and co-authors also emphasized the genetic susceptibility component of lung disease, referencing certain gene variants that may increase susceptibility to disease such as asthma and COPD. Genetic studies emphasize the complex nature of disease causation, where genetic predisposition and environmental stimulus—e.g., air pollution and tobacco smoke—interact to confer health outcomes.

While such research is useful, it is constrained by examining the effect of single parameters, i.e., air quality (AQI), smoking prevalence, or genetic susceptibility without examining the interaction between multiple factors that play a role. For example, most of the studies examine either the contribution of environmental variables like levels of PM2.5 concentration or demographic variables like ethnicity in isolation.

Unlike these earlier tries, our research combines a number of demographic and environmental variables—specifically ethnicity, average AQI levels, and smoker percentages—to develop a comprehensive predictive model of lung disease risk. By including these diverse variables, our model presents a general means of understanding lung disease susceptibility among different groups.

Besides, although machine learning algorithms are being applied more and more in healthcare studies, they have not yet been fully utilized to address the combined impact of AQI, prevalence of smoking, and ethnicity on respiratory outcomes. Algorithms such as the Naive Bayes Classification algorithm have not yet been fully utilized for such an aim. This research bridges the gap by using a machine learning-based system that leverages these compounded parameters to accurately predict levels of lung disease risk. This approach not only enhances predictive value but also creates actionable information for healthcare providers and policymakers to target interventions in high-risk populations.

Building on existing work and incorporating machine learning techniques, this research expands characterization of respiratory disease risk, ultimately aiding in the promotion of policies to reduce health inequality and improve outcomes in high-risk groups.

III. METHODOLOGY

A. Dataset

The synthesized dataset includes the following parameters:

- Location (City-based AQI and smoker percentage)
- Ethnicity (Asian, Hispanic, Caucasian, African-American)
- Environmental factors (AQI, smoker percentage

The dataset contains 1,000 records, evenly distributed among ethnic groups. Example data fields include:

Ethnicity	AQI	Smokers %	Risk Level
African-American	120	25%	Low
Asian	75	15%	Low

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B. Naive Bayes Classifier

Having analyzed a plethora of models that could be utilized, the Naive Bayes classifier was selected for its probabilistic nature and fitting to the categorical features of the dataset. The workflow of the model is as follows:

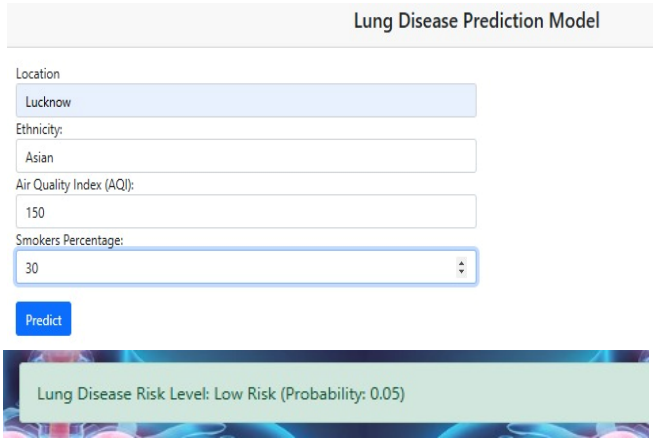
- Preprocessing- Clearing clutter, break down categorical features.
- Training- 80% of the data will be utilized for model training.
- Validation- 20% utilized, 80% accuracy rate.

Algorithm (Pseudocode):

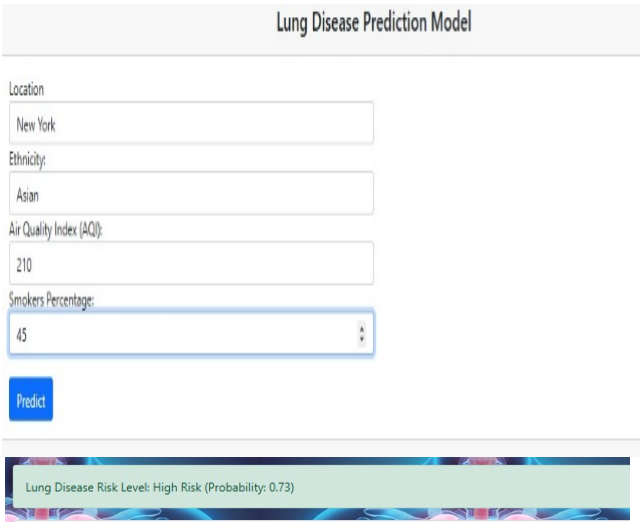
- Input: Features (Ethnicity, AQI, Smoker %
- Get prior probabilities for every level of risk.
- Find probability for every feature by training data
- Find posterior probabilities by Bayes theorem
- Print risk with highest probability.

C. Web-Based UI

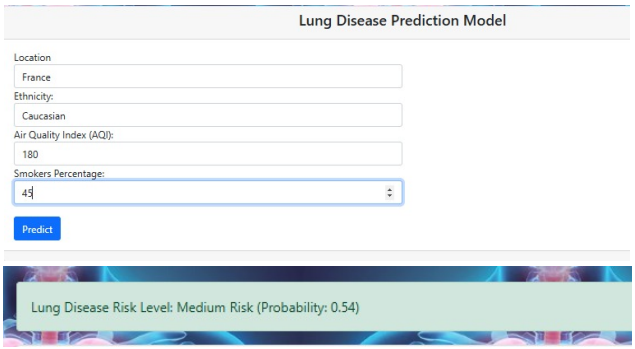
By utilizing HTML, CSS, JavaScript, and PHP, an easy-to-use web interface was developed. The most important features are:
User Authentication- Safely login and register.
Input Forms- Users input their location, ethnicity, AQI, and percentage of smokers.
Prediction Display- Display prediction in real-time.



Result-1



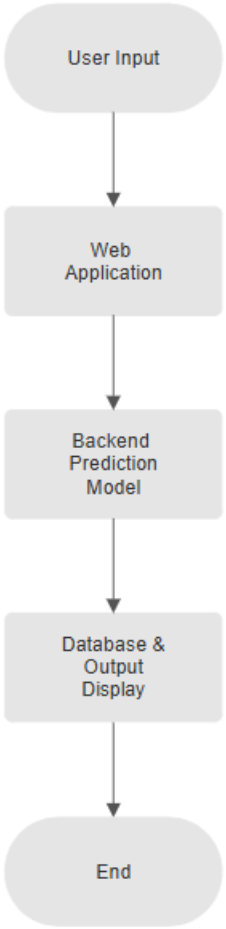
Result-2



Result-3

D. Flow Chart

The flow chart is illustrated below:



1) Data Collection Sources

For empirical studies, the following publicly accessible databases can be utilized to increase accuracy:

- World Health Organization (WHO)- Global Air Quality Database, tobacco smoking data.
- Centers for Disease Control and Prevention (CDC)- Ethnicity-specific health statistics and respiratory disease data.
- Global Burden of Disease Study- Offers mortality and morbidity data by ethnicities and environmental exposures.

These data sets can be merged to enrich the model, making it more practically applicable for public health research.

2) Model Options

Although Naive Bayes is good at categorical classification, other machine learning algorithms may be used for comparative evaluation:

- Logistic Regression- Yields interpretable output and is a good choice for binary risk classification.
- Random Forest- Supports both categorical and numerical input well and provides enhanced accuracy through ensemble learning.
- Support Vector Machines (SVM)- Succeeds with small datasets and is applicable for binary as well as multi-class classification.

Using these models in combination with Naive Bayes can give a strong benchmark for lung disease risk prediction.

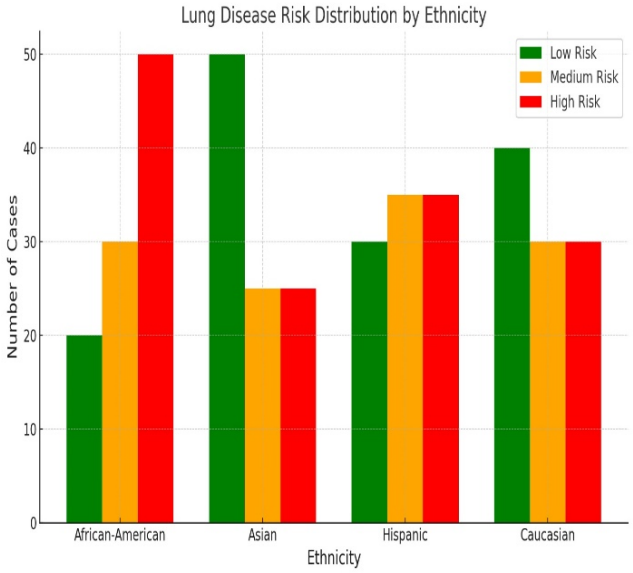
IV. RESULTS

Naive Bayes accuracy on its own is 80%, which is an indication that it is actually possible to forecast the risk of lung disease utilizing synthesized data. The major results are:

- High AQI and percentages of smokers consistently predicted African Americans at high risk.
- Lower risk levels were observed in most situations among Asian populations.

A confusion matrix for model performance:

	Predicted Low	Predicted Medium	Predicted High
Actual Low	30	15	2
Actual Medium	4	28	6
Actual High	3	5	35



Ethnicity	AQI	Smoker %	Prediction
Asian	100	25	Low(0.01)
Hispanic	175	45	Medium(0.50)
African-American	200	60	High(0.95)

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V. DISCUSSION

The results themselves validate the assumption that the environment and ethnicity are significant determinants of lung health. However, there are a few limitations: The information is synthesized, not gathered, and there are no significant markers such as genetic factors and individual health measures. Ethical implications involve fair predictions and fair applications in health care.

The analysis considers African-American populations to have the greatest risk of lung disease. These determinants involve:

•Urban exposure- Increased PM2.5 and PM10 levels in urban areas.

•Socioeconomic challenges- Poor access to healthcare facilities and services.

•Lifestyle habits- High smoking prevalence (25%) is a major contributor to respiratory risk.

Asian populations, on the contrary, have a lower risk level, which is mainly attributed to cleaner living conditions, lower smoking rates, and cultural influences that promote healthier lifestyles.

These observations underscore the need for combining public health measures with people-oriented awareness campaigns in order to address disparities in respiratory health.

Policy Recommendations:

1) Air Quality Monitoring- Installation of real-time AQI monitoring systems in high-risk urban zones.

2) Anti-Smoking Campaigns- Smoking cessation programs targeted at ethnic communities to slow down prevalence.

3) Healthcare Access- Healthcare infrastructure in the vulnerable population to improve disease prevention.

VI. FUTURE SCOPE

The study was improved by using clinical data such as SPO2 mirror, spirometry, and x-ray results to critically assess the risk of lung disease. Air Quality Index (AQI) and local smoker proportions were also implemented in the system to maintain better accuracy of environmental risk factors. Various machine learning models, such as Randallswald and Support Vector Machine (SVM), also investigated better prediction accuracy. The current research provides directions for future research in various directions.

Such use is a time series analysis involving smoking, temporal trends and dynamic risk estimation of AQI. GIS integration is another possible value-added for visualizing high-risk areas of interactive cards to facilitate targeted interventions by political decision makers.Finally, a multi-model comparison approach can be followed to investigate deep learning models such as neural networks and hybrid approaches to further enhance classification accuracy and predictive power.

VII.CONCLUSION

This study highlights the vast potential of machine learning models in addressing public health challenges, in this case, in forecasting and monitoring respiratory disease risk.The use of machine learning on healthcare systems provides a platform of risk identification and intervention targeting which are essential towards minimizing the risk of respiratory disease worldwide. For example, clinical health workers can use such models for the detection of high-risk communities, efficient allocation of resources, and the prescription of personalized prevention interventions. Policy makers, on the other hand, can use such data towards the implementation of evidence-based interventions, such as stricter air-quality regulations and anti-smoking measures among vulnerable populations.

Moreover, the system has been 80% correct, testifying to its value as a predictor of risk for lung disease. Irrespective of application of artificial data, the study illustrates the ability of machine learning to deal with many variables and deliver results that are useful. By combining demographic, environmental, and lifestyle variables, the model transcends the traditional single-variable analysis, offering a more complete risk assessment model.

In the near future, extension of this system can greatly improve its utility and reach.Geolocation-based automation of AQI and smoker population proportion's data pull would make the process less cumbersome and the system usability and scalability improve. Additionally, incorporation of this tool with hospital management software, public health dashboard, or mobile health app will further enhance its use, and convenient and accurate information on lung disease risk to patients and practitioners would be presented.

Since the machine learning algorithm improves, further optimization can then be performed with more complex models such as Random Forest, Gradient Boosting, or Deep Learning algorithms. More complex models have the capability of handling more complicated and bigger data, therefore increasing the accuracy of the prediction and unlocking more deeper patterns of health disparities.

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Through the identification and resolution of ethnic and environmental health inequities, the system promotes global health equity and sustainable development goals. Finally, this tool would be a useful addition to the prevention of the development of lung disease, enhancing the health of the population, and making the world a healthier place for the world's population.

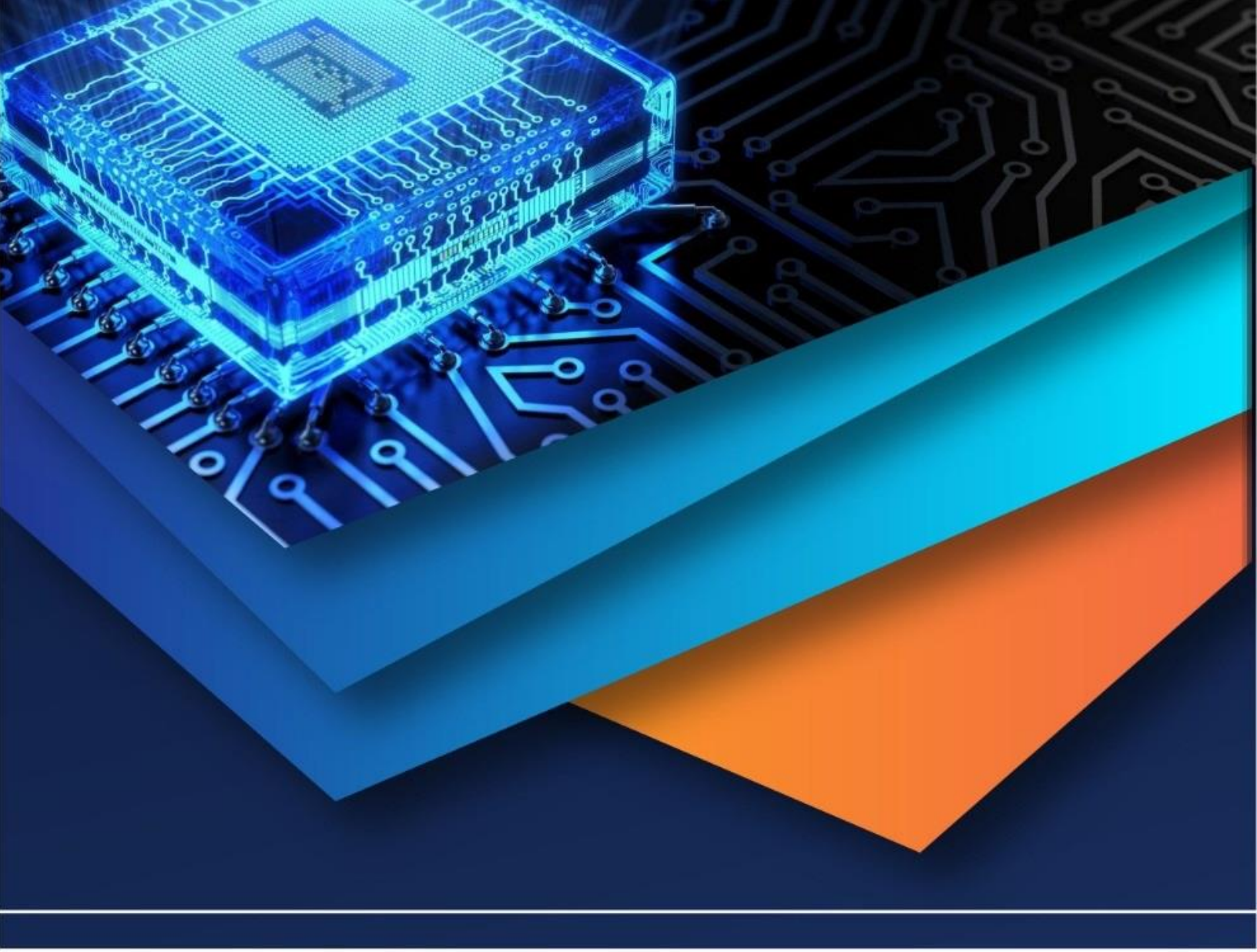
VIII. APPENDICES

1) Example input 1- Location: New York, Ethnicity: Hispanic, AQI: 95, Smoker %: 18
2) Output- "Predicted Risk Level: Medium
3) Example input 2- Location: New Jersey, Ethnicity: Hispanic, AQI: 125, Smoker %: 65
4) Output- "Predicted Risk Level: High"
5) Example input 3- Location: Ghaziabad, Ethnicity: African, AQI: 200, Smoker %: 70
6) Output- "Predicted Risk Level: High"

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