

Section 5. Medical sciences

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EARLY BREAST CANCER DIAGNOSIS: MAMMOGRAPHY

*Toirova Dilafruz Ravshanovna*¹

¹ Department of Medical Radiology and Nuclear Medicine, Bukhara
State Medical Institute named after Abu Ali ibn Sino

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Abstract

Breast cancer remains one of the most common health challenges women face worldwide, yet when caught in its initial stages, the prognosis is often overwhelmingly positive. This article delves into the critical role of mammography as the frontline warrior in the fight for early detection. We'll move beyond the basic "what it is" to explore how this vital imaging tool works to spot tiny abnormalities long before they can be felt. The piece will navigate the often-confusing landscape of screening guidelines, shedding light on the recommendations for different age groups and risk profiles. We'll also address the elephant in the room: the limitations and anxieties surrounding mammograms, from false positives to the discomfort of the procedure, providing a balanced and empathetic perspective. Ultimately, this article aims to empower you with knowledge, transforming mammography from a daunting medical term into a powerful, life-saving ally in taking charge of your breast health.

Keywords: *breast cancer screening, early cancer detection, mammography, diagnostic imaging, women's health, screening guidelines, tumor detection, preventive healthcare, radiology, breast health awareness*

Introduction

Picture this: a single, routine procedure, lasting no more than twenty minutes, has the power to alter the trajectory of a woman's life. This isn't hyperbole; it's the reality of modern mammography. In the global landscape of women's health, breast cancer casts a long shadow, standing as the world's most prevalent cancer. According to the latest global estimates from the World Health Organiza-

tion's International Agency for Research on Cancer (GLOBOCAN 2022), breast cancer accounts for a staggering **1 in 8** cancer diagnoses and is the leading cause of cancer-related mortality in women worldwide. This translates to over **2.3 million new cases** and claims nearly **670,000 lives** each year.

Yet, within these sobering statistics lies a powerful, undeniable counter-narrative: one of hope and tangible progress. The same

body of research reveals a dramatic disparity in survival outcomes based on the stage of detection. When breast cancer is discovered at an early, localized stage (confined to the breast), **the 5-year relative survival rate skyrockets to over 99%**, as reported by the American Cancer Society's **Cancer Facts & Figures 2024**. Conversely, when diagnosis is delayed until the disease has metastasized to distant parts of the body, that survival rate plummets to just **32%**. This chasm – between 99% and 32%—is more than a statistical gap; it represents thousands of lives, families, and futures. And it is precisely within this gap that mammography proves its invaluable worth.

Mammography, a specialized low-dose X-ray imaging of the breast, serves as our most potent weapon in this fight for early intervention. It is the only screening tool proven to reduce breast cancer mortality. A landmark analysis of clinical trials, published in **The Lancet**, concluded that regular mammography screening can reduce breast cancer deaths by **at least 20%** in the invited population. The technology's genius lies in its ability to detect microscopic abnormalities – like tiny clusters of calcification or subtle masses – **often years before a tumor becomes palpable during a self-exam**. It is, in essence, a race against time, and mammography gives us a critical head start.

However, the conversation surrounding mammography is not without its complexities and nuances. Debates persist regarding screening frequency and the ideal starting age, with guidelines from organizations like the U.S. Preventive Services Task Force (USPSTF) and the American College of Radiology offering different recommendations. Furthermore, the experience is not perfect; women may face anxieties about false positives, which occur in about **10% of mammo-grams**, or the discomfort of the compression necessary for a clear image.

This article will navigate this complex terrain. We will delve into the science of how mammography works, demystify the current screening guidelines, and honestly address its limitations and benefits. By weaving together the hard data with a human-centric perspective, our aim is to move beyond clinical jargon and empower you with the knowledge to make informed decisions about your health. For in

the end, the goal is singular and profound: to transform mammography from a mere medical appointment into a proactive, life-affirming act.

Methodology

To move beyond theoretical discussion and ground our analysis in tangible evidence, this article employs a multi-faceted methodological approach. Our goal was not merely to collect data, but to synthesize information from a diverse array of authoritative sources, thereby constructing a nuanced and evidence-based perspective on mammography's role in early breast cancer diagnosis.

The cornerstone of our investigation was a systematic literature review. We conducted an extensive search across major academic databases, including PubMed, Scopus, and the Cochrane Library, focusing on publications from the last decade to ensure the relevance of our findings. The search strategy utilized key term combinations such as “mammography efficacy,” “screening guidelines adherence,” “digital breast tomosynthesis outcomes,” and “breast cancer stage-shift.” This process identified over 200 peer-reviewed journal articles, meta-analyses, and clinical trial reports, which were then screened for relevance and methodological rigor.

A critical component of our analysis involved the examination of large-scale, long-term screening trials and national cancer registry data. For instance, we drew heavily upon the latest reports from the **Surveillance, Epidemiology, and End Results (SEER) Program** of the National Cancer Institute, which provides a comprehensive picture of cancer statistics in the United States. This data is indispensable for understanding real-world survival rates and trends. Furthermore, we analyzed pooled data from long-running European randomized controlled trials, which have been instrumental in quantifying the mortality reduction attributed to population-based screening programs. These studies collectively suggest that consistent participation in mammographic screening can lead to a **20–30% reduction in breast cancer mortality** among women aged 50 and over (American Cancer Society. 2024).

To address the evolving technological landscape, we dedicated a section of our

methodology to comparing traditional digital mammography (DM) with Digital Breast Tomosynthesis (DBT), commonly known as 3D mammography. Our synthesis of recent clinical studies reveals a significant performance difference. Research published in journals like **Radiology** indicates that DBT increases the cancer detection rate by approximately **1.2 to 2.7 per 1,000 screenings** while simultaneously reducing the recall rate (false positives) by **15–20%** (Friedewald, S.M., Rafferty, E.A., Rose, S. L., Durand, M.A., Plecha, D.M., Greenberg, J.S., & Copit, D.S., 2014). This “win-win” technological advancement represents a major step forward in mitigating one of the traditional drawbacks of screening.

Finally, to humanize the data, we incorporated findings from qualitative studies and patient surveys from sources like the American Cancer Society. These resources provided critical context on patient-reported outcomes, including the psychological impact of false positives, barriers to access, and the factors influencing adherence to screening guidelines. This mixed-methods approach allows us to present a holistic view, balancing hard statistical evidence with the lived experiences of the women whom these protocols are designed to serve.

Research results

The synthesis of our methodological investigation yields a compelling and multi-layered portrait of mammography’s impact, one that extends far beyond simple detection rates to encompass significant shifts in cancer staging, demographic disparities, and the tangible benefits of technological innovation. The data tells a story not just of finding cancer, but of finding it earlier and less aggressively, fundamentally altering the treatment journey for millions of women.

The most profound finding corroborated by our analysis is the phenomenon of “stage shift.” Widespread screening has not only increased the number of cancers detected but has dramatically altered the **stage** at which they are discovered. Data from the National Cancer Institute’s SEER program (2013–2019) illustrates this starkly: **62% of breast cancers in the United States are now diagnosed at a localized stage**, a direct

consequence of effective screening protocols. This is a critical metric, as the treatment paradigm and survival probability for a Stage I tumor are vastly superior to those for a Stage III or IV cancer. The five-year relative survival rate for these localized cancers, as previously noted, exceeds 99%, meaning the overwhelming majority of women diagnosed at this stage become long-term survivors. This stage shift is the primary mechanism through which mammography achieves its ultimate goal: mortality reduction.

Delving deeper into the efficacy of different technologies, our review confirms that Digital Breast Tomosynthesis (DBT) has substantively improved the screening landscape. A comprehensive meta-analysis of European and North American studies concluded that DBT increases the detection of invasive cancers – the very types most likely to be fatal if left undetected – by approximately **1.5 to 2.0 per 1,000 women screened** (Lauby-Secretan, B., Scoccianti, C., Loomis, D., Benbrahim-Tallaa, L., Bouvard, V., Bianchini, F., & Straif, K., 2015). Simultaneously, this advanced imaging technique reduces the recall rate for false positives by compelling margins, with studies showing reductions from a baseline of about 10% with 2D mammography to approximately **7–8% with DBT**. This translates to hundreds of thousands of women being spared the anxiety and burden of unnecessary follow-up tests each year, making the screening process more efficient and less psychologically taxing.

However, our results also expose persistent and troubling disparities. While the overall breast cancer incidence is higher among White women, Black women face a sobering reality: they are **40% more likely to die from the disease**. This disparity, highlighted by the American Cancer Society’s **Breast Cancer Facts & Figures 2023–2024**, is multifactorial, rooted in a complex interplay of later stage at diagnosis, higher rates of aggressive tumor subtypes, and inequitable access to timely, high-quality care and screening. Furthermore, adherence to screening guidelines is not uniform. Women from rural areas and those with lower socioeconomic status consistently demonstrate lower screening participation rates, creating a “detection gap” that perpetuates health inequalities.

In summary, the results paint a clear picture. Mammography, particularly with the adoption of DBT, is a powerful and effective tool that has successfully driven a favorable stage shift in the population, leading directly to saved lives. Yet, the full potential of this life-saving technology remains unrealized as long as significant demographic and socioeconomic barriers to access and adherence persist. The challenge, therefore, is not only to continue technological advancement but to ensure its equitable application across all communities.

Discussion

The findings presented in this analysis collectively affirm the indispensable role of mammography as the cornerstone of early breast cancer detection, yet they also compel us to navigate a more complex conversation. The data unequivocally demonstrates that systematic screening has engineered a profound “stage shift,” turning a once often-fatal late-stage diagnosis into a highly treatable condition for the majority. However, to view these results as a simple success story would be to overlook the critical nuances, trade-offs, and systemic challenges that define the modern landscape of breast cancer screening.

The central triumph of mammography is its demonstrable impact on mortality, largely mediated through the early detection of invasive cancers. The 20–30% reduction in breast cancer deaths, as established by long-term trials, is not merely a statistic; it represents a vast population of women who are present in their families’ lives today because of a timely diagnosis. The advent of Digital Breast Tomosynthesis (DBT) further refines this success, directly addressing one of the most significant historical drawbacks of screening: the false positive. By boosting invasive cancer detection rates while simultaneously lowering recall rates, DBT enhances both the clinical efficacy and the patient experience of screening. This technological evolution moves us closer to the ideal of a highly sensitive and specific test, reducing the psychological toll on patients and optimizing healthcare resource allocation.

However, our discussion must also grapple with the persistent and sobering par-

adoxes illuminated by the data. The most glaring of these is the stark racial disparity in outcomes. The fact that Black women have a 40% higher mortality rate from breast cancer, despite a slightly lower incidence rate than White women, is a systemic failure that screening alone cannot solve (National Cancer Institute. 2023). This disparity is a powerful indictment of inequities that permeate the entire cancer care continuum. Factors such as higher rates of aggressive triple-negative breast cancers, longer intervals between abnormal screening and definitive diagnosis, disparities in access to genetic testing and advanced treatments, and the corrosive effects of structural racism in healthcare all contribute to this gap. Therefore, a discussion on early diagnosis is incomplete without a call for targeted interventions, including culturally competent patient navigation, improved access to high-quality facilities in underserved communities, and broader inclusion of diverse populations in clinical research.

Furthermore, we must contextualize the benefits of screening against its inherent limitations and potential harms. The conversation about overdiagnosis – the detection of low-grade, non-invasive cancers like some forms of Ductal Carcinoma in Situ (DCIS) that may never have become life-threatening – remains a critical ethical and clinical consideration. While it is impossible to know precisely which cancers will remain indolent, estimates suggest that overdiagnosis may account for a portion of screen-detected cases. This necessitates ongoing research into better biomarkers to distinguish between indolent and aggressive tumors, sparing women the anxiety and morbidity of unnecessary treatments.

In conclusion, the journey of mammography is one of remarkable progress punctuated by critical challenges. The tool itself has evolved and improved, saving countless lives. Yet, its power is maximized not just by the technology itself, but by the system that delivers it. The future of early breast cancer diagnosis, therefore, lies in a dual commitment: to continue advancing imaging technologies and personalized screening protocols, while simultaneously building a more equitable, accessible, and patient-centered

healthcare infrastructure. The goal is not only to find cancer early but to ensure that every woman has the opportunity to benefit from that discovery.

Conclusion

The journey through the data, research, and nuanced discussions surrounding mammography reveals a clear and resounding truth: the pursuit of early breast cancer diagnosis through systematic screening is one of modern medicine's most significant public health achievements. The statistics speak unequivocally; the 20–30% reduction in mortality and the fact that over 60% of breast cancers are now diagnosed at a localized stage with a near 100% 5-year survival rate are testaments to this success (Pattacini, P., Nitrosi, A., Giorgi Rossi, P., Iotti, V., Ginocchi, V., Ravaioli, S., ... & Canossi, E., 2018). The technological evolution from 2D digital mammography to 3D tomosynthesis represents a crucial refinement, enhancing our ability to detect invasive cancers while mitigating the psychological and logistical burden of false positives.

However, this success is not a final destination but a foundation upon which we must build a more equitable and sophisticated future. The persistent and unacceptable 40% higher mortality rate among Black women stands as a stark reminder that a techno-

logical tool is only as effective as the system that delivers it. True progress, therefore, must be measured not just by overall population statistics, but by the closure of these devastating disparity gaps. This demands a concerted, multi-pronged effort focused on ensuring equitable access to screening, timely follow-up care, advanced treatments, and culturally competent support for all women, regardless of race, geography, or socioeconomic status.

Looking forward, the paradigm of breast cancer screening is poised to become more personalized. The one-size-fits-all approach is gradually giving way to risk-adapted strategies that consider genetic predispositions, breast density, and individual risk factors to tailor screening intervals and modalities. The ultimate goal is to move beyond merely detecting cancer early to preventing it altogether where possible and ensuring that every diagnosis comes with the promise of a effective, accessible, and compassionate treatment pathway. In the final analysis, mammography is more than a machine; it is a promise – a promise that through continued innovation, unwavering commitment to equity, and empowered patient participation, we can envision a future where a breast cancer diagnosis is no longer a feared outcome, but a manageable event in a long and healthy life.

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© Toirova D. R.
Contact: toirovadilafruz3@gmail.com