Assessment Of Environmental Determinants Contributing To Cancer Incidence And Patient Well-Being In Coimbatore District, Tamilnadu, India: A Review

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ABSTRACT

Environmental determinants play a significant role in shaping cancer incidence and treatment trajectories across urbanizing regions in India. Coimbatore District, a rapidly industrializing hub of Tamil Nadu, presents complex environmental exposures stemming from industrial emissions, water contamination, vehicular pollution, and lifestyle transitions. This review synthesizes empirical evidence from global, national, and regional studies to examine how environmental risk factors contribute to cancer patterns and influence patient well-being in Coimbatore. Environmental factors are assessed in connection with cancer epidemiology, including industrial effluents, pesticide exposure, heavy metals in groundwater, and air pollutants (PM2.5, PM10, and NOx). The review also addresses environmental stressors that impact patients' quality of life, such as proximity to industrial clusters, green spaces, supportive housing, and access to clean air. The results highlight the necessity of multi-sectoral regulatory frameworks, patient-centered environmental interventions, and integrative environmental health surveillance. Future research, policy, and community-level environmental monitoring recommendations are made.

KEYWORDS: Environmental Determinants, Cancer Incidence, Air and Water Pollution, Pesticide Exposure.

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INTRODUCTION

Cancer is a complicated, multifactorial illness that is influenced by a number of factors, including environmental exposures, occupational risks, lifestyle decisions, and genetic predispositions. Environmental factors, such as air pollution, tainted water, Toxins from agriculture and industrial chemicals both greatly increase the incidence of cancer. Environmental health is a critical area for preventive oncology because, according to the World Health Organization (2021), modifiable environmental factors account for nearly 23% of the global cancer burden. Anthropogenic pollutants have been linked to higher risks of lung, bladder, liver, and hematological cancers, according to numerous epidemiological studies[1&2].

Environmental problems in India have gotten worse due to the country's fast urbanization and industrial expansion. Exposure to carcinogenic agents in the air, water, soil, and food chains has increased due to weak regulatory enforcement, high population density, and poor waste management. Research from several Indian states shows a strong correlation between groundwater contamination and gastrointestinal and reproductive cancers, industrial air pollution and respiratory cancers, and pesticide exposure and hematological cancers[3&4]. These results underscore the critical need to investigate environmental factors that contribute to cancer in rapidly expanding industrial areas.

Coimbatore District of Tamil Nadu, Known as the "Manchester of South India," is rapidly expanding its industrial base, which includes textile mills, motor pump factories, engineering facilities, automotive component industries, and chemical processing facilities. Particulate matter (PM2.5, PM10), volatile organic compounds (VOCs), heavy metals, industrial solvents, and dye effluents are among the pollutants released by this industrial belt. [9]Reports from the Tamil Nadu Pollution Control Board (TNPCB) show that permissible air and water quality limits are occasionally exceeded in a number of Coimbatore industrial zones, raising questions about the long-term effects on public health.

Additionally, significant amounts of pesticides, including organophosphates, pyrethroids, and herbicides like glyphosate, are used in the district's agricultural areas, especially in Pollachi, Annur, and Thondamuthur. Studies conducted in India and around the

world have connected long-term exposure to these chemicals to prostate cancer, leukemia, and lymphoma[5&6]. The exposure scenario is made worse by water contamination from textile dyeing facilities, tannery effluents, and untreated industrial discharge, which puts the local population under cumulative environmental stress.

Cancer risk and patient well-being are also influenced by Coimbatore's built environment. Residents' long-term exposure to carcinogens is exacerbated by rising vehicle emissions, traffic jams, insufficient green space, and improperly managed waste disposal. For cancer patients, particularly those receiving chemotherapy or radiation, who are more susceptible to environmental stress, urban heat islands, rising temperatures, and indoor pollution worsen health outcomes[7&8]. Despite these environmental obstacles, there is still a dearth of systematic research on the relationship between environmental factors and cancer incidence in Coimbatore. There are a few studies on groundwater and air quality, but there is a dearth of district-level epidemiological data linking environmental risk factors to cancer outcomes. Understanding spatial cancer patterns in the area is further hampered by the lack of an integrated cancer registry connected to environmental monitoring systems.

Thus, the purpose of this review is to critically examine the scientific data that is currently available regarding environmental factors that affect patient well-being in the Coimbatore District and increase the incidence of cancer. This review places Coimbatore within the larger framework of environmental epidemiology by combining regional-specific environmental data with national and international research. The results are meant to direct future studies, bolster environmental health monitoring, and encourage the policy changes required to reduce cancer risks associated with the environment.

METHODOLOGY OF THE REVIEW

In order to compile the available data on environmental factors linked to cancer incidence and patient well-being in the Coimbatore District, this review uses a structured narrative methodology. In addition to additional sources like WHO environmental cancer reports, CPCB and TNPCB bulletins, District Environmental Status Reports, and Indian cancer registry documents, peer-reviewed articles published between 2000 and 2024 were thoroughly searched across Scopus, PubMed, Web of Science, and Google Scholar. The search terms "environmental determinants," "cancer risk," "industrial pollution India," "Coimbatore air quality," "groundwater contamination Tamil Nadu," and "environmental carcinogens" were combined using Boolean operators to narrow down the results. Studies that looked at cancer outcomes associated with exposure to air, water, soil pollutants, or industrial emissions were included; studies that were irrelevant or of poor quality were not. After screening about 120 documents, 48 studies were found to be pertinent and methodologically sound. Air pollution, water and soil contamination, industrial and occupational exposures, and environmental stressors associated with urban lifestyles were the four thematic dimensions into which the chosen literature was divided. Pollutant types, exposure pathways, documented health effects, and regional relevance were highlighted during data extraction. After that, cross-study comparisons were made to find recurring trends linking environmental risks to cancer. In order to create a thorough understanding of environmental influences on cancer risk and patient well-being, the final synthesis incorporates national, international, and Coimbatore-specific findings.

ENVIRONMENTAL DETERMINANTS INFLUENCING CANCER INCIDENCE

AIR POLLUTION AND ITS ASSOCIATION WITH CANCER

One of the most common environmental causes of cancer is still air pollution, which has a substantial global impact on both incidence and mortality. Carcinogenic pollutant emissions have increased in Coimbatore District due to the fast expansion of textile mills, engineering units, foundries, small-scale manufacturing plants, and growing vehicle density. Localized industrial corridors, especially the northern textile belt, Mettupalayam Road, Avinashi Road, and the Pollachi industrial stretch, frequently experience pollution peaks, despite Coimbatore's reputation as being more environmentally friendly than megacities like Delhi or Mumbai.

The principal cancer-linked pollutants recorded in Coimbatore include:

- Particulate Matter (PM2.5 and PM10): Lung, laryngeal, and oropharyngeal cancers are closely linked to long-term inhalation of fine particulate matter. Through oxidative DNA damage, elevated PM2.5 levels—which often exceed WHO guidelines during winter and peak industrial hours—promote cellular mutations.
- Polycyclic Aromatic Hydrocarbons (PAHs) and benzoene: These substances are known risk factors for leukemia and other hematological malignancies and are released from automobile exhaust, industrial combustion, and uncontrolled waste burning.
- Nitrogen Oxides (NOx) and Sulphur Oxides (SOx): These gases accelerate carcinogenic pathways by stimulating chronic inflammation and oxidative stress in pulmonary tissues.

Coimbatore occasionally surpasses the national allowable limits for PM2.5, according to CPCB's air quality bulletins, especially in the vicinity of mechanical workshops and textile dyeing facilities. Long-term exposure to synthetic fiber dust, dye fumes, and combustion by-products significantly increases respiratory morbidity, which can lead to malignancies over time, according to research done in Tamil Nadu's industrial clusters[12&13]. These results demonstrate how urgently the district needs to combine industrial monitoring with health surveillance.

WATER CONTAMINATION AND CANCER RISK

In Coimbatore District, groundwater is still the most common source of drinking water, particularly in rural and peri-urban areas. Aquifers, open wells, and borewells are contaminated by textile effluent discharge, metal-processing residues, chemical solvents, and agricultural runoff, all of which put significant pressure on the area.

According to regional studies, the following are important carcinogenic contaminants:

- **Heavy Metals:** Chromium, lead, cadmium, nickel, and arsenic—many exceeding BIS safety limits—pose substantial risks for liver, kidney, bladder, and skin cancers.

- **Textile Dyes and Chemical Effluents:** Dyeing units release azo dyes and aromatic amines, recognized internationally as potent carcinogens.
- **Excessive Nitrates:** Fertilizer leaching contributes to methemoglobinemia and increases gastrointestinal cancer susceptibility.
- **Pesticide Residues:** Streams and canals near agricultural regions often show organophosphate and carbamate traces.

Elevated heavy metal concentrations in groundwater close to industrial clusters are regularly reported in studies carried out in Western Tamil Nadu, including the Coimbatore–Tiruppur industrial corridor[14&15]. Continuous exposure through drinking water raises the risk of cancer at the community level because chromium and arsenic are Group I carcinogens according to the International Agency for Research on Cancer (IARC). Due to extended intake without filtration or remediation systems, rural families who rely on untreated borewells or shared village tanks are most vulnerable.

SOIL POLLUTION AND AGRICULTURAL PESTICIDE EXPOSURE

To control crop pests and increase yield, the agricultural areas around Pollachi, Annur, Karamadai, and Thondamuthur heavily rely on chemical pesticides. Pesticide residues have accumulated in soil, groundwater, and the larger food chain as a result of widespread application over time.

Typical agricultural chemicals linked to the development of cancer include:

- **Glyphosate:** Frequently used as a broad-spectrum herbicide; epidemiological studies correlate long-term exposure with non-Hodgkin lymphoma.
- **Organophosphate Pesticides:** Chronic exposure is linked to neurotoxic effects and increased risk of brain and neurological cancers.
- **Chlorinated Pesticides (including outdated compounds like DDT):** Persist in soil and fatty tissues, linked to breast, liver, and endocrine-related cancers.

Farmers who manually sprayed pesticides reported much higher levels of DNA damage biomarkers and chronic respiratory conditions, according to a review of agricultural health studies conducted in Tamil Nadu[16&17]. Exposure risk is further increased by inadequate protective gear, a lack of knowledge about chemical hazards, and the reuse of contaminated containers. Communities that are close to agricultural fields may also be indirectly exposed through locally grown produce, irrigation runoff, or contaminated soil dust.

INDUSTRIAL AND OCCUPATIONAL EXPOSURES

Due to ongoing exposure to occupational toxins, Coimbatore's industrial workforce—employed in textile mills, foundries, motor pump industries, engineering plants, and chemical units—faces an increased risk of developing cancer.

In industrial settings, common carcinogenic agents include:

- **Textile Dyes and Fixing Agents:** Associated with bladder and skin cancers due to aromatic amine exposure.
- **Silica Dust:** Widely encountered in foundries and metal-casting units; linked to lung cancer and silicosis.
- **Solvents, Lubricants, and Degreasers:** Chronic exposure increases the risk of liver and hematological cancers.
- **Asbestos:** Present in older industrial infrastructures, associated with mesothelioma and lung cancer.

Long-term exposure to fine particulates is clearly linked to elevated oxidative stress markers, which are important precursors to carcinogenesis, according to a study conducted among industrial workers in South India[18 and 19]. Because surrounding residential communities are impacted by environmental leakage and air dispersion from these industries, occupational exposure frequently extends beyond the workplace, raising cumulative cancer risks even among non-workers.

ENVIRONMENTAL DETERMINANTS INFLUENCING PATIENT WELL-BEING

In addition to having a significant impact on the incidence of cancer, environmental factors also have a significant impact on the recovery process, treatment tolerance, psychological health, and general quality of life of cancer patients. Disparities in the Coimbatore District's air quality, green space availability, soil and water safety, noise levels, and housing conditions result in multifaceted environmental stressors that have varying effects on patients according to their socioeconomic status and residential location. Because immune compromised people are more sensitive to pollutants and toxins, the combination of environmental exposures and cancer treatment (chemotherapy, radiation, immune therapy) creates a compounded risk[20]. Therefore, creating patient-centric interventions and directing public health initiatives require an understanding of environmental factors.

Table 1: Coimbatore District's Environmental Factors and Related Cancer Risks

Environmental Factor	Primary Carcinogenic Agents	Associated Cancer Types
Air Pollution	PM2.5, Benzene, PAHs	Lung, Leukemia
Groundwater Contamination	Arsenic, Chromium, Lead	Skin, Liver, Bladder
Pesticide Exposure	Organophosphates, Glyphosate	Lymphoma, Liver

Environmental Factor	Primary Carcinogenic Agents	Associated Cancer Types
Industrial Emissions	Silica Dust, Industrial Solvents	Lung, Skin

AIR QUALITY AND RESPIRATORY BURDEN

One of the most important environmental factors influencing cancer patients is air quality. Due to lowered immunity and inflammation brought on by treatment, cancer patients' respiratory systems are more vulnerable to air pollutants, especially those receiving treatment for lung, breast, or hematological malignancies. Breathing problems, exhaustion, lung irritation, and infection risk are all made worse by exposure to PM2.5, benzene, sulfur oxides, nitrogen dioxide, and polycyclic aromatic hydrocarbons. Pollutant concentrations are consistently higher in heavily trafficked urban areas like Gandhipuram, Ukkadam, Ramanathapuram, and Singanallur. Cancer patients who live in these areas frequently have more episodes of dyspnea, pulmonary toxicity from treatment, and a delayed recovery after chemotherapy when they breathe in toxic particulates[21]. On the other hand, patients who reside in outlying areas with improved air circulation, like Thondamuthur or Koundampalayam, exhibit comparatively fewer respiratory issues. Additionally, research indicates that poor ambient air quality increases hospitalization rates among radiotherapy patients and exacerbates cancer-related fatigue22. These results highlight the significance of enhancing urban air quality and promoting safety precautions like masks, indoor air purifiers, and limiting outdoor exposure during periods of high pollution.

GREEN SPACES AND PSYCHOLOGICAL WELL-BEING

Green spaces are becoming more widely acknowledged as therapeutic settings that support emotional stability and mental resilience, both of which are essential for cancer survivorship and treatment. By lowering stress hormones, improving sleep quality, and promoting positive mood states, access to natural environments enhances psychological well-being[23]. Patients who live close to parks, vegetation, or peri-urban greenery show improvements in their immune systems, pain tolerance, treatment compliance, anxiety and depression, and general quality of life. Locations close to the Western Ghats in Coimbatore, such as Marudhamalai, Perur, Vadavalli, and the foothills of Isha, provide healing surroundings that promote mental recovery. However, there isn't enough greenery in industrial areas like Ganapathy, Somanur, Irugur, and Annur, which could make cancer patients feel more stressed.

Therapeutic gardens, green hospital hallways, and urban tree-cover initiatives, according to environmental psychologists, can significantly enhance cancer recovery outcomes[24]. Expanding green buffers around healthcare facilities and industrial belts in Coimbatore can greatly improve vulnerable populations' environmental comfort.

HOUSING QUALITY, INDOOR POLLUTION, AND NOISE STRESS

Cancer patients' daily comfort and health are significantly impacted by their housing situation. Indoor pollutants that irritate the respiratory system and lower immunity, such as cooking fumes, incense burning, biomass fuel emissions, mosquito coil smoke, and aromatic sprays, are trapped by poor ventilation, damp buildings, and low natural lighting[23]. Additionally, these pollutants can exacerbate chemotherapy-related headaches, nausea, and exhaustion.

Another environmental stressor that is frequently disregarded in cancer treatment is noise pollution. Patients who live close to marketplaces, bus stops, railroad tracks, and industrial machinery facilities frequently experience sleep disturbances, increased stress, and weakened immune systems. Patients recovering from lengthy treatment cycles are especially vulnerable to the disruption of circadian rhythm caused by prolonged noise exposure[24].

Long travel times to treatment facilities, particularly from the outskirts of Pollachi, Anaimalai, or Madukkarai, also cause financial and emotional strain, which lowers follow-up frequency and delays interventions.
Patient-centered environmental care must include improving indoor air quality, increasing natural airflow, lowering household chemical exposures, and reducing noise levels.

DISCUSSION

This review demonstrates that environmental factors have a major impact on the development of cancer as well as the health of patients who have been diagnosed in the Coimbatore District. The results confirm that:

- One of the main causes of respiratory-related cancer progression and treatment complications is air pollution from vehicles, industries, and waste burning.
- Exposure to carcinogenic metals is increased by groundwater contamination from agricultural runoff and effluents.
- The use of agricultural pesticides increases the risk of cancer in farming communities in Pollachi, Annur, and Karamadai.
- Environmental stressors like poor housing, noise, and a lack of greenery have a direct impact on psychological stability and recovery; occupational exposures in textile mills, foundries, and mechanical units increase long-term carcinogenic risk for workers.

The trends seen are consistent with national environmental carcinogenesis patterns reported in India, despite the lack of comprehensive cancer registry data for Coimbatore. Coordinated efforts are needed to lessen the environmental impact on cancer patients:

Increasing awareness of indoor pollution; strengthening air and water quality monitoring; enforcing industrial waste management regulations; improving urban green infrastructure; promoting occupational safety measures; and forming partnerships between hospitals and environmental agencies

Overall, the review highlights that in order to lower community-level vulnerability and improve patient outcomes in Coimbatore, cancer management must combine medical care with environmental improvements.

RESEARCH GAPS IDENTIFIED

The review identifies a number of important research gaps that impede a thorough comprehension of the environmental factors influencing Coimbatore's cancer incidence. First, accurate epidemiological assessments are limited by the clear absence of a district-level cancer registry that is systematically connected with environmental pollution data. There are few studies concentrating on particular carcinogens found in Coimbatore's main industrial belts, which leaves large gaps in the identification of high-risk exposure areas. Long-term studies on groundwater contamination are also lacking, especially in regions impacted by industrial effluents, solid waste disposal, and textile dyeing. Furthermore, tracking cumulative exposures and their long-term health effects is hampered by the lack of an integrated environmental health monitoring system. Lastly, data sharing, early detection initiatives, and the creation of focused cancer prevention strategies are further hindered by the lack of cooperation between public health departments and industry.

RECOMMENDATIONS

In order to address the environmental determinants of cancer in Coimbatore, the study makes a number of specific recommendations for legislators, medical facilities, and community organizations. A district-level environmental cancer surveillance system must be put in place, TNPCB's industrial emissions monitoring must be strengthened, and the textile and dyeing industries must strictly adhere to effluent pre-treatment regulations. Healthcare organizations should integrate environmental counseling into oncology care, incorporate environmental exposure screening into routine cancer diagnosis, and create patient support programs that prioritize recovery in clean air. In order to increase green cover and lower the risk of cancer caused by pollution, communities and non-governmental organizations should concentrate their efforts on raising awareness of safe pesticide handling techniques, encouraging homes to install efficient filtration systems and rainwater harvesting, and supporting large-scale tree planting projects.

CONCLUSION

The Coimbatore District's cancer incidence and patient well-being are significantly influenced by environmental factors. Pesticide exposure, groundwater contamination, vehicle pollution, and industrial emissions are still major issues. Reducing cancer risk and improving patient recovery conditions require incorporating environmental health assessments into public health planning. The review highlights the necessity of district-wide environmental monitoring, public awareness campaigns, and cooperative efforts between communities, healthcare organizations, and legislators. In Coimbatore, addressing environmental factors can greatly lower the incidence of cancer and enhance the lives of those who are impacted by the disease.

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