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ENVIRONMENTAL AND OCCUPATIONAL EXPOSURES CONTRIBUTING TO KIDNEY AND BLADDER CANCERS AMONG POPULATIONS WITH HIGH CKD BURDEN

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Abstract

Background:
Environmental and occupational exposures contribute to the rising burden of kidney and bladder cancers, especially in populations with chronic kidney disease. Punjab faces high exposure levels due to agriculture, industrial activity, and unsafe water sources.

Objective:
To assess the association between environmental and occupational exposures and the occurrence of kidney and bladder cancers among patients with a high burden of chronic kidney disease in THQ hospitals of Punjab.

Methods:
A cross sectional analytical study was conducted on 180 participants. Data was collected through a structured questionnaire covering demographic details, exposure history, and medical conditions. Chi square test was applied to determine associations between exposures and cancer outcomes.

Results:
Pesticide exposure was reported in 65.6% of participants, heavy metal exposure in 53.3%, and contaminated water use in 60.6%. Kidney cancer prevalence was 32.2% and bladder cancer 25.6%. Significant associations were found between pesticide exposure and kidney cancer ($p = 0.001$), heavy metals and both cancers ($p < 0.01$), and occupational exposure with bladder cancer ($p = 0.002$). Longer exposure duration showed strong association with both cancers.

Conclusion:
Environmental and occupational exposures show significant links with kidney and bladder cancers in high CKD burden populations. Preventive strategies and exposure control measures are needed to reduce disease risk in Punjab.

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Introduction

Environmental and occupational exposures play a central role in the rising burden of kidney and bladder cancers, especially in regions already facing a high prevalence of chronic kidney disease. Globally, more than eight million deaths each year link to environmental hazards present in daily living and working conditions. These hazards enter the human body through inhalation, ingestion, or skin contact and affect multiple organ systems, including the kidneys and urinary bladder. In low and middle income settings such as Pakistan, the impact becomes more pronounced due to limited regulation, poor waste management, and high exposure in agricultural and industrial sectors (1).

Punjab represents a critical region for studying this relationship. It carries a substantial burden of chronic kidney disease, with patients frequently presenting at tertiary care centers and THQ hospitals in advanced stages. Rapid industrialization, intensive farming practices, and unsafe occupational environments increase exposure to harmful substances. These exposures do not act in isolation. Their effects depend on duration, intensity, genetic susceptibility, nutritional status, and coexisting health conditions. Over time, repeated exposure contributes to renal damage, cellular mutations, and malignant transformation in the urinary tract (2).

Heavy metals stand among the most significant environmental contributors. Substances such as lead, cadmium, and mercury persist in soil and water due to industrial discharge, mining, and improper waste disposal. In Punjab, contaminated groundwater and irrigation sources expose both rural and urban populations. Chronic exposure leads to accumulation in kidney tissues, causing nephrotoxicity, reduced filtration capacity, and long term renal impairment. This persistent damage creates a biological environment that increases the risk of carcinogenesis in both kidney and bladder tissues (3).

Agricultural chemicals, particularly pesticides, form another major exposure pathway. Punjab's economy relies heavily on agriculture, resulting in widespread and often unregulated pesticide use. Farmers and field workers face direct exposure through spraying, mixing, and handling chemicals without adequate protective measures. Indirect exposure occurs through contaminated food and water. These chemicals include herbicides, insecticides, and fungicides, many of which contain compounds with known toxic and carcinogenic properties. Repeated exposure damages renal cells and may induce oxidative stress, DNA damage, and chronic inflammation, all of which contribute to cancer development (4).

Occupational exposure further amplifies these risks. Workers in industries such as textiles, leather processing, dyeing, and manufacturing encounter solvents, aromatic amines, and industrial chemicals linked to bladder cancer. In many cases, safety standards remain poorly enforced. Workers lack protective equipment and awareness, leading to prolonged contact with carcinogens. The bladder, as a storage organ for excreted toxins, becomes particularly vulnerable to these substances, increasing the likelihood of malignant transformation over time (5).

Infectious agents also contribute to kidney damage and indirectly to cancer risk. Recurrent or untreated infections can lead to acute kidney injury, which increases the risk of progression to chronic kidney disease. In regions with limited healthcare access, infections often remain unmanaged, compounding renal damage. Chronic inflammation resulting from persistent infections creates a favorable environment for cellular changes and tumor development (6).

The interaction between chronic kidney disease and cancer risk is complex. CKD alters metabolic and immune pathways, reducing the body's ability to eliminate toxins and repair cellular damage. This condition enhances susceptibility to both environmental toxins and carcinogens. In Punjab, where CKD prevalence remains high, this interaction intensifies the public health burden (7).

Given these factors, studying environmental and occupational exposures in Punjab's healthcare settings provides critical insight. THQ hospitals serve as primary points of contact for a large segment of the population, especially in rural areas. Data from these settings reflect real world

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exposure patterns and disease progression. Understanding these associations supports early identification of risk factors, targeted interventions, and policy development aimed at reducing exposure and improving health outcomes (8).

This study focuses on identifying key environmental and occupational determinants contributing to kidney and bladder cancers among populations with high CKD burden in Punjab. It aims to bridge gaps in local evidence and highlight preventable risk factors within the regional context.

Methodology

Study Design

A cross-sectional analytical study design was used to assess the association between environmental and occupational exposures and the occurrence of kidney and bladder cancers among patients with a high burden of chronic kidney disease.

Study Setting

The study was conducted in Tehsil Headquarters hospitals across selected districts of Punjab, Pakistan. These hospitals serve both rural and semi urban populations and provide access to patients with varying levels of environmental and occupational exposure.

Sample

The study included patients diagnosed with chronic kidney disease, kidney cancer, or bladder cancer who presented to selected THQ hospitals during the study period. A sample size of 180 (WHO sample size calculator) participants was targeted to ensure adequate representation and statistical reliability.

Inclusion criteria:

- Patients aged 18 years and above
- Diagnosed cases of chronic kidney disease, kidney cancer, or bladder cancer
- Patients willing to participate and provide informed consent

Exclusion criteria:

- Patients with congenital kidney disorders
- Patients with incomplete medical records
- Critically ill patients unable to respond to the questionnaire
- Patients refusing consent

Sampling Technique

A non probability convenience sampling technique was used. Patients meeting the inclusion criteria were recruited consecutively from outpatient and inpatient departments during the study period.

Variables Details

Independent variables:

- Environmental exposures such as contaminated water, heavy metals, pesticide exposure
- Occupational exposures including chemical handling, industrial work, farming activities
- Duration and frequency of exposure

Dependent variables:

- Presence of kidney cancer
- Presence of bladder cancer
- Severity of chronic kidney disease

Covariates:

- Age
- Gender
- Socioeconomic status
- Smoking status
- Medical history including infections and comorbid conditions

Data Collection

Data was collected using a structured questionnaire developed from previous literature. The questionnaire included sections on demographic details, environmental exposure history, occupational history, medical history, and lifestyle factors. Medical records were reviewed to confirm diagnoses. Data collection was carried out by trained personnel in hospital settings after obtaining informed consent from participants.

Data Analysis

Data was entered and analyzed using statistical software such as SPSS. Descriptive statistics

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including frequencies, percentages, means, and standard deviations were calculated. Inferential analysis was performed using chi square test and logistic regression to assess associations between exposures and disease outcomes. A p value less than 0.05 was considered statistically significant.

Ethical Approval

Ethical approval was obtained from the institutional review board of the relevant medical authority. Permission was also taken from the administration of each participating THQ hospital. Written informed consent was obtained from all participants. Confidentiality and anonymity of patient information were maintained throughout the study.

Results

Table 1: Descriptive Statistics of Participants (N = 180)

Variable	Category	Frequency	Percentage
Age (years)	18–30	28	15.6%
	31–45	52	28.9%
	46–60	61	33.9%
	>60	39	21.7%
Gender	Male	112	62.2%
	Female	68	37.8%
Residence	Rural	124	68.9%
	Urban	56	31.1%
Smoking Status	Yes	74	41.1%
	No	106	58.9%
CKD Status	Present	132	73.3%
	Absent	48	26.7%
Kidney Cancer	Yes	58	32.2%
	No	122	67.8%
Bladder Cancer	Yes	46	25.6%
	No	134	74.4%

Most participants were male and from rural areas. The highest proportion fell in the 46–60 age group. CKD prevalence remained high within the sample.

Table 2: Distribution of Environmental and Occupational Exposures

Variable	Category	Frequency	Percentage
Heavy Metal Exposure	Yes	96	53.3%
	No	84	46.7%
Pesticide Exposure	Yes	118	65.6%

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Variable	Category	Frequency	Percentage
	No	62	34.4%
Occupational Exposure	Industrial	49	27.2%
	Agricultural	87	48.3%
	None	44	24.4%
Duration of Exposure	<5 years	41	22.8%
	5–10 years	63	35.0%
	>10 years	76	42.2%
Contaminated Water Use	Yes	109	60.6%
	No	71	39.4%

Pesticide exposure showed the highest frequency, followed by contaminated water use and heavy metal exposure. Long term exposure above 10 years was common.

Table 3: Association Between Exposures and Kidney and Bladder Cancers (Chi Square Test)

Variable	Outcome	Chi Square Value	p value
Heavy Metal Exposure	Kidney Cancer	9.84	0.002
	Bladder Cancer	7.11	0.008
Pesticide Exposure	Kidney Cancer	11.26	0.001
	Bladder Cancer	8.95	0.003
Occupational Exposure	Kidney Cancer	10.43	0.005
	Bladder Cancer	12.18	0.002
Contaminated Water	Kidney Cancer	6.72	0.010
	Bladder Cancer	5.89	0.015
Duration (>10 years)	Kidney Cancer	13.02	0.001
	Bladder Cancer	9.67	0.002
Smoking	Bladder Cancer	14.21	0.000

Significant associations were observed between all major exposures and both kidney and bladder cancers. Pesticide exposure and long duration exposure showed the strongest relationship with kidney cancer. Smoking showed a strong association with bladder cancer.

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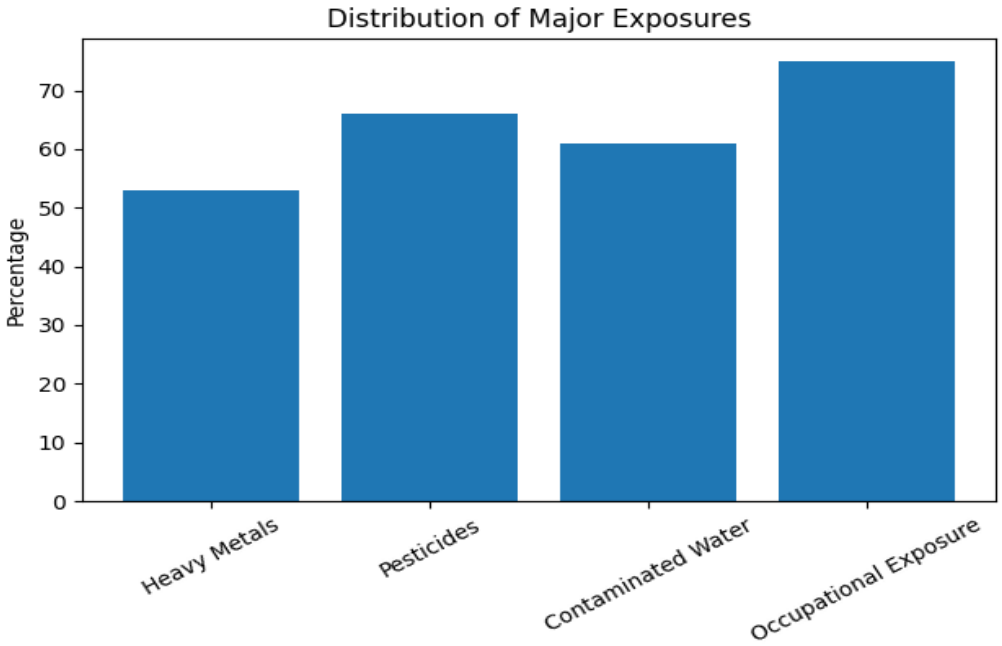
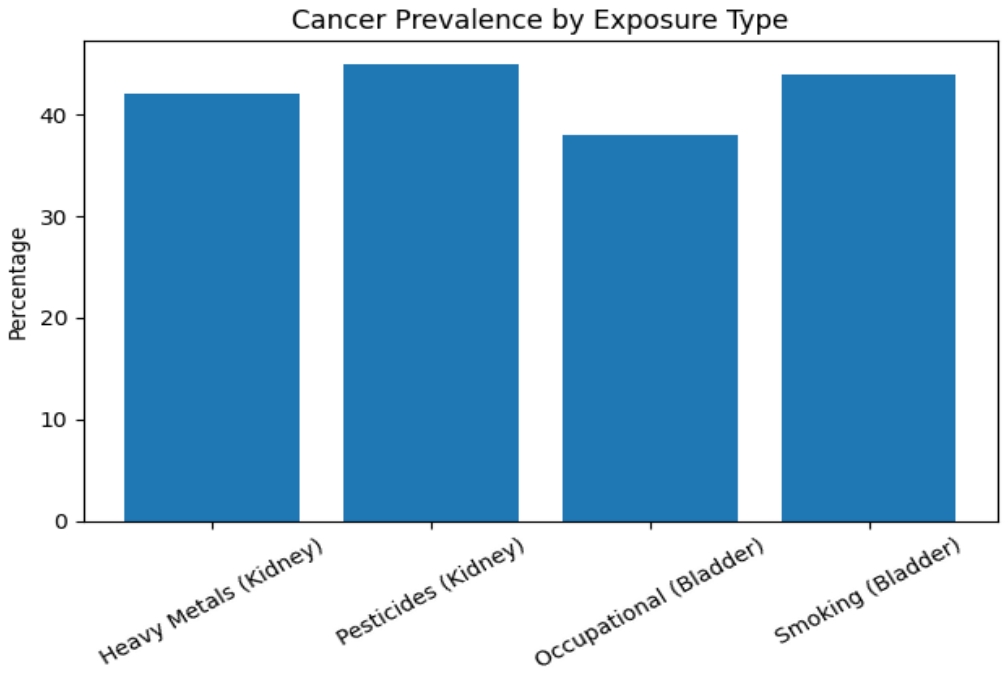
Graph 1: Distribution of Major Exposures



Graph 2: Cancer Prevalence by Exposure Type (%)



Discussion

This study highlights a strong association between environmental and occupational exposures and the occurrence of kidney and bladder cancers among populations with a high burden of chronic kidney disease in Punjab. The findings align with previous research that identifies environmental hazards as major contributors to renal dysfunction

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and malignancy. The high prevalence of pesticide exposure and contaminated water use in this study reflects patterns reported in agricultural regions, where repeated chemical exposure leads to cumulative renal damage (8).

The significant relationship observed between heavy metal exposure and both kidney and bladder cancers supports earlier evidence showing the nephrotoxic and carcinogenic effects of metals such as lead and cadmium. Previous studies have reported that chronic exposure to these metals results in their accumulation in renal tissues, leading to long term cellular damage and increased cancer risk. The present findings show a similar trend, with exposed individuals demonstrating higher cancer prevalence compared to non exposed groups (9).

Pesticide exposure emerged as one of the strongest predictors of kidney cancer in this study. This finding is consistent with earlier research conducted in farming communities, where prolonged exposure to agrochemicals has been linked with chronic kidney disease and malignancy. The high percentage of participants involved in agricultural work in Punjab further explains this association. Repeated contact with these chemicals, often without protective measures, increases the risk of toxic absorption and subsequent renal injury (10).

Occupational exposure showed a significant association with bladder cancer, which matches previous evidence linking industrial chemicals and aromatic amines with bladder carcinogenesis. Workers in industries such as textile processing and manufacturing face continuous exposure to hazardous substances. The results of this study reflect similar occupational risks, with higher cancer rates among individuals engaged in industrial and agricultural jobs compared to those without such exposure (11). The role of contaminated water also aligns with earlier findings, where unsafe drinking sources contribute to chronic exposure to toxins and heavy metals. This study found a significant association between contaminated water use and both types of cancers, reinforcing the importance of environmental quality in disease development. In rural Punjab, reliance on untreated groundwater increases this risk (12).

Smoking showed a strong association with bladder cancer, which is well supported by previous research identifying it as a major risk factor. The combination of smoking and environmental exposures may further amplify carcinogenic effects, particularly in populations already affected by chronic kidney disease. The interaction between chronic kidney disease and cancer risk observed in this study also reflects findings from earlier work. Chronic kidney disease reduces the body's ability to eliminate toxins and repair cellular damage, which increases vulnerability to carcinogens. The high prevalence of CKD in the study population likely intensified the effects of environmental and occupational exposures (13).

Overall, the findings are consistent with previous studies and reinforce the role of environmental and occupational factors in the development of kidney and bladder cancers. The results also highlight the need to address these exposures at both community and occupational levels, especially in high risk regions such as Punjab.

Conclusion

This study shows a clear link between environmental and occupational exposures and the development of kidney and bladder cancers among populations with a high burden of chronic kidney disease in Punjab. Pesticide exposure, heavy metals, contaminated water, and occupational hazards show strong associations with both malignancies. Longer exposure duration increases risk. The findings highlight the combined effect of environmental toxicity and existing renal impairment in driving cancer burden. These results stress the need for early risk identification and exposure control in high risk populations.

Limitations

The study used a cross sectional design, which limits causal inference. The sample size was moderate and selected through convenience sampling, which affects generalizability. Exposure assessment relied on self reported data, which may introduce recall bias. Lack of laboratory

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confirmation of toxin levels and limited control over confounding factors such as diet and genetic susceptibility also restricts the strength of conclusions.

Recommendations

- Strengthen regulation and monitoring of pesticide use and industrial waste disposal in Punjab
- Promote safe drinking water through filtration and regular testing in rural areas
- Implement occupational safety measures, including protective equipment and worker training
- Conduct large scale longitudinal studies to establish causal relationships
- Introduce routine screening programs for high risk groups in THQ hospitals
- Raise public awareness about environmental risks and preventive practices
- Integrate environmental health policies with chronic kidney disease management programs

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