

**Title:**

Sex-Based Analysis of Cancer Mortality and Its Association with Education Levels among Cancer Patients at Tertiary Cancer Centers in Northern India: A Retrospective Study

**Authors:**

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**Background:**

Gender roles and educational attainment significantly shape health-seeking behavior in low- and middle-income countries (LMICs), particularly in the context of cancer. Traditional norms often place women in dependent roles, delaying access to timely medical care and contributing to advanced-stage diagnoses. Education, as a key determinant of health literacy, influences individuals' recognition of early symptoms and prompt health system engagement. In India, where disparities in cancer mortality persist, understanding how sex and education intersect can guide public health strategies for early detection and equitable care.

**Objective:**

To examine sex-based cancer mortality patterns and assess the association between educational status and stage at death among cancer patients treated at tertiary care centers in Northern India.

**Methods:**

This retrospective, quantitative study was conducted at three units of the Tata Memorial Centre (TMC): MPMMCC and HBCH in Varanasi (Uttar Pradesh), and HBCH & RC in Muzaffarpur (Bihar). Data from 2,694 medically certified cancer deaths recorded between January 2019 and December 2022 were analyzed. Information on age, sex, cancer diagnosis, stage at death (metastatic vs. primary), and educational attainment was extracted from Electronic Medical Records (EMRs), MCCD forms, and death reporting forms. Descriptive analyses were performed using Stata version 14 to explore associations between variables.

**Results:**

Among the 2,680 (14 unknown cancer deaths) cancer deaths analyzed (1,535 males, 1,145 females), metastatic-stage deaths outnumbered primary-stage deaths across most educational

categories and cancer types. In females, the leading causes of cancer mortality included breast, gall bladder, ovary, lung, and cervix & uterine cancers. Illiterate women had the highest mortality burden. However, chi-square analyses across each cancer type revealed no statistically significant associations between education level and stage at death (e.g., breast cancer:  $p=0.515$ ; gall bladder:  $p=0.406$ ; ovary:  $p=0.762$ ).

Among males, the primary cancers included lung, oral cavity, gall bladder, tongue, and colorectal cancers. While tongue cancer in males showed a statistically significant association between education and cancer stage ( $p=0.032$ ), other sites such as lung ( $p=0.778$ ) and colorectal ( $p=0.156$ ) did not demonstrate significant associations. When aggregated, both male ( $p=0.278$ ) and female ( $p=0.548$ ) groups showed no significant correlation between education and cancer stage.

**Conclusion:**

The study revealed widespread late-stage (metastatic) presentation among cancer deaths across educational strata and both sexes, with no consistent or statistically significant association between education and stage at death. This trend may be attributed to the tertiary referral nature of the centers, where patients often present after failed or delayed treatment at peripheral institutions. The findings underscore the urgent need to strengthen early detection, referral pathways, and health literacy—especially among low-education and underserved populations.