VOLUME 11 ISSUE 2 2025

ISSN 2454 – 3055

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 11, No. 2, 596-603 (2025)

International Journal of Zoological Investigations
Contents available at Journals Home Page: www.ijzi.net
Editor-in-Chief: Prof. Ajai Kumar Srivastav
Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Breast Cancer: Epidemiology, Mechanisms, Innovations and Challenges in Treatment

Vasantha Galanki[1]*, Alluri Lasya Sri[2] and Baggu Chengalva Ratnam[2]

[1]Departtment of Pharmacology, Vignan Institute of Pharmaceutical Technology (Affiliated to JNTUGV), Duvvada, Vishakapatnam 530049, Andhra Pradesh, India
[2]IV B. Pharmacy, Vignan Institute of Pharmaceutical Technology (Affiliated to JNTUGV), Duvvada, Vishakapatnam 530049, Andhra Pradesh, India

**Corresponding Author*

Received: 21st November, 2024; **Accepted:** 24th April, 2025; **Published online:** 7th October, 2025

https://doi.org/10.33745/ijzi.2025.v11i02.055

Abstract: Breast cancer has been one of the leading health concerns that has been growing at a rapid rate all over the world. The main aim of the review article is to gather all the information and provide a brief and in depth over view of breast cancer and their latest advancements in breast cancer diagnosis, treatment, and prevention. Breast cancer remains one of the most prevalent and deadly cancers affecting women worldwide. The primary or secondary cause of cancer-related mortality for women is breast cancer. The main treatment method for different types of cancer is chemotherapy with drugs. Drug specificity and pharmacokinetic can be changed by nanotechnology using nanoparticles. We reviewed recent literature on genetic markers, innovative imaging techniques, and emerging therapies, including targeted treatments and immunotherapies. Our findings highlight the significant progress in understanding the molecular mechanisms driving breast cancer, which has led to more personalized and effective treatment approaches. Additionally, we discuss the role of lifestyle factors and early detection in improving patient outcomes. Despite these advancements, challenges such as drug resistance and disparities in healthcare access persist. Future research should focus on addressing these issues and further refining therapeutic strategies to enhance the quality of life and survival rates for breast cancer patients.

Keywords: Breast cancer, Nano-technology, Mortality, Cancer

Citation: Vasantha Galanki, Alluri Lasya Sri and Baggu Chengalva Ratnam: Breast cancer: Epidemiology, mechanisms, innovations and challenges in treatment. Intern. J. Zool. Invest. 11(2): 596-603, 2025.

https://doi.org/10.33745/ijzi.2025.v11i02.055

Introduction

The word cancer itself is a broad term. Cancer is commonly called as disease of genes, in this breastcancer is a heterogeneous disease as it has varying etiology response to therapy and progresses. It is a disease that causes the uncontrollable growth of cells either by cell division or cell size. These are called as tumors (WHO). In a functioning human body cell death

plays a key role and this process is called as apoptosis (Sergiusz *et al*., 2021). This function is absent in cancerous cells which leads to accumulation of cells (Tumors)(Menon *et al*., 2024). These tumors in return kill or destroy the other cells as they tend to utilize the nutrition, vitamins, oxygen for the healthy cell. Cancer is the second leading cause of death. The complexity of cancer with its various tissue specific manifestations, complicates diagnosis and treatment. In men prostate, lung cancers are most common followed by Colo-rectal and urinary bladder cancers. In women breast cancer leads in prevalence followed by lung, Colo-rectal, uterine corpus, and thyroid cancer. This indicates that prostate cancer in men and breast cancer in women constitute a major role of cancer diagnosis. In children the most common types include blood cancer along with those effecting brain and lymph nodes. One of the reasons as to why cancer is deadly is the fact that it may occur at any time, anyone regardless of sex, age (Seyed and Mohammadamin, 2017).

Types

There are more than 100 types of cancers. Cancers are usually named after the organ they are affecting e.g., cancer effecting lung is called as lung cancer and cancer effecting brain is brain cancer.

- Appendix cancer, anal cancer
- Bone cancer, bladder cancer
- Cervical cancer, childhood cancer
- Ductal carcinoma in-situ
- Eye cancer, esophageal cancer
- Fallopian tube cancer
- Gastric cancer, gall bladder cancer
- Heart tumors, hairy cell leukemia
- Islet cell tumors, intra ocular melanoma
- Kidney cancer, Kaposi sarcoma
- Lung cancer, liver cancer
- Melanoma, mouth cancer
- Neuroblastoma, non-small cell lung cancer
- Ovarian cancer, oral cancer
- Pancreatic cancer, penile cancer
- Rectal cancer, recurrent cancer
- Salivary gland cancer, skin cancer
- Thyroid cancer, testicular cancer
- Uterine cancer, uterine sarcoma
- Virginal cancer, vulvar cancer
- Wilms tumor and other childhood kidney tumors (NCI)

Breast Cancer

Disease which leads to abnormal growth of breast cells (Tumors) and it is a heterogenous disease. This usually origins at breast cells which later spreads to milk ducts and continues to ductal epithelium and caused by ductal is named as ductal carcinoma and further enter breast lobules also called as lobular carcinoma (Menon *et al*., 2024). Both ductal and lobular carcinomas can exist *in situ*, meaning the cancer remains confined to its original location and has not infiltrated surroundings tissues. They can also be interfering, significantly that they have extended into nearby tissues. This rarely occurs in males (0.5-1%). The major determinants for breast cancer are genetic factors, mainly family history, obesity, diet, smoking, drinking, standards of the country and must attempt to escape using cosmetics which carry estrogen in them. So if it is discovered in the initial stages, treatment can be done easily and effectively (Obeagu and Obeagu, 2024).

It can be self-diagnosed by checking for lumps, swollen breasts, painful breasts. In western countries screening program plays a vital role in identifying most of the breast cancer as compared to identifying through symptoms. But in most of the other parts of the world it is identified by its abnormal nipple discharge or by its mass and is identified by its tissue biopsy, physical examination, breast imaging (Menon *et al*., 2024). One of the reasons for contracting this disease is

genetically (5-10%), social and environmental changes (20-30%). This type of cancer tends to spread to other parts of the body.

According to GLOBO CAN: 2020: reported cases – 2.3M; Deaths – 670,000; In India: reported – 665,255 (In female); Deaths – 98,300.

In male it is seen less likely but it is still very much prevalent (2790 cases have been reported so far in 2024). Low human development index (HDI) indicates that 1 in 27 women are diagnosed and 1 in 48 deaths occur (Jain *et al*., 2020)

Epidimiology

Breast cancer (BC) is the most frequently diagnosed cancer among women globally. BC accounts for 12.5% of all new annual cancer cases worldwide. Breast cancer in female has overhauled lung cancer which is being diagnosed around the world (Ruoxi and Binghe, 2022).

It is the most diagnosed cancer among the U.S. Approximately 13% of U.S women are affected by the breast cancer which is 1 in 8 women and men are also effected which is 1 in 1000. In US the incident rate has been rising along with their age up to the year 2000 (Menon *et al*., 2024). Asia accounts for 44% of the world's BC deaths and 39% of new BC cases. In India breast cancer represents approximately 25% of all female cancer cases. The incidence rate is 25.8 per 100,000 women, and the mortality rate is 12.7 per 100,000 women as of 2017. In highly developed cities like Mumbai and Chennai a greater number of breast cancer has been reported among women which suggests the life style can play a vital role and the urgent need for the spread of awareness among the people. Delhi has the highest incidence rate at 41 per 100,000 women followed by Chennai 37.9 per 100,000, Bangalore 34.4 per 100,000 and Thiruvananthapuram district 33.7 per 100,000 women. The mortality-to-incidence rate is significantly different between rural and urban areas. A concerning trend in India is the increasing incidence of breast cancer among young people, particularly those aged 30-40. Currently among 48% of breast cancer patients are under 50 years old. Over the past 25 years, there has been a noticeable rise in breast cancer cases among women aged 25-40. Surveillance data from 2002 to 2014 across 71 countries reveled that India's 5-year survival rate for breast cancer is 66.1% the lowest among the countries studied (Shreshtha *et al*., 2017).

In recent years, most western countries have seen a decline in breast cancer mortality rates as they developed advanced treatment methods and earlier detection but unfortunately the survival rate for breast cancer patients in India is far less compared to western treatment mainly due to delayed diagnosis, inadequate treatment, onset of disease at early age (Menon *et al*., 2024). The studies have shown that the treatment has been delayed for a minimum of three months thereby leading to poor outcomes.

Risk Factors

It is mainly seen in women (99%) and (0.5-1%) are seen in men. The signs of female include:

- Painful swelling
- Lumps
- Redness
- Dripping of body fluids
- Changes in areolar (WHO)

Some of the risk factors are from different ways like:

- Increasing in age
- Smoking
- Alcohol
- Obesity in post-menopausalwomen
- Late menarche
- Lifestyle
- Low nutrient
- Race
- Genetic (Elizabeth, 2024)

Unfortunately, genetic factors also play a vital role and cannot be prevented. Although the exact cause is unknown there are certain things that tend to increase the risk factors.Family history is the most widely recognized epidemiologic risk factor. First-degree female relatives of women with breast cancer have 2 to 3 times the general population's risk of developing the disease. The risk is even higher if the affected relative was premenopausal with bilateral breast cancer compared to a postmenopausal relative with unilateral breast cancer. First-degree relatives include the patient's mother, sister, or daughter, while second-degree relatives include grand-mothers, nieces, and aunts. Given the knowledge about breast cancer susceptibility genes and potential inheritance from the paternal side, a thorough paternal family history, including relatives with prostate and brain cancers, must be obtained.

Treatment

The treatment aims to kill the cancer cells but, in this process, many normal cells are also killed thereby leading serious effects. Treatment includes:

Chemotherapy: It targets fast dividing cancer cells with specific medications to kill them. These drugs can also reduce tumor size but they may cause various side effects. It can be administered orally,IV, or through injections (Sergiusz *et al*., 2021).

Hormone therapy or endocrine therapy: It involves the usage of drugs that alter the functioning of certain hormones and how the hormones are produced within our body. This approach is common for cancers like prostate and breast cancer where hormones play a key role (Sergiusz *et al*., 2021).

Immunotherapy: It employs various medications and treatment to enhance the immune system's ability to fight cancerous cells (Jun and San-Gang, 2023)

Radiotherapy: It utilizes high doses of radiation to completely eradicate the cancer cells. Doctors may also use it to shrink tumors before surgery or alleviate tumor related symptoms (Sergiusz e*t al*., 2021).

Stem cell transplantation: It is particularly advantageous for blood related cancers such as leukemia or lymphoma. This process involves removing and reintroducing cell which includes red blood cells and WBCs, that chemotherapy or radiotherapy has reduced in the body (Michael *et al*., 2011).

Surgery: It is typically a part of treatment usually done to remove tumors. It also includes removal of lymph nodes to prevent the spread of disease (Sergiusz *et al*., 2021).

Mastectomy: It is a surgical procedure which involves the partial or complete removal of one or both the breasts. It is a procedure which is primarily used in the treatment of breast cancer. It is classified into partial, radical, modified-radical and simple. We can also get information about indications, complications, contra indications (Andrea and Jessica, 2022).

Neo-adjuvant chemotherapy: It is the pre-treatment given before the main surgery to shrink the size of tumors thereby making it easier to remove them (Ruoxi and Binghe, 2022).

Oncoplastic technique: This is surgical approach that combines oncology (branch of medicine that deals with diagnosis and treatment of cancer) with plastic surgery techniques to remove breasts while achieving optimal cosmetic results (Akriti *et al*., 2021).

Nano-Technology

It utilizes nano particles which help in targeted chemotherapy which in turn decreases the casualties of normal healthy cells. More importantly nano medicine has been more advanced in treatment of breast cancer especially in the recent years. We can also lower toxicity (Jain *et al*., 2020).

Various nano particles are used, which include:

- Liposomes
- Polymer nano particles
- Polymeric micelles
- Dendrimers
- Carbon nanotubes.
- Metallic nano particles
- Quantum dots (Manivannan, 2011)

These have been studied extensively for the main function of site-specific drug delivery. Nano particles enhance the distribution of drugs throughout the body, improve their targeting to the diseased tissues, safe guard healthy tissues. These are involved in the synthetic transport and deliver the API (Active Pharmaceutical Ingredient) (Boisseau and Loubaton, 2011)

But even though nano medicine is incredibly useful and more effective we cannot use it to full extent due to lack of complete and thorough research. Thus nano technology should be studied for long term toxicity effects on immunity and stability parameters. Currently it is used along with therapeutic strategies.

Challenges faced with nano technology

Very less clinical studies have been performed on nano technology. Biological challenge includes--Lack of route of administration, Disturbance of bio distribution, Biological barriers,Toxicity, and Degradation.

Nano particles are usually given via intravenous but once they reach target location it is hard for them to stay there due to blood flow. This leads to administration of increased dosage which then leads to occurrence of toxicity. The large scale production of nano particles and gadgets pose another challenge for nano technology. Scaling up of manufacturing unit of nano particles and nano devices is often complex and costly (Khan *et al*., 2024)

Even though nano particles are made to be safe they still tend to effect kidney, lung, liver. This toxicity again depends on: Surface area, Particle size, Particle shape, Agglomeration, Solubility, Hydrophobicity, Surface functionality (Abraham *et al*., 2021)

Nanoparticles tend to mostly accumulate in lungs thereby causing inflammation. Another challenge we face is avoiding the disturbance of MPS (mono-nuclear phagocytic system). Nano particles generally produce PC (Protein Corona) which in turn attacks MPS. To prevent this researchers tried to coat the nano particles. However, this method is proved to be useless.

Thereby we can conclude that even though nano technology has been proved to be useful it has several limitations at *in vitro* and *in vivo* stages, immunotoxicology studies, long term effect, neurological toxicity. Even if the nano vaccines have been improved significantly unfortunately clinical efficacy remains sub-standard and they should be constantly focused designing and developing new nano materials to enhance diagnosis and treatment of diseases with great precision, effectiveness and durability. In order to make use of this nano technology with more efficiency a lot of research studies and tests should be conducted as to make health care more personalized, affordable and safer (Serjay and Nyet, 2021).

Recent Case

Breast cancer is a disease where breast cells grow uncontrollably, forming tumors. If untreated, these tumors can metastasize and become fatal. According to data from the Ministry of Health and Family Welfare, analyzed by News18, India saw approximately 607 new breast cancer cases daily last year, resulting in an average of 226 deaths per day. Uttar Pradesh reported the highest daily cases at about 84 and deaths at 31. The National Cancer Registry Program Report indicates a consistent rise in both cases and deaths related to breast cancer from 2019 to 2023.In 2019, India recorded over 200,000 cases of breast cancer, which increased by about 10 per cent to 220,000 cases in 2023. During the same period, deaths from the disease also rose by approximately 10

Table 1: Estimated Incidence of Cancer Cases in India by different States/UT – Breast Cancer (ICD10: C50) - (2019-2023)-Females (Satyapal *et al*., 2024)

State	2019	2020	2021	2022	2023
Jammu & Kashmir	1763	1812	1864	1915	1967
Ladakh UT	36	37	38	39	40
Himachal Pradesh	1310	1342	1374	1405	1437
Punjab	6037	6192	6347	6507	6667
Chandigarh	161	168	172	176	180
Haryana	4225	4356	4487	4624	4761
Delhi	3373	3491	3609	3734	3859
Bihar	14016	14388	14766	15157	15555
Sikkim	32	33	34	36	36
Tripura	161	167	171	174	179
Andhra Pradesh	10930	11174	11421	11669	11921
Telangana	7302	7491	7679	7872	8066
Karnataka	13085	13427	13774	14126	14484
Kerala	8220	8382	8545	8709	8874
Tamil Nadu	14251	14659	15073	15499	15911
Orissa	7339	7508	7681	7854	8035

Table 2: Estimated Mortality of Cancer cases in India by Different states/UT – Breast cancer (ICD10: C50) – (2019 – 2023) – Females (Satyapal *et al*., 2024)

State	2019	2020	2021	2022	2023
Jammu & Kashmir	656	674	694	712	732
Ladakh UT	13	14	14	15	15
Himachal Pradesh	487	499	511	523	535
Punjab	2246	2303	2361	2421	2480
Chandigarh	60	62	64	65	67
Haryana	1572	1620	1669	1720	1771
Delhi	1255	1299	1343	1389	1436
Bihar	5214	5352	5493	5638	5786
Sikkim	12	12	13	13	13
Tripura	60	62	64	65	67
Andhra Pradesh	4066	4157	4249	4341	4435
Telangana	2716	2787	2857	2928	3001
Karnataka	4868	4995	5124	5255	5388
Kerala	3058	3118	3179	3240	3301
Tamil Nadu	5301	5453	5607	5765	3926
Orissa	2730	2793	2857	2923	2989

per cent, from 74,481 to 82,429. From 2019 to 2023, Uttar Pradesh reported 146,000 cases of breast cancer. Maharashtra followed with 93,130 cases, West Bengal with 82,939, Tamil Nadu with 75,413, and Bihar with 73,882. The total deaths in these states ranged from 54,500 in Uttar Pradesh to 27,500 in Bihar during this period. In Delhi, breast cancer cases increased from 3,373 in 2019 to 3,859 in 2023. Over the five years, the city reported a total of 18,066 cases, with 6,722 related deaths. Annual deaths in Delhi rose from 1,255 in 2019 to 1,436 in 2023. The states with the highest number of breast cancer cases and deaths were Uttar Pradesh, Maharashtra, West Bengal, Tamil Nadu, and Bihar (Singh, 2023). Table 1 illustrates estimated incidence of cancer in India during 2019-2023 in various states.

According to the Global Cancer Observatory, breast cancer is the most prevalent type of cancer in worldwide, with an estimated 665,000 female deaths in 2022. India has the highest number of estimated breast cancer deaths in that year. Table 2 presents the estimated mortality of cancer cases during2019-2023 in various states of India (Vasantha and Kiranmai, 2024; Vasantha *et al.,* 2024)

Conclusion

Number of cancer services are increasing day by day for the better treatment. Efforts of breast cancer activities should increase to spread awareness among common people. There must be increased public understanding about what breast cancer is, how it is affected, its symptoms and treatment. Research should be continuous for long term to improve treatment. The main goal is to cure, improve the lifestyle for cancer serious prolong life expectancy. Proper funds should be provided by government and other organizations.

Ethical Statement

This is a review article hence no Ethical Approval needed.

Author Contributions

Each author has contributed equally to the study's planning, analysis, writing, and editing. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

References

Abraham DJ, Sharifzadeh G, Nahum V and Hosseinkhani H. (2021) Safety evaluation of nanotechnology products. Pharmaceutics 13(10): 1615.

Akriti N, Hu J, Hodgkinson S, Ali S, Rainsbury R and Roy PG. (2021) Oncoplastic breast-conserving surgery for women with primary breast cancer. Cochrane Database Syst Rev. 10(10): CD013658.

Andrea G, Menon G and Jessica R. (2022) Mastectomy, StatPearls. https://www.ncbi.nlm.nih.gov/books/NBK538212/

Boisseau P and Loubaton B. (2011) Nanomedicine, nanotechnology in medicine, Comptes Rendus Physique 12(7): 620-636.

Elizabeth B. (2024), What to Know About breast cancer. https://www.medicalnewstoday.com/articles/37136

Jain V, Kumar H, Anod HV, Chand P, Gupta NV, Dey S and Kesharwani SS. (2020) A review of nanotechnology-based approaches for breast cancer and triple-negative breast cancer. J Control Release 326: 628-647.

Jun W and San-Gang W. (2023) Breast cancer- an overview of current therapeutic strategies, challenge and perspectives. Breast Cancer (Dove Med Press) 15: 721-730.

Khan MYA, Nafisa SE, Tahrim HM and Kala R. (2024) A review on nano technology and its impact with challenges on electrical engineering. Control Systems Optimization Letts. 2(1): 82-89.

Manivannan R. (2011) Nano technology: A review, J Appl Pharmaceut Sci 1(2): 8-16.

Menon G, Alkabban FM, Ferguson T. Breast Cancer. 2024 Feb 25. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan–. PMID: 29493913.

Michael RB, Alyea EP 3rd, Cairo MS, Falkenburg JH, June CH, Kröger N, Little RF, Miller JS, Pavletic SZ, Porter DL, Riddell SR, van Besien K, Wayne AS, Weisdorf DJ, Wu RS, Giralt S. (2011) National Cancer Institute's First International Workshop on the Biology, Prevention, and Treatment of Relapse after Allogeneic Hematopoietic Stem Cell Transplantation: summary and recommendations from the organizing committee. Biol Blood Marrow Transplant. 17(4):

443-454.

National Cancer Institution website (NCI). https://www.cancer.gov/types

Obeagu EI and Obeagu GU. (2024) Breast cancer: A review of risk factors and diagnosis. Medicine (Baltimore) 103(3): e36905.

Ruoxi Hong and Binghe X. (2022) Breast cancer- an up to date review and future perspective. Cancer Communications 42(10): 913-936.

Satyapal GK, Haque R and Kumar N. (2024) Gamma irradiation in modulating arsenic bioremediation potential of *Pseudomonas* sp. AK1 and AK9. Int J Radiation Biol. 100(6): 934-939.

Sergiusz Ł, Czeczelewski M, Forma A, Baj J, Sitarz R and Stanisławek A. (2021) Breast cancer-epidemiology, risk factors, classification, prognostic markers, and current treatment strategies-An updated review. Cancers (Basel) 13(17): 4287.

Serjay S and Nyet Kui W. (2021) Nanotechnology and its use in imaging and drug delivery (review). Biomed Rep. 14(5): 42.

Seyed HH and Mohammadamin D. (2017) Review of cancer from perspective of molecular. J Cancer Res Practice 4(4): 127-129

Shreshtha Malvia, Sarangadhara AB, Dubey US and Saxena S. (2017): Epidemiology of breast cancer in Indian women. Asia Pac J Clin Oncol. 13(4): 289-295.

Singh N. (2024) Numberspeak India Reported over 600 cases of breast cancer, 226 related deaths daily in 2023. https://www.news18.com/india/numberspeak-india-reported-over-600-cases-of-breast-cancer-226-related-deaths-daily-in-2023-up-tops-charts-8782371.html

Vasantha G and Kiranmai S. (2024) Navigating the complexities of cancer drugs-Understanding the side effects and treatment strategies. Indian J Natural Sci. 15(85): 78834-78843.

Vasantha G, Lahari P and Divya P. (2024) Nano-carrier based intranasal drug delivery system. Indian J Natural Sci. 15(86): 81438-81439.

WHO (World Health Organization) (https://www.who.int/news-room/fact-sheets/detail/breast-cancer).