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Exploring the Genetic and Environmental Factors Contributing to Ovarian Cancer in Women in Mumbai, India

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Abstract

Background: *Ovarian cancer incidence in Mumbai has risen by 30% over the past decade, with an age-standardized rate of 9.1 per 100,000 women, contrasting stable trends in Western nations. This study investigates the interplay of genetic and environmental factors driving this disparity in Mumbai's diverse population.* ***Methods:*** *A hospital-based case-control study was conducted at a hospital, enrolling 200 epithelial ovarian cancer cases (aged 30–70 years) and 400 age-matched controls. Germline genetic testing (BRCA1/2 and 25 homologous recombination genes) was combined with geospatial environmental exposure assessments (PM2.5, dietary carcinogens, occupational hazards) and socioeconomic analyzing. Gene-environmental interactions were evaluated using multiplicative models.* ***Results: Genetic Factors:*** *21.0% of cases carried BRCA1/2 mutations (BRCA1: 14.0%; BRCA2: 6.0%), with 13.0% having other HR gene mutations (notably RAD51C: 4.0%).* ***Environmental Exposures:*** *Significant associations included high PM2.5 (OR = 2.95; 95% CI: 2.07–4.20), processed meat consumption (OR = 2.92; 2.05–4.16), and biomass fuel use (OR = 2.79; 1.87–4.16).* ***Gene-Environment Interactions:*** *BRCA carriers with high PM2.5 exposure had 6-fold increased risk (OR = 6.12; synergy index = 1.98; p = 0.01).* ***Socioeconomic Disparities:*** *35.0% of cases were from low-SES backgrounds (vs. 10.0% controls; p < 0.001), with spatial clustering in northern industrial wards.* ***Conclusion:*** *Ovarian cancer in Mumbai reflects synergistic effects of population-specific genetic susceptibility (e.g., elevated RAD51C mutations) and urban environmental carcinogens (e.g., air pollution, processed diets), disproportionately impacting low-SES communities. Findings advocate for precision prevention strategies integrating genetic counseling and environmental mitigation in high-risk groups.*

Keywords: ovarian cancer, BRCA mutations, gene-environment interaction, air pollution, socioeconomic disparities, Mumbai

INTRODUCTION

Ovarian cancer remains one of the most lethal gynecological malignancies worldwide, with particularly poor prognosis seen in the developing world such as India [1]. In Mumbai, data from the National Cancer Registry Programme [2] show that the age standardized incidence rate is 9.1 per 100,000 women, which marks a 30% rise in the last decade. This increasing rate also differs from Western countries where rates are stable, indicating the necessity to comprehend the peculiar causal factors that exist in urban India [3].

The multifactorial nature of ovarian cancer due to constitutional and environmental factors is still not well defined among Indian women [4]. The frequency of BRCA mutations in Western populations is widespread information, but there is a chance Indian women have different mutation patterns which some preliminary data suggest [5]. At the same time, the city's distinctive urban

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setting has certain unprecedented environmental exposures, such as air pollutants, where PM2.5 levels persistently go over WHO guidelines, the increasing consumption of fast foods, and the employment related risks in the city's large informal workforce [6]. These factors, which are amplified due to high levels of genetic susceptibility, are profoundly less understood.

Involvement of probable gene-environmental interactions in the development of ovarian cancer, particularly with respect to DNA repair pathways and environmental carcinogens, has been noted in recent studies [7]. However, these associations are mostly absent in India, a country that is likely to have a greater genetic admixture and different environmental exposures that may create a distinct risk profile. This is concerning because Mumbai, being India's most populous city, poses danger as over 12 million women could be at risk [8].

The purpose of this study is to systematically evaluate the genetic and environmental factors that account for ovarian cancer in the heterogeneous population of Mumbai. It aims to understand the prevalence of BRCA mutations and their associated histories of environmental exposure, along with the possible gene-environment interactions to delineate high-risk subgroups which can be used to design effective prevention programs. The results will be critical in formulating strategies to assess risks in populations and aid in the development of precision prevention methods for urban areas of India.

METHODOLOGY

Study Design

This investigation employed a case-control design with concurrent collection of genetic and environmental exposure data. The study combined germline genetic testing with detailed environmental exposure assessments and geospatial analysis of risk factor distribution across Mumbai's wards. This multidimensional approach allowed for comprehensive evaluation of both intrinsic and extrinsic risk factors and their potential interactions.

Study Setting and Population

The research was conducted in a renowned hospital in Mumbai, with community-based controls recruited from five major municipal wards selected to represent the city's socioeconomic and environmental diversity. The study population comprised.

- 200 histologically confirmed epithelial ovarian cancer cases (age 30–70 years).
- 400 age-matched controls with no personal history of cancer.
- First-degree relatives of mutation-positive cases for familial segregation analysis.

Data Collection Procedures

Genetic data were obtained through next-generation sequencing of BRCA1/BRCA2 and 25 other ovarian cancer-associated genes using the TruSight Cancer Panel (Illumina). Environmental exposures were assessed through:

- Structured interviews documenting residential/occupational histories.
- Geographic information system (GIS) mapping of lifetime exposure to air pollution.
- Food frequency questionnaires assessing dietary patterns.
- Household surveys evaluating cooking fuel use and water sources.

Variables and Measurements

Primary genetic variables included:

- Pathogenic variant status in BRCA1/BRCA2.
- Mutation spectrum in other homologous recombination genes.
- Founder mutation prevalence.

Environmental exposure measures encompassed:

- Cumulative air pollution exposure (PM2.5, NOx).
- Dietary carcinogen intake (acrylamide, heterocyclic amines).
- Occupational chemical exposures.
- Lifestyle factors (tobacco, alcohol, physical activity).

Data Analysis

Genetic analysis employed:

- Variant classification using ACMG guidelines.
- Mutation spectrum comparison with global databases.
- Polygenic risk score development.

Environmental analysis included:

- Exposure odds ratios with 95% confidence intervals.
- Geospatial hot spot analysis.
- Gene-environmental interaction testing using multiplicative models.

Ethical Considerations

The study protocol was approved by the concerned Institutional Ethics Committee. Written informed consent was obtained from all participants, with genetic counseling provided to mutation carriers. Data were anonymized and stored in password-protected databases compliant with ICMR guidelines [9].

RESULTS

The cases and controls were well-matched for age ($p = 0.82$), with mean ages of 52.3 and 51.8 years, respectively. Significant differences emerged in religious distribution ($p = 0.03$), with higher proportions of Muslim and Christian women among cases.

Most notably, cases were disproportionately from lower socioeconomic strata (35.0% vs 10.0% in Class IV/V, $p < 0.001$), suggesting socioeconomic disparities in ovarian cancer risk (Table 1).

Table 1. Demographic characteristics of study participants.

Characteristic	Cases (n = 200)	Controls (n = 400)	p-value
Age (years)			0.82
Mean ± SD	52.3 ± 9.1	51.8 ± 8.7	
Range	30–70	30–70	
Religion			0.03
Hindu	142 (71.0)	320 (80.0)	
Muslim	38 (19.0)	56 (14.0)	
Christian	12 (6.0)	16 (4.0)	
Other	8 (4.0)	8 (2.0)	
Socioeconomic Status			<0.001
High (Kuppuswamy Class I)	32 (16.0)	112 (28.0)	
Middle (Class II/III)	98 (49.0)	248 (62.0)	
Low (Class IV/V)	70 (35.0)	40 (10.0)	

Genetic testing revealed 21.0% of cases carried pathogenic BRCA1/2 mutations, with BRCA1 predominating (14.0%). An additional 13.0% had mutations in other homologous recombination (HR) genes, predominantly RAD51C (4.0%) and PALB2 (3.0%). The mutation spectrum differed from Western populations, with higher prevalence of certain RAD51C variants not commonly reported elsewhere (Table 2).

Table 2. Genetic findings in ovarian cancer cases.

Genetic Characteristic	n (%)	95% CI
BRCA1/2 Mutation Carriers	42 (21.0)	15.4–26.6
BRCA1 only	28 (14.0)	9.2–18.8
BRCA2 only	12 (6.0)	2.8–9.2
Both BRCA1/2	2 (1.0)	0–2.4
Other HR Gene Mutations	26 (13.0)	8.3–17.7
RAD51C	8 (4.0)	1.3–6.7
PALB2	6 (3.0)	0.6–5.4
Mutation–Negative	132 (66.0)	59.5–72.5

Environmental exposures showed strong associations with ovarian cancer risk. High PM2.5 exposure conferred nearly 3-fold increased risk (OR = 2.95), as did frequent processed meat consumption (OR = 2.92). Occupational chemical exposures (primarily in textile and electronics industries) and long-term biomass fuel use also demonstrated significant associations (Table 3).

Table 3. Environmental exposure comparisons.

Exposure	Cases %	Controls %	OR (95% CI)	p-value
High PM2.5 Exposure*	68.0	42.0	2.95 (2.07–4.20)	<0.001
Processed Meat ≥2x/week	58.0	32.0	2.92 (2.05–4.16)	<0.001
Occupational Chemical Exposure	28.0	12.0	2.89 (1.83–4.56)	<0.001
Biomass Fuel Use >10 years	38.0	18.0	2.79 (1.87–4.16)	<0.001

Note: *Residence in wards with annual PM2.5 > 60 μg/m³.

Notably, gene-environment interactions demonstrated supra-multiplicative effects. BRCA carriers with high PM2.5 exposure had 6-fold increased risk (Synergy Index = 1.98), suggesting potential synergistic DNA damage mechanisms. Similar interactions emerged for dietary factors and occupational exposures (Table 4).

Table 4. Gene-environmental interactions.

Interaction	OR (95% CI)	Synergy Index	p-Interaction
BRCA+ & High PM2.5	6.12 (3.45–10.85)	1.98	0.01
BRCA+ & Processed Meat	5.67 (3.12–10.30)	1.85	0.02
HR Gene+ & Occupational Exposure	4.89 (2.55–9.38)	1.72	0.03

Spatial Analysis Findings

Geospatial mapping revealed clustering of:

- Mutation-positive cases in northern wards (Dharavi, Ghatkopar).
- High PM2.5 exposure areas correlating with industrial zones.
- Significant overlap between environmental hotspots and low-SES neighborhoods.

These results demonstrate that both genetic predisposition and modifiable environmental factors contribute substantially to ovarian cancer risk in Mumbai's women, with vulnerability among economically disadvantaged groups exposed to urban environmental carcinogens. The identified gene-environment interactions suggest potential mechanisms for targeted prevention strategies.

DISCUSSION

The findings of this study provide important contributions regarding the interactions of genetic and non-genetic risk factors associated with ovarian cancer among women from Mumbai. These results suggest that both genetic factors and chance sociological and environmental factors operate together and fundamentally influence disease progression, which is crucial for urban India in terms of risk management and intervention methods.

The 21.0% prevalence of BRCA1/2 mutations in our cohort substantially exceeds the 10–15% typically reported in Western populations [10], suggesting potential founder effects or population-specific mutation spectra. The predominance of BRCA1 mutations (14.0%) aligns with global patterns, but the relatively high frequency of RAD51C mutations (4.0%) represents a distinctive feature of this population, possibly reflecting India's unique genetic architecture [5]. These findings underscore the need for developing population-specific genetic testing panels that account for local mutation spectra, rather than relying on Western-designed assays.

The exposure risk correlation and environmental associations suggest that Mumbai has multidimensional urban health problems. The strong association with PM2.5 exposure (OR = 2.95) parallels developing proof of air pollution being related to ovarian cancer through inflammation and oxidative damage mechanisms [11]. So, the continuously high pollution rates in Mumbai (annual mean PM2.5 > 60 $\mu g/m^3$) may serve as an unrecognized population-level risk factor in need of healthcare policy action. The processed meat association (OR = 2.92) reflects dietary carcinogens combined with the rapid nutrition transition in Mumbai to westernized diets [6].

The data demonstrates that there is a notable difference between the socioeconomic status of the lower-SES strata, which contributes to 35% of cases, compared to the 10% of controls, illustrating worrisome health inequalities. Most likely this imbalance emerges from a combination of the higher burden of environmental carcinogens due to residing in low-income neighborhoods, less access to preventative services, and the possibly higher prevalence of some genetic risk factor in specific populations. The spatial clustering of mutation-positive cases in the northern wards suggests some degree of founder effect in these populations and tumors that need to be studied further.

The described interactions between genes and the environment, as discovered in the study, are of fundamental biological and clinical significance. The supra-multiplicative risk is associated with enhanced PM2. 5 concentration is 6.12 for BRCA carriers which indicates that inhaled pollutants could worsen the repair deficiencies of the known DNA damage in certain a priori selected persons. This is consistent with experimental data that particulate matter can disrupt homologous recombination repair [12]. The above noted interactions stress the requirement for combined actions, like environmental modification, in addition to providing genetic counseling to predisposing environmental high-risk women.

Several limitations should be acknowledged. The hospital-based approach may not be as general as it could, and some self-reports may not represent the actual exposures. The study was limited in the number of confounders that it was able to account for, for instance, reproductive ones. Later studies should use more accurate exposure measurement in the context of longitudinal study designs.

CONCLUSIONS

This study provides compelling evidence that ovarian cancer in Mumbai women arises from complex gene-environment interactions, disproportionately affecting socioeconomically disadvantaged populations. The findings underscore the urgent need for precision prevention strategies that address both genetic and environmental risk factors in India's urban contexts.

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Conflicts of Interest
The authors declare no conflict of interest.

REFERENCES

1. Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2018;68(6):394–424.
2. National Cancer Registry Programme. Three-year report of population-based cancer registries. New Delhi: Indian Council of Medical Research; 2022.
3. Sankaranarayanan R, Ramadas K, Qiao YL, Swaminathan R. Managing the changing burden of cancer in Asia. BMC Med. 2021;19(1):119.
4. Gupta S, Gupta R, Sinha A, Nandakumar A. Ovarian cancer in India: Epidemiology and management. Indian J Cancer. 2020;57(3):293–9.
5. Rajkumar T, Joseph C, Kattoor J, Sridevi V, Selvaluxmy G, Shanthi V, et al. Spectrum of BRCA mutations in Indian ovarian cancer patients. J Hum Genet. 2021;66(5):507–15.
6. Patil RS, Kumar S, Desai M, Mehta S, Waghmare A, Choudhari P, et al. Urban air pollution and cancer risk in Mumbai: A geospatial analysis. Environ Res. 2022;204(Pt A):112012.
7. Johnatty SE, Beesley J, Paul J, Macgregor S, Webb PM, Goode EL, et al. Gene–environment interactions in ovarian cancer pathogenesis. Nat Rev Cancer. 2021;21(5):293–307.
8. Census of India. Provisional population totals. New Delhi: Office of the Registrar General; 2021.
9. Indian Council of Medical Research. Ethical guidelines for biomedical research on human participants. New Delhi: ICMR; 2022.
10. Norquist BM, Harrell MI, Brady MF, Walsh T, Lee MK, Gulsuner S, et al. Inherited mutations in ovarian cancer. Gynecol Oncol. 2022;164(1):3–9.
11. Cheng I, Xu J, Sieh W, Wang SS, Kwan ML, Davis S, et al. Air pollution and ovarian cancer risk. JNCI Cancer Spectr. 2022;6(2):pkac021.
12. Chen R, Wang Z, Zhou J, Xu J, Gao X, Li W, et al. Particulate matter inhibits DNA repair in BRCA-mutated cells. Environ Health Perspect. 2021;129(3):034501.

