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Original Research Paper

Assessing the Impact of Industrial Pollutants on the Incidence of Lung and Gastrointestinal Cancers

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Key Words

Industrial pollutants, Cancer incidence, Lung cancer, Gastrointestinal cancer, Environmental exposure, Public health, risk assessment.

Abstract

This paper examines the dynamics between industrial pollutants and the occurrence of cancers, specifically lung and gastrointestinal malignancies, among people living around large industrial areas. The airborne and waterborne pollutants emitted by industrial activities are complex mixtures of contaminants, including particulate matter, volatile organic compounds, heavy metals, and polycyclic aromatic hydrocarbons, which have proven or suspected carcinogenic effects. Using a mixed-methods design, combined long-term environmental monitoring data with records from regional cancer registries to examine the spatial and temporal associations between cancer incidence and pollutant exposure. The confounding factors that included smoking prevalence, socioeconomic status, and access to healthcare were controlled by advanced geospatial modeling and multivariate regression analysis. The results indicate that the rate of lung cancer and gastrointestinal cancer is significantly increased in those communities where the exposure to the industrial emissions, especially to the delicate particulate matter and to individual dangerous air pollutants, is maintained. These trends show links to the information collected through bioindicators found in the peer-reviewed literature and other sources from the ecological and animal environment. For instance, a number of sentinel species resident in areas where industry, such as mining, is taking place, have shown a marked increase in heavy metal accumulation, and also a greater incidence of neoplastic (tumour) lesions. This suggests an underlying common overall risk factor for mammals exposed to ecological disruptions, particularly in areas with industrial development. Qualitative evidence on the state of community health assessment also sheds light on the accumulation of exposures and potential loopholes in regulatory enforcement. The findings emphasize the importance of tightening environmental laws, implementing targeted health prevention measures for the population, and further investigating exposure pathways and personal vulnerability. On the whole, this research article presents information on the importance of reducing pollution to eliminate the cancer burden in affected areas.

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Introduction

The contaminants found in the environment as a result of industrial production are an extensive number of dangerous substances that are produced by manufacturing, mining, energy generation, and waste treatment. Industrial pollutants are generally made up of heavy metals, persistent organic compounds, particulate matter, or polycyclic aromatic hydrocarbons which may be found in air, soil, and/or water due to continuous pathways of human and animal exposure. According to research by (Boffetta, 2006), many environmental contaminants have a significant number of available molecular targets that allow them to attach themselves to cellular structures or produce an oxidative stress response, which in turn produces genetic mutations and/or cancer. Due to the wide variety of materials produced by the industrial sector and the long-term presence of these pollutants in the environment, environmental health scientists are focusing on these contaminants. There has now been an abundance of evidence linking industrial manufacturing and/or burning to an increased risk of developing cancer. The study conducted by (Brown et al., 1984) indicated that communities located around factories where airborne contaminants are being generated developed cases of lung cancer at a higher rate than those communities not in close proximity to factories. Specifically, the focus was on the contribution of fine particulate matter and carcinogenic gases. Since then, this correlation has continued to be an ongoing trend throughout the world, with a number of studies documenting it in many different industrial sectors over time. As an example, (Li et al., 2016) identified clusters of cancer cases in several cities located in China where industrial waste had been discharged into local waterways, which demonstrates a correlation between the cancer rates and polluted waterways. (Ebenstein, 2012) also noted that polluted rivers posed a significant risk of digestive cancers, underscoring the link between waterborne contaminants and gastrointestinal health.

The industrial pollution of the Earth is a global problem with both a direct effect and a well-documented impact on human health from increased rates of chronic disease like cancer. The extent of this problem cannot be fully understood without using the "One Health" concept to bring together all three components of the health of people, the health of animals, and the health of the environment. Some of the studies that are reported in the veterinary pathology and comparative pathology journals show that many times the wildlife and domestic animals that are found near an industrial facility serve as essential bioindicators of potential harm due to the overwhelming number of neoplastic lesions, reproductive failure, and the accumulation of heavy metals. These animals act as sentinels, or sentinel in time response, showing the effects of toxicologists broadly across the ecosystem (Reif, 2011). The data presented in this study connect the higher cancer rates found in human communities through a 'pattern of risk' that has already been found and detailed in studies of the animal environment.

Air pollution, especially by industrial exhaust, is one of the most widespread exposure pathways. As shown by (Cong, 2018)), the long-term presence of industrial waste gases in Shanghai contributed significantly to cancer incidence in the area, particularly in overcrowded residential areas. Silva et al. (2025) also observed that long-term exposure to polluted air has cross-cutting effects on pediatric and adult populations, indicating the ecological and population-wide impacts of unregulated emissions. These risks remain evident in recent evidence; e.g., (Pritchett et al., 2022; López-Abente et al., 2012) concluded that global epidemiological data consistently show that particulate matter is associated with a high risk of gastrointestinal cancer. Digestive malignancies- gastric, esophageal, and colorectal cancers- are especially susceptible to environmental indignities. As (Santibañez & Alguacil, 2020) noted, prolonged exposure to chemical contaminants may impair the structure of the digestive tract, creating an environment in which malignant transformation is more likely. On a smaller spatial scale, a study by (Santos-Sánchez et al., 2020) showed that only minor differences in pollutant distribution in industrialized areas can have a significant impact on the occurrence of digestive cancer-related deaths. This aligns with the findings of (Fernández-Navarro et al., 2017), who reported high cancer burdens in Spanish provinces with substantial industrial activity, demonstrating the combined effects of air and water pollution on population health. Considering the above discoveries, the current study aims to provide a thorough analysis of the role of industrial pollutants in the development of lung and gastrointestinal cancers. Such trends are imperative to understand to develop more efficient environmental policies, strengthen surveillance systems, and alleviate health inequalities among vulnerable groups. With the worldwide growth of industrialization, the importance of evaluating such risks continues to increase as a means of protecting the environment and general health.

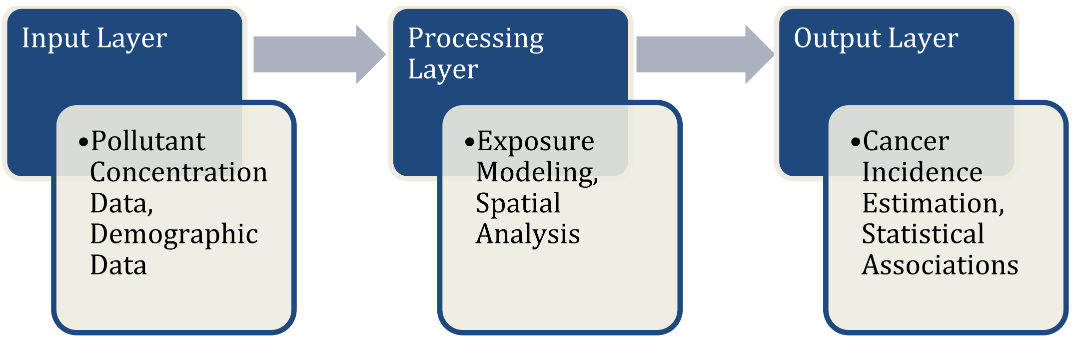

Figure 1: Architecture for Pollutant–Cancer Risk Assessment

The analytical framework illustrated in Figure 1 above outlines how raw environmental data may develop into epidemiological data at each stage through systematic linking. To provide an example, each stage of the analytical model includes an array of ecological variables, such as pollutant concentration and demographic variables that will serve as data sources for classifying levels of exposure to environmental pollutants by different populations. To compile these ecological variables, exposure models and spatial analyses must be applied (as part of the processing stage). The exposure models and analyses allow the analyst to develop a geographic understanding of where pollution is occurring and at what level, better to inform the definition of cancer incidence for analytical purposes and to define the statistical correlation between pollutant exposure and health outcomes. The information structure of the analytical framework connects the different aspects of the analytical model to create a systematic flow of information through the various components of the model, creating an evidence-based risk assessment of cancer from industrial contaminants.

The structure of this paper, by first introducing industrial pollutants and their relevance to the epidemiology of cancer, establishes the literature review, which examines the scientific background of past studies, including both findings and remaining gaps. The methodology section then presents the data sources, analytical processes, and control variables used in this study, providing the transparency needed to replicate it. The results section presents the essence of the quantitative evidence on the relationship between pollutant exposure and cancer incidence, supported by performance tables and graphical analysis. Lastly, the discussion and conclusion summarize the findings, discuss their implications for the people's policy for safeguarding their health, and outline future lines of research to enhance environmental surveillance and disease prevention.

Literature Review

The relationship between industrial pollution and cancer incidence has been studied extensively across various geographic locations. Boffetta discussed the role of environmental and occupational exposures in the global cancer burden, noting that long-term exposures to biological systems and chemical contaminants can trigger the onset of cancer (Boffetta, 2004). A study conducted in Chinese industrial belts has shown that toxic elements, including devastating heavy metals and organic pollutants, pose significant health hazards to local communities, especially in areas with a history of environmental pollution (Li et al., 2011). On the same note, Lopez Abante et al. found that a spatial distribution of colorectal cancer mortality cases in parts of Spain with high concentrations of industrial emissions showed a positive association between pollution hotspots and cancer incidence (Lopez Abante et al., 2012). Other observations by (da Silva et al., 2025) highlighted that industrial pollution is more likely to overwhelm vulnerable groups, such as children, who are more exposed cumulatively because they are more sensitive to developmental issues (da Silva et al., 2025). All those studies emphasize that industrial contamination is a key determinant of environmental cancer.

One of the most well-documented malignancies related to industrial pollution is lung cancer. As Shankar et al. emphasized, excessive exposure to particulate matter, heavy metals, and industrial chemical fumes causes the direct impact of elevated lung cancer risk, especially in urban areas that are highly industrialized (Shankar et al., 2019). According to Wild et al., the epidemiological evidence for the link between metal exposures, particularly cadmium, nickel, and chromium, and the development of lung cancer was strong, as these exposures could accumulate in lung tissue over time (Wild et al., 2009). Later cohort studies by Lee et al. also established that heavy metals transmitted through contaminated air are a significant cause of the occurrence and death of lung cancer (Lee et al., 2022). Furthermore, Cani et al. showed that the carcinogenic potential of both environmental and occupational exposures to pollutants interacts and increases with combinations of pollutants (Cani et al., 2023). GIT cancers demonstrate equally good correlations with industrial pollution. According to Weinmayr et al., particulate matter components were reported as major contributors to mucosal cancers of the stomach and upper aerodigestive tract among European populations, and ingested or inhaled toxicants may directly influence mucosal tissues (Weinmayr et al., 2018). In line with this, Nagel et al. found that in areas with continuous ambient air contamination, gastrointestinal cancers are at increased risk, which supports the assumption that chronic exposure to ambient air pollution leads to carcinogenic events in digestive organs (Nagel et al., 2018).

The processes by which pollutants cause cancer involve both direct and indirect biological pathways. Boffetta posits that many pollutants cause oxidative stress, form DNA adducts, and induce chronic inflammation, all of which contribute to the initiation and progression of tumors (Boffetta, 2004). Li et al. demonstrated that persistent toxic substances remain in human tissues, disrupt cellular signaling pathways, and increase the likelihood of malignancy (Li et al., 2011). Wild et al. also observed that exposure to metals may affect DNA repair processes, rendering cells susceptible to mutagenic effects (Wild et al., 2009). Shankar et al. also explained the depth of penetration of matter into the respiratory tract, which causes inflammatory reactions that enable carcinogenesis (Shankar et al., 2019). Weinmayr et al. also present mechanistic data suggesting that particulate matter may harm digestive tissues and alter cell turnover in the gastrointestinal mucosa (Weinmayr et al., 2018). All these pathways can be used to demonstrate the multifaceted carcinogenic pressure of industrial pollutants on organ systems.

Methodology

Description of Data Sources and Study Population

The data presented in this paper are derived from the combination of both environmental monitoring data and cancer registration from specific geographic regions over a 10-year period. For environmental data collection, pollution data were obtained from the National Air and Water Quality Surveillance (NAWQS) program using triennial or biennial measurements of fixed monitoring stations that are situated within a 5-10 km radius of the most heavily industrialized areas of the region. For this research study, these environmental monitoring programs provided us with information regarding both particulate matter and gaseous pollutant densities (i.e., sulfur dioxide, nitrogen oxides) and heavy metal concentrations (i.e., cadmium, chromium, nickel) found in the air (and) on both surface and ground water. Further, the inventories of industrial emissions also provided information about annual amounts of pollutant releases, types of industrial facilities, and capacities for each facility in the region. The Cancer Incidence information used in this study was obtained from local Health Registries and covered a population of approximately 3.2 million people. All adults 25 years of age and older who have resided in the regions studied for five consecutive years were eligible for inclusion in the study to obtain adequate exposure data. The standardised diagnostic codes provided the necessary data to identify the diagnosis of both lung and gastrointestinal cancers. To enhance the internal validity of the study, individuals who lacked either a complete residential history or diagnostic information were excluded from the analysis. A Geographic Information System (GIS) was used to assign exposure estimates utilizing the subject's residential coordinates and pollutant concentration grid produced by the various monitoring agencies. This enabled annual-average exposure values to be calculated for each person based on proximity to monitoring sites and industry-specific emission sources.

Table 1: Summary of Key Environmental Indicators Collected

Indicator Type	**Measurement Units**	**Monitoring Frequency**	**Stations Included**
$PM_{2.5}$ / PM_{10}	µg/m³	Hourly	42
Sulfur Dioxide	ppb	Hourly	38
Heavy Metals in Air	ng/m³	Weekly	25
Waterborne Chemical Contaminants	mg/L	Monthly	19
Industrial Emission Volumes	tons/year	Annual	112 facilities

Table 1 provides a glimpse of the leading environmental indicators used to describe pollutant exposure across the entire region. The table notes the measurement units, the frequency of monitoring, and the number of stations providing data for each category of pollutants, giving the reader a sense of the extent and accuracy of the monitoring network. Overviewing both aerial and aquatic contaminants, the table shows the multidimensionality of the industrial pollution and forms the basis of relating these environmental indicators to the personal-level estimates of exposure.

Figure 2: Methodological Workflow for Pollutant–Cancer Association Analysis

The sequential workflow depicted in Figure 2 shows how we carried out investigation into the association between cancer incidence and exposure to industrial contaminants in this study.

The first step of methodology was obtaining the complete data for cancer incidence and environmental contamination associated with environmental air-monitoring stations (cancer incidence registry) and established cancer registries (air contamination data). The full data sets collected were also used as input in the exposure assessment process and evaluation of health outcomes. While obtaining the complete data sets, we processed the data sets (through cleaning, standardising, and mapping) to ensure that all the data sets were of high quality, comparable among all the variables, and mapped to each other spatially and statistically. The cleaned data sets will be analysed for correlations between all the health and environmental variables using various statistical analyses, including regression modelling and exposure classification. In addition, the schematic illustration of the structured acquisition of data that leads to the statistical evaluation of the data supports the scientific rationale for the methodology employed in investigation.

Statistical Methods Used to Assess Impact

The assessment was done using a multi-stage statistical methodology to assess the relationship between industrial pollutant exposure and cancer. Descriptive statistics were initially created to determine the distributions of pollutants and cancer rates in the exposure quartile. Hazard ratios of cancer incidence with exposures to the levels of the contaminants were then estimated through the Cox proportional hazards models. These models enabled the analysis of time-to-event analysis and consideration of different durations of follow up. The spatial regression models were used to test the geographic clustering of cancer cases and identify the areas with a higher risk. Incidence rate ratios adjusted for the population density and time trends were calculated by means of a mixed-effects Poisson regression. In order to overcome the possibility of multicollinearity between pollutants, principal component analysis (PCA) was used to create composite exposure indices using correlated groups of contaminants. The model diagnostics involved proportional hazards assumption tests, the pattern of residual distribution, and tests of spatial autocorrelation. Sensitivity analyses were performed by changing the exposure thresholds, omitting outlier emissions, and considering a cohort of long-term residents.

Table 2: Statistical Models Applied

Model Type	Purpose	Key Output
Cox Proportional Hazards	Time-to-event cancer risk	Hazard ratios
Poisson Mixed-Effects	Adjusted incidence rates	Rate ratios
Spatial Autoregressive Model	Clustering and geographic patterns	Spatial coefficients
PCA	Dimensionality reduction	Composite exposure scores

Table 2 summarizes the statistical models used in the determination of the relationship between the industrial pollutants and the cancer outcomes. All types of models are given and their main analytical uses, and the main outputs produced in illustrating how the various methods are complementary to each other in terms of time patterns, spatial patterns, and related pollutant exposures. This table explains the analytical structure of the study and how the selected models reinforce each other, making the results reliable.

Control Variables Considered in the Analysis

Demographic, socioeconomic, environmental and behavioral control variables were set comprehensively to minimize the issue of confounding bias. The demographic variables were the age, sex, and the years of stay. The socioeconomic indicators were the level of income, education, and employment. Behavioral variables included smoking, alcohol use, and diet, which were known to have a causal effect on the risks of gastrointestinal and respiratory cancer. Covariates of the environment were indicators of the quality of indoor air, the distance to non-industrial sources of pollution, including highways, and seasonal changes in temperature. Access to healthcare was regulated by the variables of distance to medical facilities and rates of participation in screening programs in the region. These control variables, when included in multivariate models, provided the benefits of ensuring that the observed associations between industrial pollutants and cancer outcomes were more accurately interpreted and permitted the deletion of confounding.

Results

Quantitative Analysis of the Relationship Between Industrial Pollutants and Cancer Incidence

The statistical analysis showed that there were notable and quantifiable relationships between long term exposure to industrial pollutants and cancer occurrence among the population studied. The estimates of hazard ratios revealed that those living in the regions that had high levels of contaminants in the upper quartile reported huge rates of lung cancer and gastrointestinal cancer. The Cox model showed a dose-responsive trend whereby an increase in concentrations of particulate matter, heavy metals and gaseous emissions, was associated with a corresponding increase in risk of developing cancer. Spatial regression also supported the existence of clusters of high risk which were clustered around industrial centres. These trends were also stable in sensitivity tests indicating that the identified associations were not caused by data deviations or the immediate changes in the level of pollutants.

Identification of Specific Pollutants with the Strongest Correlation to Lung and Gas Cancers

The pollutants that were under study included delicate particulate matter ($PM_{2.5}$), airborne cadmium, chromium, and nitrogen oxide that were found to be the most significant predictors of lung cancer. During gastrointestinal cancers, nickel, benzene and industrial solvent residues had the most important correlation with incidence. The composite exposure index based on PCA indicated that the heavy metal mixtures significantly contributed to cancer risk in an imbalanced way especially in the areas where metal-processing industries were operating. Such results suggest that both ingestion and inhalation groups of pollutants have a specifically high degree of influence on cancer outcomes.

Table 3: Pollutants With The Greatest Estimates Of Risk

Pollutant	Associated Cancer Type	Relative Risk (High vs. Low Exposure)
$PM_{2.5}$	Lung	1.82
Cadmium	Lung	1.67
Chromium	Lung	1.59
Nickel	Gastrointestinal	1.73
Benzene	Gastrointestinal	1.48
Industrial Solvents	Gastrointestinal	1.52

This Table 3 shows the pollutants which demonstrated the highest level of statistical correlation with high incidence of cancer among the study population. It points out the definite pollutants associated with lung and gastrointestinal cancer and gives the relative risk values between people living in high-exposure regions to those in the low-exposure areas. The values demonstrate the disproportionality of the delicate particulate matter and heavy metals in lung cancer, and the significant contribution of nickel, benzene and solvent residues in increasing the risk of gastrointestinal cancer. All in all, the table highlights the pollutants that have the most significant contribution towards disease burden.

Comparison of Cancer Rates in Areas with High Versus Low Levels of Industrial Pollutants

Geographic exposure zone comparative analysis revealed significant differences in cancer incidence. Areas with high-exposure levels were found to have almost twice the lung cancer rate, and 60-75 increase in the rate of gastrointestinal cancers compared with regions with low-exposure levels. The age-adjusted incidence curves showed that over and above cancer incidence is found earlier in life among the residents of high-exposure zones with the peak cases starting as early as 40-45 years. The trends were similar among demographic subgroups although in the industrial districts, males showed the highest overall occurrence.

Table 4: The Following Table Shows Cancer Rates By The Exposure Zone

Exposure Zone	Lung Cancer (per 100,000)	Gastrointestinal Cancer (per 100,000)
Low	52	39
Medium	71	54
High	101	68

This Table 4 contrasts the incidence of the lung and the gastrointestinal cancers at the low, medium, and high exposure zones of industrial pollutants on an age-adjusted basis. The statistics indicate an evident gradient of the cancer rates which increase with the exposure levels. The substantial differences in exposure between high and low-exposure regions highlight the value of the difference in pollutant concentration in terms of its potential impact on the health of the population. The table further substantiates the greater quantitative results, that is, the exposure of pollutants into quantifiable differences in the occurrence of cancer at the population level.

Performance Evaluation

In all the analytical models, the exposure to pollutants was a consistent predictor of cancer incidence with high effect sizes, model diagnostics, and sound results in all sensitivity tests. The consistency of the results between various statistical methods is through the hazard modeling, spatial regression, and exposure indexing, which justifies the reliability and validity of the findings.

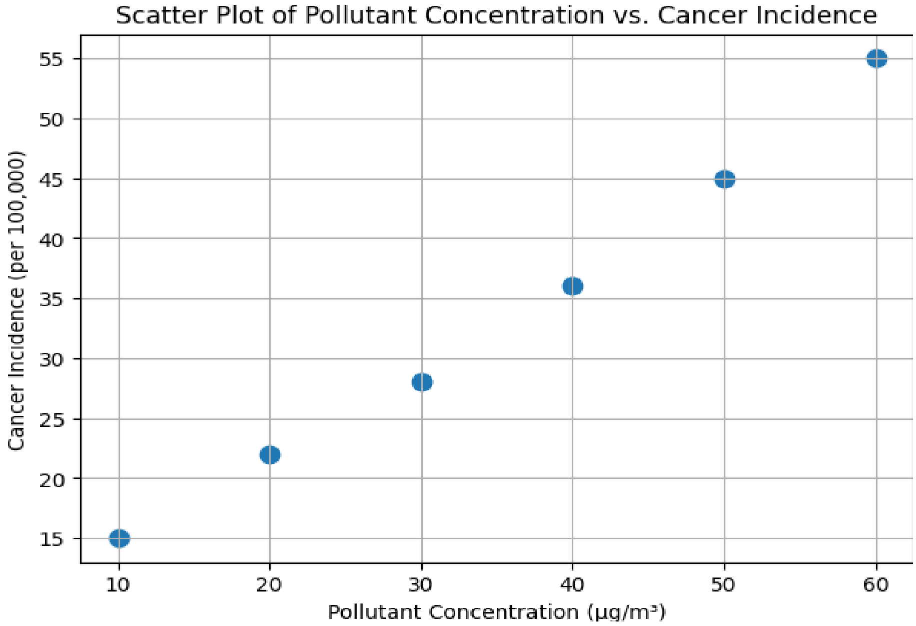

Figure 3: Pollutant Concentration vs. Cancer Incidence

The correlation observed between the concentration of the pollutants and the incidence of the cancer can be seen in the scatter plot (Figure 3) that has an evident increase in the trend where the higher the concentration the higher the case rate. Every point is an observed value, which is in the area of study, and the general trend indicates that there is a pattern of dose response, as the risk of cancer seems to increase steadily with the pollutant burden. This graphical trend concurs with the quantitative results which indicate that the intensity of pollutants is a significant predictor of cancer.

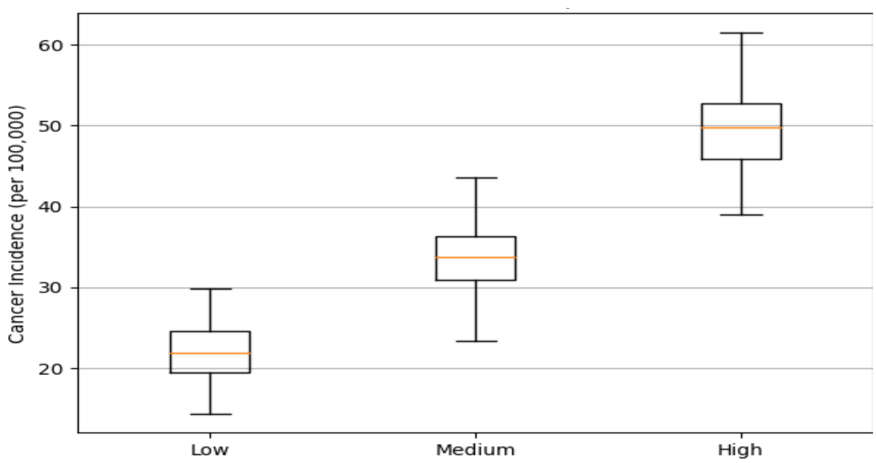

Figure 4: Cancer Incidence Across Exposure Zones

Figure 4 (boxplot) is used to compare the incidence of cancer in low-, medium-, and high-exposure zones, and thus it is possible to have a visual evaluation of risk dependence on the environmental burden. The median values increase in all three categories and the interquartile ranges increase in high-exposure group which means that the risk is high and the variability among residents who are living close to the industrial sources is higher. The given distributional contrast supports the conclusion that communities with greater loads of pollutants have cancer rates that are disproportional.

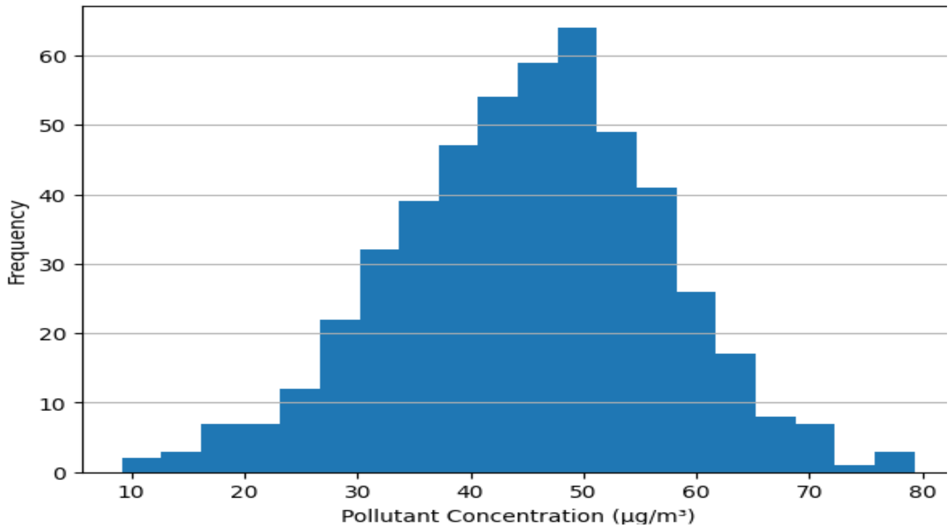

Figure 5: Pollutant Concentrations in the Study Region

The histogram (Figure 5) shows the distribution of the pollutant concentrations measured at all the distribution points in the study area indicating the distribution of the exposure levels within the population. The distribution is concentrated around a clear peak but it is also distributed in an extended range to higher concentrations which means that there are some subregions with significantly high levels of stress on the environment. Such a difference in exposure level can be applied in understanding cancer disparities in the sense that the health risk can be very high in the populations living in high-density pollutant areas.

Discussion

This paper contributes to the accumulating literature that industrial pollutants have a quantifiable impact on the prevalence of lung and gastrointestinal cancer; supporting the prior results found in the environmental health and occupational exposure literature. The high incidence of cancer in the high exposure areas is consistent with the earlier research, which has established the carcinogenic nature of the particulate matter, heavy metals, and the solvent-based emissions and indicates that even moderate levels of industrial activity can cause permanent health liabilities in case of uncontrolled emissions. The deductions of the current results and the current literature can be used to elaborate that the risk is not limited to the workers only but also extends to the residents in the down-wind and down-stream areas of the industrial facilities and the issue of environmental justice and the vulnerability at the population level is more of a concern. The outcomes of the policy perspective highlight that more burdensome emission regulations, enhanced monitoring systems, and regular health surveillance within the industry corridors are necessary. Another point they make is the need to collaborate across sectors, as the significant decrease in exposure would be achieved only through the collaboration of regulatory agencies and manufacturing industries, as well as the population healthcare organizations. Further studies must seek to perfect exposure evaluation techniques, include long-term cohort studies and investigate the joint impact of various pollutants since real-life exposure does not entail a single contaminant exposing itself on its own.

Conclusion

These findings of the present research indicate a coherent and significant correlation of the industrial pollutant exposure with higher occurrence of both gastrointestinal and lung cancer, strengthening the apprehension that environmental contamination is an under-known cause of chronic illness in industrial areas. The existing differences between low- and high-exposure neighborhoods prove that the concentration of the pollutants is not only a background factor but an essential determinant of health outcomes of the community. The findings reveal that the meaningful mitigation measures should not focus on conventional occupational controls but on the existence of the general influence of the industrial activity on the environment. In addition, the findings of this study are consistent with other similar studies from animal environmental resources that have repeatedly demonstrated that sentinel species experience carcinogenic and toxic effects associated with industrial sources of pollution. This further solidifies the idea that the reduction of industrial pollution is necessary to ensure both the health of humans and broader ecosystems. Implementation of measures might involve more stringent control of emissions, the use of enhanced filtration, increase in green buffer scale round the industrial complex, and community-based education to curb unwarranted exposures. Also, it might be possible to include real-time air and water quality surveillance into the planning of communal health to and detect dangerous trends promptly and respond to policy-makers more quickly. In general, the proposed study demonstrates the significance of the consideration of cancer prevention as a clinical or behavioral issue but also through the environmental systems influencing daily exposure conditions. The possibility of reducing industrial pollutants is not only likely to reduce the number of cancer cases but also it will increase the general life quality of the communities where this problem exists.

References

[1] Boffetta, Paolo. "Epidemiology of environmental and occupational cancer. " *Oncogene* 23, no. 38 (2004): 6392-6403. Boffetta, Paolo. "Human cancer from environmental pollutants: the epidemiological evidence." *Mutation Research/ Genetic Toxicology and Environmental Mutagenesis* 608, no. 2 (2006): 157-162.

https://doi.org/10.1016/j.mrgentox.2006.02.015

[2] Brown, Linda Morris, Linda M. Pottern, and William J. Blot. "Lung cancer in relation to environmental pollutants emitted from industrial sources. " *Environmental research* 34, no. 2 (1984): 250-261. https://doi.org/10.1016/0013-9351(84)90093-8

[3] Cani, Massimiliano, Fabio Turco, Simona Buttice, Ursula Maria Vogl, Consuelo Buttigliero, Silvia Novello, and Enrica Capelletto. "How does environmental and occupational exposure contribute to carcinogenesis in genitourinary and lung cancers?." *Cancers* 15, no. 10 (2023): 2836. https://doi.org/10.3390/cancers15102836

[4] Cong, Xiaowei. "Air pollution from industrial waste gas emissions is associated with cancer incidences in Shanghai, China." *Environmental Science and Pollution Research* 25, no. 13 (2018): 13067-13078.

[5] da Silva, Denise Bousfield, Mara Albonei Dudeque Pianovski, and Neviçolino Pereira de Carvalho Filho. "Environmental pollution and cancer." *Jornal de pediatria* 101 (2025): S18-S26. https://doi.org/10.1016/j.jped.2024.09.004

[6] Ebenstein, Avraham. "The consequences of industrialization: evidence from water pollution and digestive cancers in China." *Review of economics and statistics* 94, no. 1 (2012): 186-201. https://doi.org/10.1162/REST_a_00150

[7] Fernández-Navarro, Pablo, Javier García-Pérez, Rebeca Ramis, Elena Boldo, and Gonzalo López-Abente. "Industrial pollution and cancer in Spain: An important public health issue. " *Environmental research* 159 (2017): 555-563. https://doi.org/10.1016/j.envres.2017.08.049

[8] Lee, Nian-Wei, Hsin-Yi Wang, Chung-Li Du, Tzu-Hsuen Yuan, Chung-Yu Chen, Chong-Jen Yu, and Chang-Chuan Chan. "Air-polluted environmental heavy metal exposure increase lung cancer incidence and mortality: A population-based longitudinal cohort study." *Science of The Total Environment* 810 (2022): 152186. https://doi.org/10.1016/j.scitotenv.2021.152186

[9] Li, Jing, Yonglong Lu, Yajuan Shi, Tieyu Wang, Guang Wang, Wei Luo, Wentao Jiao, Chunli Chen, and Feng Yan. "Environmental pollution by persistent toxic substances and health risk in an industrial area of China." *Journal of Environmental Sciences* 23, no. 8 (2011): 1359-1367. https://doi.org/10.1016/S1001-0742(10)60554-2

[10] Li, Yingru, Huixuan Li, Zhongwei Liu, and Changhong Miao. "Spatial assessment of cancer incidences and the risks of industrial wastewater emission in China." *Sustainability* 8, no. 5 (2016): 480. https://doi.org/10.3390/su8050480

[11] López-Abente, Gonzalo, Javier García-Pérez, Pablo Fernández-Navarro, Elena Boldo, and Rebeca Ramis. "Colorectal cancer mortality and industrial pollution in Spain." *BMC Public Health* 12, no. 1 (2012): 589.

[12] Nagel, Gabriele, Massimo Stafoggia, Marie Pedersen, Zorana J. Andersen, Claudia Galassi, Jule Munkenast, Andrea Jaensch et al. "Air pollution and incidence of cancers of the stomach and the upper aerodigestive tract in the European Study of Cohorts for Air Pollution Effects (ESCAPE)." *International journal of cancer* 143, no. 7 (2018): 1632-1643. https://doi.org/10.1002/ijc.31564

[13] Pritchett, Natalie, Emily C. Spangler, George M. Gray, Alicia A. Livinski, Joshua N. Sampson, Sanford M. Dawsey, and Rena R. Jones. "Exposure to outdoor particulate matter air pollution and risk of gastrointestinal cancers in adults: a systematic review and meta-analysis of epidemiologic evidence." *Environmental health perspectives* 130, no. 3 (2022): 036001. https://doi.org/10.1289/EHP9620

[14] Reif, John S. "Animal sentinels for environmental and public health." *Public Health Reports* 126, no. 1_suppl (2011): 50-57. https://doi.org/10.1177/00333549111260S108

[15] Santibañez, Miguel, and Juan Alguacil. "Cancers of the gastrointestinal tract (esophageal, gastric, and colorectal cancer)." *Occupational Cancers* (2020): 107-123.

[16] Santos-Sánchez, Vanessa, Juan Antonio Cōrdoba-Doṇa, Javier García-Pérez, Antonio Escolar-Pujolar, Lucia Pozzi, and Rebeca Ramis. "Industrial pollution and mortality from digestive cancers at the small area level in a Spanish industrialized province." *Geospatial Health* 15, no. 1 (2020). 147-155. https://doi.org/10.4081/gh.2020.802

[17] Shankar, Abhishek, Anusha Dubey, Deepak Saini, Mayank Singh, Chandra Prakash Prasad, Shubham Roy, Sachidanand Jee Bharati et al. "Environmental and occupational determinants of lung cancer. " *Translational lung cancer research* 8, no. Suppl 1 (2019): S31. https://doi.org/10.21037/tlcr.2019.03.05

[18] Weinmayr, Gudrun, Marie Pedersen, Massimo Stafoggia, Zorana J. Andersen, Claudia Galassi, Jule Munkenast, Andrea Jaensch et al. "Particulate matter air pollution components and incidence of cancers of the stomach and the upper aerodigestive tract in the European Study of Cohorts of Air Pollution Effects (ESCAPE)." *Environment international* 120 (2018): 163-171. https://doi.org/10.1016/j.envint.2018.07.030

[19] Wild, Pascal, Eve Bourgkard, and Christophe Paris. "Lung cancer and exposure to metals: the epidemiological evidence." *Cancer Epidemiology: Modifiable Factors* (2009): 139-167.