BMC Public Health

RESEARCH

Open Access

Prevalence and associated factors of mammography uptake among the women aged 45 years and above: policy implications from the longitudinal ageing study in India wave I survey

Priyanka Sharma[1†], Dipak Das[3†], Divya Khanna[2,4*†], Atul Budukh[3,4], Anita Khokhar[5], Satyajit Pradhan[4,6], Ajay Kumar Khanna[7], Pankaj Chaturvedi[4,8,9] and Rajendra Badwe[4,8]

Abstract

Background Breast cancer emerged as number one cancer among women worldwide in terms of incidence and mortality. Majority of breast cancers diagnosed in India are among women aged 45 years and above. A low proportion of Indian female population in reproductive age group (30–49 years) underwent breast cancer screening. The national operational framework includes mammography as one of the investigation modalities under the algorithm for early detection and management of breast cancer. This study describes prevalence and associated factors of mammography uptake in women aged 45 years and above.

Methods We utilized data from 35,083 women aged ≥ 45 years in the Longitudinal Aging Study of India, a nationwide representative survey of the Indian population. The outcome variable was self-reported history of undergoing mammography in past two years before the survey as a representation of early detection of breast cancer. Demographic, behavioural, and clinical characteristics were taken as independent variables. Univariable and multivariable models were applied for the following age groups: 45–59 years and ≥ 60 years, and unadjusted and adjusted odds ratios were calculated.

Results The prevalence of mammography was 1.3% among Indian women aged 45 years and above, 1.7% among 45–59 years and 0.9% among women ≥ 60 years. The highest prevalence was reported in Kerala and the lowest was in Nagaland. Among women in 45–59 years age group, secondary or higher education, being currently in union, having diabetes, neurological illness, hearing problems, and reproductive health problems, better cognition level, and self-history of cancer were found to be associated with increased mammography uptake. Urban residence, being

†Priyanka Sharma, Dipak Das and Divya Khanna equally contributed to this manuscript as first authors.

*Correspondence:
Divya Khanna
dkhannakgmc@gmail.com

Full list of author information is available at the end of the article

currently in union, having bone/joint disease, hearing problem, and one or multi-morbidity, better cognition level and self and family history of cancer were associated with higher mammography uptake among elderly women.

Conclusions Low rates of mammography among women across the country, along with inter-state disparities, highlight inadequate coverage of early detection of breast cancer under National program. Increasing burden of breast cancer in all states underscores need to implement early detection program proactively. Disparities in mammography uptake by age, residence and co-morbidities reflect the need for special focus and context-specific research for pragmatic interventions.

Keywords Breast cancer, Mammography, Early detection, Healthcare disparities, Lower- and middle-income countries, India

Background

Globally, female breast cancer emerged as the second-leading cancer in terms of incidence and the fourth-leading cause of cancer mortality [1]. In 2022, 157 out of 185 countries have reported breast cancer as the leading cancer site among women [1]. As per the projected global estimates, by 2040, the incidence will rise by 41% and mortality by 51.8%.[2] The situation in India is no different, where breast cancer has surpassed cervical cancer as the number one cancer in women [2]. Recently, the National Cancer Registry Programme reported a significant rising trend of breast cancer incidence in India across all population-based cancer registries (PBCRs) [3]. Some of the reasons for this increase are rapid urbanization, demographic transition, westernized lifestyle, low breastfeeding rates, substance use and obesity [4–8]. The registries established by Tata Memorial Centre in different parts of India also show breast cancer as the predominant cancer in women with age-adjusted rates in the range of 12.2 (Sindhudurg, a district in Maharashtra state) to 30.2 (Chandigarh, a Union Territory) per 100,000 population [9, 10].

Although the incidence of breast cancer in India is much lower than that of the Western population, the mortality rate is higher or comparable to that of developed countries [2]. This can be attributed to several reasons, including but not limited to (i) the median age of Indian breast cancer patients, which is a decade younger than Western counterparts, with younger age of presentation generally associated with aggressive breast cancer, (ii) delayed detection leading to diagnosis in advanced stage due to poor screening coverage and various community and system-related barriers, (iii) high burden of triple-negative breast cancer and breast cancer gene mutations in Indian population which are generally associated with poor prognosis [7].

Therefore, the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke (NPCDCS) has recommended screening through clinical breast examination (CBE) for women aged 30–65 years at 5-year intervals [11]. Together with regular clinical examinations and monthly breast self-examinations, radiological investigations, including ultrasonography for women < 40 years and mammography among women aged ≥ 40 years, are key elements in the early diagnosis of breast cancer [11]. However, the latest National Family Health Survey (NFHS-5) reported that only 1% of the Indian female population in the reproductive age group (aged 30–49 years) underwent breast cancer screening through CBE [12, 13]. A recent review reported that only 5% of Indian women aged 40 years or above participated in breast cancer screening services [14]. This is much lower than the recommended guidelines of 70% coverage [15]. Previous research has explored barriers in the early detection of cancer among reproductive age group women, but the middle-aged and elderly population is traditionally neglected. The nationwide data for breast cancer screening comes mainly from the NFHS. However, this survey does not include women aged 50 years and above.

The epidemiology and management of breast cancer among premenopausal and peri/postmenopausal women are different with regards to (i) late detection because of higher breast density in premenopausal Asian women, (ii) specific molecular subtypes presentation with distinct prognosis and management in menopausal women, and (iii) variable outcomes of breast cancer in younger and older patients [16]. The median age of breast cancer diagnosis in India is 49 years [17], and about 75% of estimated breast cancer cases (132252/178361) for the year 2020 occurred in women > 45 years of age in India [2]. Therefore, understanding the behaviour for accessing the early detection services for breast cancer and the associated factors in this age group will be most beneficial and might give the highest yield.

To date, there is a paucity of representative data for the utilisation of breast cancer early detection services among women aged 45 years and above in India. This study utilises data from the Longitudinal Aging Study of India (LASI) [18], a nationally representative survey amongst the Indian population aged 45 years and above for estimating the prevalence and associated factors of mammography which can serve as a representative for

the utilisation of breast cancer early detection services in Indian women aged ≥ 45 years.

Methods

Data sources and participants

The present study is derived from the first wave of the LASI, a cross-sectional nationwide representative survey, data from 72,250 Indian population aged 45 years and above and their spouses. LASI is conducted by the International Institute of Population Sciences (IIPS), Mumbai, India, in collaboration with T.H. Chan School of Public Health, USA and the University of Southern California (USC), USA. In 2017-18, the survey covered 29 states and six union territories (excluding Sikkim). This survey aimed to study the health status and the social and economic well-being of older adults in India. The survey employed a multi-stage, stratified area probability cluster sampling design, with three-stage sampling in rural areas and four-stage sampling in urban areas, to generate national and state-level estimates. The survey included households with at least one person aged 45 or older and gathered information about the economic, social, health, and functional aspects of all adults aged 45 or older and their spouses, regardless of age. In total, 72,250 participants (both men and women aged 45 or older and their spouses) took the survey, with an individual participation rate of 87.3% [18]. We utilized the data of 35,083 women ≥ 45 years of age for our study to calculate mammography prevalence and associated factors and created heat maps for the state-wise prevalence of mammography.

Ethical consideration

The LASI received ethical approval from the Indian Council of Medical Research (ICMR), and all respondents provided written or oral informed consent [18]. This study derived the findings based on secondary survey data available in the public domain, and therefore, no further IRB approval was required from the authors' institutions for this manuscript. All the methods followed relevant guidelines and regulations following the Declaration of Helsinki.

Patient and public involvement

Patients and the public were not involved in the design or the planning of this secondary data analysis. The data was extracted from the LASI, Wave-I, 2017–2018 database and contained no personal identifying information.

Study variables and outcome

The study outcome variable was the self-reported history of undergoing mammography in the two years preceding the survey. Based on existing literature, the following explanatory variables were included in our study:

a. Demographic characteristics like age, place of residence for rurality and Indian state of residence, socio-economic status (SES as monthly per capita expenditure categorized into five quintiles by LASI), education, caste, and tribal status, working status, marital status, living arrangement (alone or with others and satisfaction with the living arrangement), household size, life satisfaction, health insurance.
b. Behavioral characteristics included the history of tobacco, alcohol, and physical activity frequency.
c. Clinical characteristics included self-reported chronic health conditions such as cancer, cardiovascular diseases (CVD), chronic obstructive pulmonary disease (COPD), diabetes mellitus (DM), hypertension (HTN), bone and/or joint diseases, ophthalmological problems, stroke, hearing problem, neurological problems, and injuries. Any reproductive health-related problems and depression were also included. The weight and height of the study participants were recorded.
d. Functional characteristics included the use of hearing aids, cognition (correctly recalls set of words), self-rated health, and variables representing daily function limitations.
e. Self and family histories of cancer were also asked from the study respondents.

Assessment of the study variables

Overweight and obesity variables were derived according to the Body Mass Index (BMI) classification for the World Health Organization (WHO) guidelines for the Asian population using the height and weight data recorded in the survey. BMI between 23.0 and 24.99 kg/m^2 was categorized as overweight and ≥ 25.0 kg/m^2 as obesity.

Depression was measured using the 10-item Center for Epidemiological Studies-Depression (CES-D) scale. The 10 items included three positive symptoms (feeling hopeful, happy, and satisfied) and seven negative symptoms (feeling depressed, trouble concentrating, fear of something, low energy, bothered by things, feeling alone, and everything is an effort). Response options included rarely or never (< 1 day), sometimes (1 or 2 days), often (3 or 4 days), and most or all the time (5–7 days) in a week before the interview. For negative symptoms, rarely or never (< 1 day) and sometimes (1 or 2 days) were scored zero, and often (3 or 4 days) and most or all the time (5–7 days) categories were scored one. Scoring was reversed for positive symptoms. The overall score ranges from zero to 10, and scores of ≥ 4 are used to calculate the prevalence of depressive symptoms [19]. We defined multi-morbidity if the respondent was diagnosed by a health professional with at least two chronic health conditions.

Daily functions were assessed by having participants complete the Activities of Daily Living (ADL) and Instrumental Activities of Daily Living (IADL) questionnaires. To identify ADL limitations, LASI respondents were asked if they had any of the following limitations and expected the limitation to last for more than three months: difficulty with dressing, walking across the room, bathing, eating, getting in or out of bed, or using the toilet (including getting up and down). In the LASI, respondents were asked if they were having any difficulties that were expected to last more than three months, such as preparing a hot meal, shopping for groceries, making a telephone call, taking medications, doing work around the house or garden, managing money (such as paying bills and keeping track of expenses), and getting around or finding an address in unfamiliar places. All LASI survey participants were asked about using any aid or supportive device to assist them in their ADL. Any aid or supportive devices include hearing aid, spectacles/contact lenses, dentures, and any aid for physical disabilities, such as walker/walking sticks, wheelchairs, adjustable shower tools/ commodes, back/neck collar, any orthosis or prosthesis, and any other aid.

Statistical analysis

We generated a dichotomous variable for mammography status and calculated the prevalence of mammography in women aged ≥ 45 years. To understand the geographical variations and clustering of mammography prevalence among women aged 45 years and above ($n = 35083$) throughout the different states of India, a heat map was constructed with ArcGIS 10.8. A mix of colour coding was used from brown (lowest) to maroon (highest) and converting the undefined states to black. The prevalence (expressed as a percentage) was classified into five quantiles or classes (< 0.5, 0.5–0.99, 1-1.49, 1.5-2, and > 2). The States Reorganization Act of 1956 divided Indian states into six regions, namely- Northern, Northeastern, Central, Eastern, Western and Southern regions. We used the same categorization to calculate the regional prevalence for women aged ≥ 45 years. Weighted prevalence was calculated for the age groups 45–59 years ($n = 18,717$) and ≥ 60 years ($n = 16,366$), as different age groups can have unique health and socio-demographic characteristics.

To understand the association of the explanatory variables with mammography in the different age groups, univariate models were applied for the following age groups: 45–59 years and ≥ 60 years and unadjusted odds ratios (with 95% Confidence Interval (CI) were calculated. The variables found significant on univariable analysis (p-value < 0.20) were entered into multivariable models [20], after excluding multi-collinearity through the variance inflation factor. Through multivariable logistic regression, we estimated adjusted odds ratios (AOR with 95% CI) of the association between mammography uptake and the above-mentioned explanatory variables. Information regarding education and working status was missing for more than half of the study participants, so these variables were not included in the multivariable model. Among women aged ≥ 60 years, data related to reproductive health problems was available for only eight participants, so it was excluded from uni- and multivariable analysis. Missing data were excluded from the study. A table detailing the list of variables and their corresponding missing data has been included in the appendix file (Supplementary Material 1).

Stata 13 was utilized for all analyses, applying sampling weights at both household and individual levels to address the complex multi-stage sampling method. Following recommendations from the main survey report, these weights helped mitigate bias resulting from the survey design, varying sampling rates, non-responses, and post-stratification adjustments. Statistical tests were reported as significant at p values < 0.05.

Results

Among the 35,083 women (aged ≥ 45 years), the overall prevalence of mammography was 1.3%. It was 1.7% among women aged 45–59 years and 0.9% among women aged ≥ 60 years. Less than one-fourth (7604; 21.7%) of participants had health insurance coverage. The majority were from rural backgrounds (22535; 64.2%). Nearly one-third belonged to the poor wealth quintile (11631; 33.1%), from scheduled caste and tribes (12432; 35.4%), were unmarried or not living with a partner (12846; 36.6%), and never/rarely watched television or listened to radio (11522; 32.8%).

Disparity in mammography prevalence among women ≥ 45 years in different States/Union territories

Figure 1 represents the prevalence of mammography in different states and Union territories in India according to the LASI survey findings. The highest prevalence of mammography was reported in Kerala (4.5%), followed by Karnataka (2.9%) and Lakshadweep (2.7%). Nagaland reported the lowest prevalence (0%), followed by Andhra Pradesh (0.1%), Uttarakhand (0.27%) and Assam (0.28%).

Predictors of mammography among women in 45–59 years' age group

The prevalence of mammography was significantly lower among the women aged 45–59 years residing in northern (AOR: 0.46; 95% CI: 0.31–0.69), eastern (AOR: 0.53; 95% CI: 0.35–0.83) and northeastern regions (AOR: 0.48; 95% CI: 0.26–0.86) compared to their southern counterparts. Mammography prevalence was significantly lower in women from other castes (AOR: 0.66; 95% CI: 0.48–0.92) than in the general caste. Women currently in the

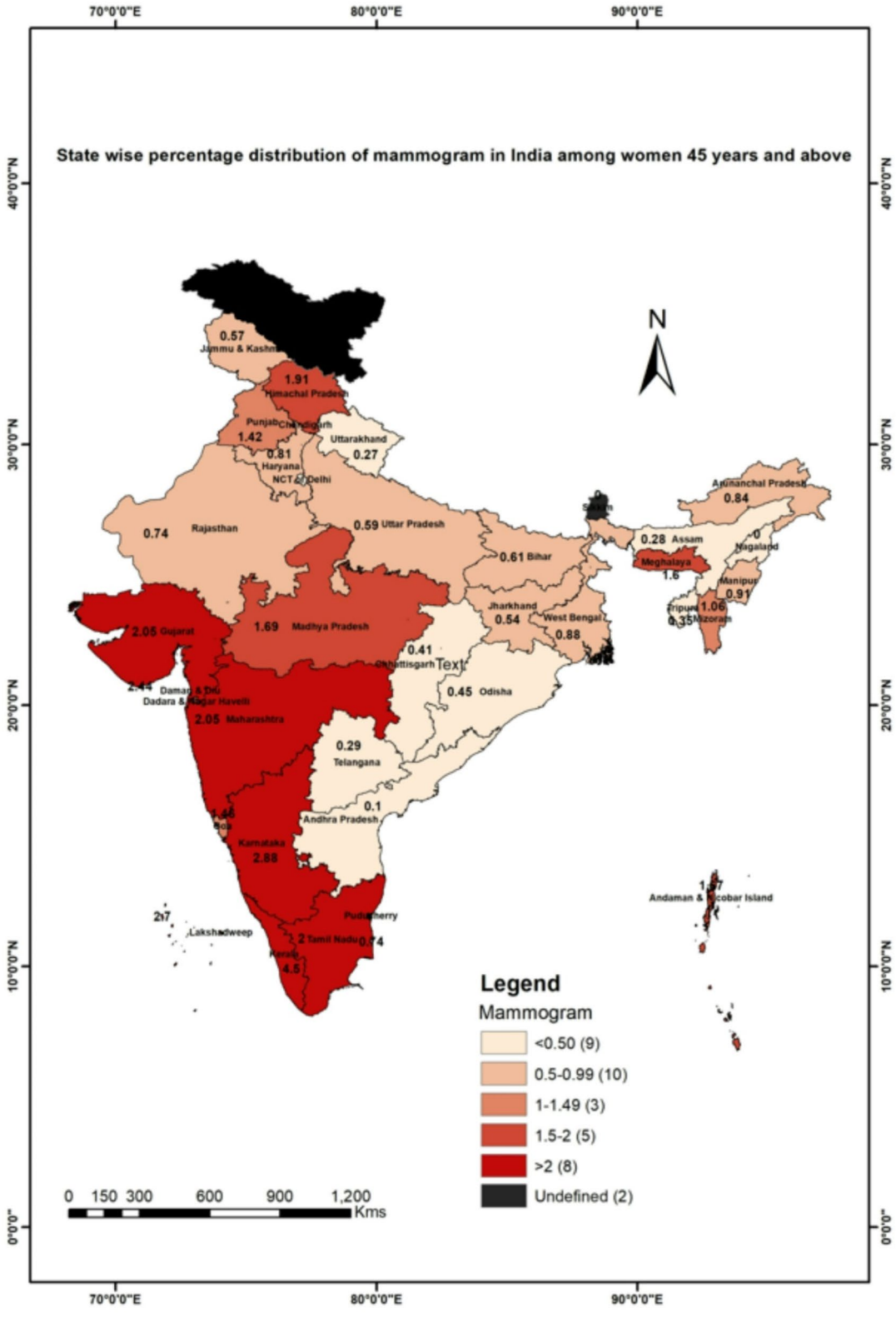

Fig. 1 State/UT-wise Mammography uptake prevalence in women aged ≥ 45 years in India

union had higher odds (AOR: 1.43; 95% CI: 1.02–2.01) of undergoing mammography testing than their counterparts. Tobacco users had lower odds (AOR: 0.58; 95% CI 0.36–0.92) of getting mammography than non-users. Women who rated their health as good were less likely to undergo mammography (AOR: 0.67; 95% CI: 0.45–0.99) than those who rated their health as poor. A diagnosis of DM (AOR: 1.57; 95% CI: 1.11–2.22), neurological illness (AOR: 1.89; 95% CI: 1.01–3.55), and hearing problems (AOR: 1.62; 95% CI: 1.03–2.56), self-reported by women, were positive predictors of mammography. Those with better cognition had higher odds (AOR: 1.59; 95% CI: 1.22–2.08) of undergoing mammography than their counterparts. Women who self-reported a history of cancer were ten times (AOR: 10.63; 95% CI: 6.39–17.71) more likely to undergo mammography than those who did not have cancer. Education and wealth displayed a significant association with mammography in univariable analysis, revealing higher mammography prevalence among women with higher education and wealth status than women with lower education and wealth. (Table 1)

Predictors of mammography among women in the 60 years and above age group

Among women aged ≥ 60 years, the prevalence of mammography was significantly lower in northern regions (AOR: 0.48; 95% CI: 0.27–0.85) compared to those residing in the southern region. Elderly women residing in urban areas were two times (AOR: 2.01; 95% CI: 1.39–2.89) more likely to undergo mammography than their rural counterparts. Currently living in the union was a positive predictor (AOR: 1.69; 95% CI: 1.20–2.40) for mammography uptake. Women having bone or joint diseases (AOR: 1.61; 95% CI: 1.11–2.32), hearing problems (AOR: 2.06; 95% CI: 1.32–3.21), and at least one morbidity (AOR: 3.6; 95% CI: 1.06–12.59) or multi-morbidities (AOR: 5.06; 95% CI: 1.38–18.48) were more likely to undergo mammography. Better cognition was positively associated (AOR: 1.57; 95% CI: 1.10–2.22) with mammography uptake. Elderly women with a history of cancer or a family history of cancer had 15-(AOR: 15.33; 95% CI: 8.63–27.22) and 2- times (AOR: 1.89; 95% CI: 1.13–3.18) higher odds of undergoing mammography, respectively than those who did not have any such history. (Table 2) The predictors of mammography uptake have been summarized in Table 3.

Discussion

Estimating the prevalence of mammography uptake among women aged ≥ 45 years in India serves as a pivotal indicator for evaluating the coverage of early detection of breast cancer within this demographic group. WHO advocates regular screening through CBE as the best approach for breast cancer prevention in low- and middle-income countries (LMICs) [8]. India, facing constraints of a large population and limited resources, has opted for CBE as the screening method of choice [11]. Screened-positive individuals are referred for an age-appropriate radiological examination (mammography and ultrasonography) through the established referral pathways under the national operational framework for cancer control [11]. While CBE is conventionally recommended, a notable gap exists in the availability of data regarding CBE coverage among women aged ≥ 50 years in previous national surveys [12]. Consequently, we turned to the assessment of available data for mammography uptake prevalence as a representative measure for the coverage of early detection services for breast cancer in women aged ≥ 45 years. We believe this is the first nationwide representative study to estimate the prevalence of mammography among women aged ≥ 45 years in India. This population-based cross-sectional study assessed mammography uptake disparities and associated factors in more than 35,000 women aged ≥ 45 years. As this age group comprises the highest burden and mortality due to breast cancer [21], the prevalence of mammography uptake in this age group can significantly reflect upon the early detection of breast cancer and the overall mortality and incidence rates.

Prevalence of mammography uptake

We found that only 1.3% of women aged ≥ 45 years reported undergoing mammography in the two years preceding the survey. The reported prevalence is much lower than the findings across the globe, where mammography rates ranged from 4.5% (in African countries) and 40-59.7% (mainly in Asian countries like Korea, Japan, Taiwan, and Singapore) to 84% (in European and American populations) in the similar age groups [22–32]. Poor knowledge, familial negligence, stigma, inefficient referral system, paucity of essential healthcare infrastructure in regional centres, inaccessibility of diagnostic centres, inadequate and incomplete treatment and follow-up, are some of the major reasons resulting in poor coverage of early diagnosis services and subsequently late detection and increased mortality due to cancer in LMICs [33–35]. The situation in India is no different. As CBE is the preferred screening tool for LMICs, including India, and only screen-positive individuals are referred for mammography, low rates of mammography uptake may partly reflect upon the inadequate coverage of breast cancer prevention and control programs in our country. This is evident from findings of NFHS-5 where < 1% of women in the 30–49 years age group ever underwent CBE [12]. The health infrastructure required for cancer care is insufficient in the national three-tier health system and in existing cancer programs [36]. There is a scarcity of trained medical professionals in remote areas

Table 1 Distribution of women (aged 45–59 years) undergoing mammography according to socio-demographic characteristics ($n = 18717$)

Characteristics	Sample distribution	Weighted prevalence (%)	ORC (95% CI)	ORA (95% CI)
Residence				
Rural	11,887	1.2	Reference	Reference
Urban	6830	2.8	**2.09 (1.64–2.65)***	1.27 (0.96–1.68)
Region				
South	4324	3	Reference	Reference
North	3974	0.9	**0.49 (0.34–0.71)***	**0.46 (0.31–0.69**)*
West	3092	2.1	0.97 (0.70–1.33)	1.01 (0.69–1.45)
North-East	2466	0.5	**0.27 (0.16–0.47)***	**0.48 (0.26–0.86)***
East	3527	0.8	**0.52 (0.36–0.75)***	**0.53 (0.35–0.83)***
Central	1334	1.6	0.61 (0.37–1.02)	0.89 (0.51–1.54)
Wealth quintile				
Poor	6144	1.1	Reference	Reference
Middle	6243	2.5	**1.39 (1.02–1.89)***	1.13 (0.82–1.58)
Rich	6330	1.5	**1.43 (1.05–1.94)***	1.08 (0.77–1.51)
Education#				
No education or < primary	1822	1.4	Reference	----------
Primary complete	2412	1.5	1.19 (0.73–1.95)	----------
Secondary	3136	2.6	**1.84 (1.18–2.88)***	----------
Higher secondary and above	1420	5.2	**2.47 (1.53-4)***	----------
Working status#				
Not Working	2588	1.4	Reference	----------
Working	7413	1.2	0.75 (0.52–1.09)	----------
Category				
General	6590	1.1	Reference	Reference
Scheduled Caste and Tribes	7003	2.1	**0.63 (0.46–0.85)***	0.96 (0.69–1.36)
Others	4434	1.9	**0.69 (0.51–0.92)***	**0.66 (0.48–0.92)***
Household size				
> 6 members	6275	1.9	Reference	----------
1–5 members	12,442	1.7	1.28 (0.98–1.66)	----------
Marital status				
Single/widowed/divorced	4064	1.1	Reference	Reference
In union	14,653	1.9	1.28 (0.94–2.17)	1**.43 (1.02–2.01**)*
Living arrangement				
Living Alone	465	0.7	Reference	----------
Living with others	18,252	1.8	1.14 (0.51–2.58)	----------
Satisfaction with the living arrangement				
Not satisfied	750	1.6	Reference	----------
Satisfied	14,848	1.9	0.89 (0.51–1.57)	----------
Neither satisfied nor dissatisfied	2867	0.9	0.54 (0.28–1.05)	----------
Perceived life satisfaction				
Not satisfied	3219	1.5	Reference	----------
Satisfied	12,279	1.4	1.23 (0.88–1.73)	----------
Neither satisfied nor dissatisfied	2901	3.1	0.97 (0.62–1.53)	----------
Health-insurance status				
No	14,222	1.6	Reference	----------
Yes	4315	2.4	1.13 (0.86–1.48)	----------
Tobacco use				
No	3235	0.9	Reference	Reference
Yes	15,334	1.9	**0.43 (0.28–0.66)***	**0.58 (0.36–0.92)***
Alcohol use				
No	751	0.1	Reference	Reference
Yes	17,824	1.8	**0.17 (0.04–0.7)***	0.28 (0.68–1.13)

Table 1 (continued)

Characteristics	Sample distribution	Weighted prevalence (%)	ORC (95% CI)	ORA (95% CI)
Physical activity				
Never	11,535	1.4	Reference	Reference
Regularly	4085	3	**0.69 (0.5–0.95)***	0.93 (0.66–1.31)
Rare	2925	1.2	**0.64 (0.44–0.93)***	0.89 (0.61–1.32)
Cardiovascular disease				
No	18,265	1.7	Reference	Reference
Yes	404	2.5	**2.11 (1.17–3.8)***	1.09 (0.56–2.15)
Chronic Obstructive Pulmonary Disease				
No	17,960	1.7	Reference	Reference
Yes	709	1.8	**1.9 (1.19–3.05)***	1.23 (0.73–2.08)
Diabetes Mellitus				
No	16,698	1.4	Reference	Reference
Yes	1968	4.3	**2.52 (1.89–3.36)***	**1.57 (1.11–2.22)***
Hypertension				
No	13,695	1.5	Reference	Reference
Yes	4972	2.6	**1.72 (1.34–2.2)***	1.01 (0.73–1.39)
Bone/joint disease				
No	15,875	1.7	Reference	Reference
Yes	2794	1.9	**1.89 (1.43–2.49)***	1.14 (0.82–1.60)
Neurological illness				
No	18,322	1.5	Reference	Reference
Yes	342	14	**2.5 (1.39–4.5)***	**1.89 (1.01–3.55)***
Cancer				
No	18,523	1.6	Reference	Reference
Yes	145	21.5	**16.96 (10.96–26.25)***	**10.63 (6.39–17.71)***
Ophthalmological morbidity				
No	10,548	1.3	Reference	Reference
Yes	8117	2.4	**2.5 (1.94–3.21)***	1.15 (0.78–1.69)
Stroke				
No	18,541	1.7	Reference	Reference
Yes	128	5.9	**3.36 (1.47–7.69)***	1.59 (0.61–4.21)
Hearing problem				
No	17,803	1.7	Reference	Reference
Yes	861	2.5	**2.19 (1.45–3.3)***	**1.62 (1.03–2.56)***
Injury or fall				
No	16,725	1.8	Reference	----------
Yes	1936	1	0.9 (0.6–1.35)	----------
Co-morbidity				
No disease	6334	0.7	Reference	Reference
One morbidity	5979	1	**2.23 (1.49–3.32)***	1.41 (0.87–2.23)
Multi morbidity	6358	3.5	**4.64 (3.23–6.66)***	1.38 (0.73–2.57)
Activities of daily living limitation (ADL)				
No	16,838	1.7	Reference	Reference
Yes	1879	2	**2.33 (1.73–3.13)***	1.34 (0.93–1.93)
Instrumental activities of daily living limitation (IADL)				
No	13,074	1.9	Reference	Reference
Yes	5643	1.4	**1.32 (1.03–1.7)***	1.08 (0.81–1.45)
Uses any aid/supporting device				
No	12,308	1.2	Reference	Reference
Yes	6326	2.9	**2.58 (2.02–3.28)***	1.32 (0.96–1.82)
Self-rated health				
Poor	2460	2.6	Reference	Reference
Average	8003	1.8	**0.55 (0.41–0.75)***	0.85 (0.61–1.20)

Table 1 (continued)

Characteristics	Sample distribution	Weighted prevalence (%)	ORC (95% CI)	ORA (95% CI)
Good	8131	1.4	**0.38 (0.27–0.52)***	**0.67 (0.45–0.99)***
Reproductive health problems				
No	15,695	1.5	Reference	Reference
Yes	2874	2.8	**2.84 (2.2–3.66)***	**2.29 (1.73–3.02)***
Cognition				
Up to 5 words	10,021	1.7	Reference	Reference
Above 5 words	8436	1.8	**1.83 (1.43–2.34)***	**1.59 (1.22–2.08)***
Depression				
No	15,265	1.7	Reference	Reference
Yes	3229	2	**1.49 (1.12–1.97)***	1.17 (0.85–1.61)
Overweight and obesity				
No	9029	2	Reference	----------
Yes	7525	1.5	1.24 (0.95–1.6)	----------
Family history of cancer				
No	17,583	1.5	Reference	Reference
Yes	1005	3.1	**2.05 (1.38–3.04)***	1.29 (0.83–2.01)

#- omitted due to missing data

*- significant association

ORA- Odds ratio adjusted

ORC- Odds ratio crude

CI- Confidence interval

who can conduct CBE. Socio-cultural and economic factors further aggravate the problem of poor coverage [37]. Mammography facilities required to diagnose suspicious lesions are scarce in rural areas. Ultrasound is a valuable diagnostic tool regulated by the Pre-conception and Prenatal Diagnostic Techniques (Prohibition of Sex Selection) Act, 1994, to prevent misuse for sex determination and ensure ethical practices in prenatal care. The Act requires that only qualified providers in registered facilities perform ultrasonography. While essential for public interest, these regulations may limit access in rural areas with fewer registered setups, highlighting the need for strategies to improve availability in underserved regions.

Disparity in mammography uptake

The disparity in the prevalence of mammography was evident across different states of India (range: 0.0% in Nagaland state to 4.5% in Kerala state). The country's southern region was found to have a higher prevalence of mammography compared to the northern and northeastern states. This inter-state disparity within the country in mammography uptake can be explained by the interplay of multiple socio-demographic as well as healthcare-related contextual factors such as (i) better literacy, socio-economic status and health literacy in southern states, (ii) hard-to-reach terrains and limited health infrastructure in northeastern states (iii) focused women cancer research in southern and central states such as Tamil Nadu, Kerala and Maharashtra, (iv) poor cancer awareness and limited infrastructure in states with lower development indicators such as Uttar Pradesh, Bihar, Jharkhand, Chhattisgarh and many other states (iv) active government-led early detection programmes such as the Tamil Nadu Health Systems Project [38–42]. Furthermore, the highest age-adjusted rates for breast cancer have been observed in the Southern regions as reported by registries under the National Cancer Registry Programme and Tata Memorial Centre. This could also have been partially attributed to higher mammography testing in these regions [3, 6]. However, breast cancer rates are increasing in all the PBCRs of India. Therefore, it is essential that early detection efforts are not restricted to just some parts of the nation; they should be intensified in all the states and regions.

Socio-demographic factors associated with mammography uptake

Mammography prevalence was higher in women aged 45–59 compared to those aged ≥ 60 years, consistent with prior studies indicating older women are less likely to undergo mammography [26, 43]. However, conflicting results have also been reported in the literature [23, 27, 31]. On univariable analysis, a higher proportion of educated women underwent mammography than those with lower or no education, akin to the results of other studies [14, 24, 26, 31, 43, 44]. Similarly, a higher proportion of women in upper wealth quintiles were likely to get mammography than the lower ones, in line with other studies [14, 24, 26, 31, 44].

Educated women are likely to have better health literacy, health-seeking behaviour and higher autonomy to access screening services for cancer, leading to higher

Table 2 Distribution of women (aged 60 years and above) undergoing mammography according to socio-demographic characteristics ($n = 16366$)

Characteristics	Sample distribution	Weighted prevalence (%)	ORC (95% CI)	ORA (95% CI)
Residence				
Rural	10,648	0.5	Reference	Reference
Urban	5718	1.6	**3.24 (2.36–4.47)***	**2.01 (1.39–2.89)***
Region				
South	3785	0.9	Reference	Reference
North	3490	0.5	**0.38 (0.23–0.62)***	**0.48 (0.27–0.85)***
West	2923	1.4	0.88 (0.59–1.3)	1.11 (0.69–1.75)
North-East	1970	0.4	**0.18 (0.08–0.42)***	0.47 (0.17–1.24)
East	3141	0.5	**0.42 (0.26–0.69)***	0.61 (0.34–1.11)
Central	1057	1.2	0.51 (0.25–1.04)	1.17 (0.54–2.58)
Wealth quintile				
Poor	5487	0.7	Reference	Reference
Middle	5465	0.9	**1.67 (1.1–2.55)***	1.34 (0.43–1.18)
Rich	5415	1.1	**2.04 (1.36–3.07)***	1.33 (0.85–2.10)
Education#				
No education or < primary	1597	1.4	Reference	----------
Primary complete	1484	1.4	1.37 (0.75–2.52)	----------
Secondary	1307	1.5	**2.29 (1.3–4.01)***	----------
Higher secondary and above	568	3.9	**3.84 (2.1–7.02)***	----------
Working status#				
Not Working	5365	1.1	Reference	----------
Working	2976	62	0.61 (0.36–1.01)	----------
Category				
General	4248	1.3	Reference	Reference
Scheduled Caste and Tribes	5429	0.6	**0.35 (0.22–0.55)***	0.72 (0.44–1.19)
Others	6105	0.8	0.72 (0.5–1.02)	0.81 (0.54–1.22)
Household size				
> 6 members	5516	0.7	Reference	Reference
1–5 members	10,850	1	**1.47 (1.03–2.09)***	1.46 (0.99–2.16)
Marital status				
Single/widowed/divorced	8782	0.7	Reference	Reference
In union	7584	1.1	**1.62 (1.18–2.22)***	1**.69 (1.20–2.40)***
Living arrangement				
Living Alone	1257	0.5	Reference	----------
Living with others	15,109	0.9	1.62 (0.79–3.3)	----------
Satisfaction with the living arrangement				
Not satisfied	825	1	Reference	----------
Satisfied	12,189	0.9	0.78 (0.42–1.45)	----------
Neither satisfied nor dissatisfied	2906	0.5	0.46 (0.22–0.98)	----------
Perceived life satisfaction				
Not satisfied	2952	0.7	Reference	----------
Satisfied	10,379	1	1.36 (0.88–2.12)	----------
Neither satisfied nor dissatisfied	2501	0.6	0.83 (0.45–1.56)	----------
Health-insurance status				
No	12,942	0.9	Reference	----------
Yes	3289	0.8	1.17 (0.81–1.69)	----------
Tobacco use				
No	12,520	0.9	Reference	Reference
Yes	3743	0.8	**0.5 (0.31–0.78)***	0.75 (0.45–1.56)
Alcohol use				
No	15,583	0.9	Reference	----------
Yes	685	1.1	0.72 (0.3–1.77)	----------

Table 2 (continued)

Characteristics	Sample distribution	Weighted prevalence (%)	ORC (95% CI)	ORA (95% CI)
Physical activity				
Never	12,568	0.9	Reference	Reference
Regularly	1990	0.7	0.68 (0.4–1.17)	0.83 (0.46–1.51)
Rare	1702	0.4	**0.48 (0.24–0.94)***	0.63 (0.29–1.31)
Cardiovascular Disease				
No	15,656	0.8	Reference	Reference
Yes	686	1.9	**2.17 (1.25–3.78)***	1.21 (0.66–2.18)
Chronic Obstructive Pulmonary Disease				
No	15,222	0.8	Reference	Reference
Yes	1120	1.4	**1.81 (1.12–2.93)***	1.13 (0.68–1.95)
Diabetes Mellitus				
No	13,927	0.7	Reference	Reference
Yes	2416	1.7	**2.09 (1.47–2.96)***	1.02 (0.68–1.53)
Hypertension				
No	9986	0.7	Reference	Reference
Yes	6355	1.2	**2 (1.47–2.73)***	0.91 (0.62–1.33)
Bone/joint disease				
No	12,975	0.7	Reference	Reference
Yes	3368	1.4	**2.45 (1.79–3.37)***	**1.61 (1.11–2.32)**
Neurological illness				
No	15,902	0.9	Reference	----------
Yes	440	1.1	1.39 (0.7–3.15)	----------
Cancer				
No	16,209	0.7	Reference	Reference
Yes	134	20.2	**22.52 (13.84–36.63)***	**15.33 (8.63–27.22)***
Ophthalmological morbidity				
No	7259	0.5	Reference	Reference
Yes	9078	1.2	**2.75 (1.9–3.97)***	1.12 (0.69–1.81)
Stroke				
No	15,994	0.9	Reference	----------
Yes	347	0.2	1.16 (0.43–3.16)	----------
Hearing problem				
No	14,794	0.8	Reference	Reference
Yes	1542	1.3	**2.19 (1.47–3.27)***	**2.06 (1.32–3.21)***
Injury or fall				
No	14,074	0.8	Reference	----------
Yes	2258	1	1.3 (0.86–1.95)	----------
Co-morbidity				
No disease	3495	0.2	Reference	Reference
One morbidity	4595	0.5	**3.82 (1.46–9.99)***	**3.6 (1.06–12.59)**
Multi morbidity	8254	1.3	**11.45 (4.68–27.98)***	**5.06 (1.38–18.48)**
Activities of daily living limitation (ADL)				
No	12,393	0.7	Reference	Reference
Yes	3973	1.3	**1.78 (1.29–2.45)***	1.36 (0.94–1.97)
Instrumental activities of daily living limitation (IADL)				
No	7781	0.7	Reference	----------
Yes	8585	1	1.03 (0.76–1.41)	----------
Uses any aid/supporting device				
No	9443	0.6	Reference	Reference
Yes	6878	1.3	**2.45 (1.77–3.37)***	1.21 (0.82–1.78)
Self-rated health				
Poor	4026	1.3	Reference	Reference
Average	7160	0.8	**0.51 (0.36–0.73)***	0.74 (0.51–1.10)

Table 2 (continued)

Characteristics	Sample distribution	Weighted prevalence (%)	ORC (95% CI)	ORA (95% CI)
Good	4834	0.6	**0.43 (0.28–0.65)***	0.66 (0.40–1.07)
Reproductive health problems#				
No	7	0	----------	----------
Yes	1	100	----------	----------
Cognition				
Up to 5 words	11,314	0.8	Reference	Reference
Above 5 words	4441	1.2	**2.01 (1.46–2.76)***	**1.57 (1.10–2.22)***
Depression				
No	12,953	0.7	Reference	Reference
Yes	3002	1.4	**1.68 (1.18–2.38)***	1.41 (0.95–2.07)
Overweight and obesity				
No	7783	0.9	Reference	----------
Yes	6719	0.9	0.98 (0.7–1.38)	----------
Family history of cancer				
No	15,444	0.8	Reference	Reference
Yes	769	2.2	**2.86 (1.78–4.6)***	**1.89 (1.13–3.18)***

#- omitted due to missing data

*- significant association

ORA- Odds ratio adjusted

ORC- Odds ratio crude

CI- Confidence interval

Table 3 Factors associated with mammography uptake among Indian women aged 45 years and above

Explanatory variables included	Women aged 45–59 years*	Women aged ≥ 60 years*
Socio-demographic characteristics: Age, place of residence, wealth quintile, education, caste, tribal status, working status, marital status, living arrangement, household size, life satisfaction, health insurance	-Place of residence (rural/urban) -Geographical region -Wealth status -Caste -Marital status	-Place of residence (rural/urban) -Geographical region -Marital status
Behavioral characteristics: History of tobacco and alcohol use, and physical activity frequency.	-Tobacco use	-
Clinical characteristics: History of cancer, cardiovascular diseases, chronic obstructive pulmonary disease, diabetes mellitus, hypertension, bone and/or joint disease, ophthalmological problems, stroke, hearing problem, neurological problems, injuries, reproductive health problems, overweight, obesity, depression, and multi-morbidity (at least two chronic health conditions).	-Cancer -Diabetes Mellitus -Neurological illness -Hearing problems -Reproductive health problem	-Cancer -Hearing problems -Bone and joint diseases -Any one morbidity -Multi-morbidity
Functional characteristics: Daily function limitations such as Activities of Daily Living (ADL), and Instrumental Activities of Daily Living (IADL), use of hearing aids, cognition, and self-rated health, and using any supporting device or aid.	-Self-rated health -Cognition	-Cognition
Family history	-	-Family history of cancer

*Variables found significant on multivariable analysis

screening uptake [45]. Enhanced coverage of breast cancer screening invariably results in higher utilization of mammography services [14]. Interventions such as improving awareness for early detection of breast cancer through community health educators, patient navigation, offering free and mobile mammography, and availability of trained primary care providers who can recommend mammography to eligible women through regular visits can be effective in increasing the mammography uptake rates among women aged ≥ 45 years [43, 45]. Affordability through universal health coverage is critical to lessen the socioeconomic disparities in health practices [46]. Health insurance has been consistently linked to an increased likelihood of medical examinations among women, as indicated by prior studies [14, 24, 28–31, 43]. While our study produced similar findings, they did not

reach statistical significance in regression analysis. Nonetheless, these results suggest the potential importance of health insurance in promoting healthcare access and merit further exploration. Monitoring indicators for early detection programs can further minimize socio-economic differences and enhance health service uptake [47].

We observed that more urban women underwent mammography than rural ones in the elderly age group, similar to the findings of Mahumud RA [14]. Still, no such association was found among women aged 45–59 years. In addition to the previously discussed factors, the paucity of sophisticated mammography testing facilities, their regular maintenance, and the lack of adequately trained manpower for mammography interpretation are more pronounced in rural areas in our country. A study on NFHS-5 data also reported similar findings for women in the reproductive age group [12, 48]. Poor transportation facilities coupled with restricted mobility due to various co-morbidities further aggravate the misery, especially in rural elderly women [45]. Previous studies have highlighted the detrimental effects of rural settings in the form of delayed diagnosis, poor survival and higher mortality among patients with cancer [21, 49]. Mobile-based breast health promotion and early detection of cancer through community health workers guided by smartphone applications, similar to the POSHAN tracker for malnourished children, can be developed, introduced and promoted in low-resource settings to target women from rural areas to improve the uptake of health services [14, 50].

Being in a union was positively associated with undergoing mammography, which is in tune with findings of previous studies [26, 31, 37], suggesting that married individuals are more likely to engage in healthy behaviour and preventive healthcare than unmarried ones. It is well documented that having a partner is a motivating factor for self-care, healthier lifestyles, and compliance with regular check-ups [51]. This can also be partly due to better socio-economic status among married women and, thus, better access to healthcare [52].

Behavioural factors associated with mammography uptake

Lower mammography testing among tobacco users in the 45–59 years' age group, similar to other studies [25, 26, 31, 43, 51, 53, 54], signifies the lower uptake of preventive behaviors among them. They are ignorant regarding their health status and the harmful effects of tobacco. They are also more likely to engage in other detrimental health choices like alcohol use, inadequate physical activity and unhealthy dietary intake [55, 56]. Another explanation could be that their knowledge about the ill effects of tobacco may discourage them from availing of early detection services due to pessimistic and avoidant beliefs about cancer [57]. Lower rates of mammography among tobacco users could lead to more advanced presentation and poor outcomes [54]. Additionally, a study reported that married people who quit tobacco are more likely to have a health insurance plan compared to single individuals, which can positively affect participation in the early detection of cancer [53].

Clinical and functional factors associated with mammography uptake

We observed that women with cancer were more likely to undergo mammography, which is in concordance with the findings of a previous study [31]. This phenomenon can be attributed to two factors: (i) healthcare providers may routinely advise mammography as part of standard care practices for cancer patients, and (ii) personal experiences of cancer diagnosis likely enhance awareness, motivating survivors to undergo regular check-ups. Higher odds of undergoing mammography were also found among women with a family history of cancer, akin to studies conducted in other parts of the world [57, 58]. This could be attributed to improved health literacy among these women and healthcare providers recognizing the increased risk associated with personal or family cancer history and recommending mammography accordingly [59].

Women with better cognition were more likely to undergo mammography than those with poor cognition, similar to other studies [60, 61]. Co-morbidities, especially diabetes, were positive predictors of mammography in our study. This is in tune with the results of several previous studies [24, 25, 32, 62]. This could be because of more physician interactions among women with pre-existing morbidities, which might increase the likelihood of cancer screening recommendations, including mammography. Women who receive such recommendations are more likely to get a mammography than women who did not receive any such recommendation [24].

Furthermore, DM and cancer share common risk factors, which could also prompt physicians to recommend mammography among diabetic women [63]. Mammography uptake was positively associated with DM which also suggest a potential avenue for targeted interventions and early detection strategies. Advocating integrated healthcare to address diabetes management and breast cancer detection through collaborative efforts of primary care providers, endocrinologists, surgeons, and oncologists will facilitate holistic healthcare. Hearing problems were found to be positively associated with mammography. However, Kushalnagar P found no difference in mammography uptake rates among hearing-impaired and hearing-abled women [64].

Limitations

This study has several limitations. The survey was cross-sectional; therefore, temporal association between variables could not be assessed. In addition, changes in prevalence over time could not be commented upon. The reference period for mammography in LASI was two years. Therefore, we could not estimate the lifetime prevalence of mammography among women aged ≥ 45 years. However, as most of the consensus guidelines recommend annual or biannual mammography screening intervals, our findings remain valid and highlight inadequate coverage of breast cancer prevention services. The responses for many variables were self-reported and, therefore, are subject to information bias. The data lacks information related to CBE, so that could not be assessed. Additionally, as we utilized the secondary data collected in LASI, in which information about mammography was based on self-reports, we could not distinguish whether the mammograms were conducted for early detection or for diagnostic evaluation. The information regarding the availability of mammography facilities could not be included in the analysis, as it was not a part of the LASI survey.

Information regarding the major determinants that could have important policy implications, such as breast diseases and related complaints, perception and awareness regarding mammography, barriers, and facilitators to mammography uptake, were unavailable. This has also limited our scope for qualitative assessment of the LASI survey data. While this limitation exists, it is important to note that our study still provides valuable insights into the coverage of early detection of breast cancer through mammography. Despite the low number of self-reported breast cancer cases, our findings remain informative in understanding the extent of coverage of breast cancer detection services within our studied population. As the present study specifically targeted mammography uptake among women aged ≥ 45 years, aligned with early detection services outlined in national guidelines, the data on mammography can reflect service coverage within this age group.

Strengths

We believe that this study pioneers estimating the prevalence of mammography among women aged ≥ 45 years in India. We utilised the data from a nationally representative survey, enhancing our study findings' generalizability. Our study facilitates inter-state comparisons by delineating the state-wise prevalence of mammography, thereby enriching the discourse on regional disparities. A comprehensive inclusion of potential explanatory variables, encompassing socio-demographic and health-related factors, helped explain the associated factors of mammography uptake in women aged ≥ 45 years. The use of Asian cut-offs to define obesity and overweight ensured the contextual relevance of our data within the Asian population.

Conclusion

Previous studies have shown a higher incidence of breast cancer and poorer survival rates with increasing age [21]. Our study sheds light on the issue of low mammography uptake rates among Indian women aged 45 years and above. This underscores the imperative for targeted interventions to enhance early detection services for breast cancer in this demographic group, particularly by encouraging high-risk and symptomatic women to undergo further diagnosis through mammography whenever available. In addition, the stark inter-state disparity in the prevalence of mammography, with Nagaland state reporting zero prevalence, calls for a comprehensive Pan-India survey to understand the reasons for such variations. The escalating burden of breast cancer in every state serves as a clarion call for proactive measures from state health authorities in the form of implementing the program with unwavering commitment. The disparities in mammography uptake by age, urban-rural residence and co-morbidities necessitate research and context-specific interventions and innovations. Early detection of breast cancer is the key to tackling the growing morbidity and mortality due to cancer. Therefore, it should be one of the priority strategies to achieve universal health coverage and sustainable development goals.

Abbreviations

PBCR	Population-Based Cancer Registry
CBE	Clinical Breast Examination
LASI	Longitudinal Aging Study of India
WHO	World Health Organization
ADL	Activities of Daily Living
IADL	Instrumental Activities of Daily Living

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-22261-x.

Supplementary Material 1: Summary of variables and corresponding missing data by age groups (45–59 years and ≥60 years)

Acknowledgements

We acknowledge the LASI survey, done by the nodal agency International Institute for Population Sciences (IIPS), Mumbai, for providing the relevant data for this study.

Author contributions

PS, and DK conceptualized and designed the study. PS, DD, and DK analysed, and interpreted the data. DD developed the heat map in the study. PS, DK, AB, AK, SP, AKK, PC, RB participated in the drafting of the manuscript. All authors contributed to the review of the manuscript and approved the final summitted version.

Funding

All authors declare that they have not received any financial or other form of support for the study.

Data availability
The International Institute for Population Sciences was the nodal agency for collecting LASI Wave-1 data on behalf of the Ministry of Health and Family Welfare, Government of India. The de-identified version of the LASI Wave-1 data is in the public domain and available to the researchers and policymakers upon formal request to the International Institute for Population Sciences (link for the data request form LASI_DataRequestForm_0.pdf (iipsindia.ac.in) and link for the information for LASI dataset LASI Wave-I| International Institute for Population Sciences (IIPS) (iipsindia.ac.in).

Declarations

Ethics approval and consent to participate
Not applicable for this study. This is a secondary-data based study and the de-identified data was used for the analysis. As per the National guidelines for the ethical considerations, individual researchers do not require ethics approval to undertake this study. International Institute for Population Sciences collected the LASI Wave-1 data under the approved ethical consideration of the Indian Council of Medical Research (ICMR) guidelines. (National Ethical Guidelines for Biomedical and Health Research Involving Human Participants. Indian Council of Medical Research 2017 from https://ethics.ncdirindia.org/asset/pdf/ICMR_National_Ethical_Guidelines.pdf.).

Consent for publication
Not applicable to this study.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Community Medicine, ESIC Medical College & Hospital, Faridabad, Haryana 121012, India
[2]Department of Preventive Oncology, Mahamana Pandit Madan Mohan Malaviya Cancer Centre and Homi Bhabha Cancer Hospital, Tata Memorial Centres, Varanasi, Uttar Pradesh 221005, India
[3]Centre for Cancer Epidemiology, Advanced Centre for Treatment, Research and Education in Cancer (ACTREC), Tata Memorial Centre, Navi Mumbai, Maharashtra 410210, India
[4]Homi Bhabha National Institute, Training School Complex, Anushaktinagar, Mumbai, Maharashtra 400094, India
[5]Department of Community Medicine, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi 110029, India
[6]Department of Radiation Oncology, Mahamana Pandit Madan Mohan Malaviya Cancer Centre and Homi Bhabha Cancer Hospital, Tata Memorial Centres, Varanasi, Uttar Pradesh 221005, India
[7]Department of Surgery, Institute of Medical Sciences, Banaras Hindu University Varanasi, Varanasi, Uttar Pradesh 221005, India
[8]Department of Surgical Oncology, Tata Memorial Hospital, Mumbai, Maharashtra 400012, India
[9]Advanced Centre for Treatment, Research and Education in Cancer (ACTREC), Tata Memorial Centre, Navi Mumbai, Maharashtra 410210, India

Received: 12 April 2024 / Accepted: 10 March 2025
Published online: 19 March 2025

References

1. International Agency for Research on Cancer. Cancer Today. Globocan 2022. Breast. World Health Organization. Geneva, Switzerland. 2024. Available from https://gco.iarc.who.int/media/globocan/factsheets/cancers/20-breast-fact-sheet.pdf. [Accessed December 2024].
2. International Agency for Research on Cancer. Cancer Tomorrow. World Health Organization. Geneva, Switzerland. 2024. Available from https://gco.iarc.fr/tomorrow/en/dataviz/isotype?cancers=20%26single_unit=100000%26sexes=2%26types=1. [Accessed February 2024].
3. Report of National Cancer Registry Programme. Indian Council of Medical Research. National Centre for Disease Informatics and Research. Government of India. Bengaluru, India. 2020. Available from https://ncdirindia.org/All_Reports/Report_2020/default.aspx. [Accessed February 2024].
4. Wild CP, Weiderpass E, Stewart BW, editors. World Cancer Report: Cancer Research for Cancer Prevention. Lyon, France: International Agency for Research on Cancer. World Health Organization. Geneva, Switzerland. 2020. Available from: http://publications.iarc.fr/586. [Accessed February 2024].
5. Ginsburg O, Bray F, Coleman MP, et al. The global burden of women's cancers: a grand challenge in global health. Lancet. 2017;389:847–60. https://doi.org/10.1016/s0140-6736(16)31392-7.
6. Engmann NJ, Golmakani MK, Miglioretti DL, et al. Breast cancer surveillance consortium. Population-attributable risk proportion of clinical risk factors for breast cancer. JAMA Oncol. 2017;3:1228–36. https://doi.org/10.1001/2Fjamaoncol.2016.6326.
7. Malvia S, Bagadi SA, Dubey US, et al. Epidemiology of breast cancer in Indian women. Asia Pac J Clin Oncol. 2017;13:289–95. https://doi.org/10.1111/ajco.12661.
8. World Health Organization. Breast Cancer. World Health Organization. Geneva, Switzerland. 2024. Available from https://www.who.int/news-room/fact-sheets/detail/breast-cancer. [Accessed February 2024].
9. Lokhande D, Sarade M, Bhise M et al. Cancer Incidence and Mortality in Sindhudurg District, Maharashtra State, India: 2017–2018. Tata Memorial Centre (TMC). Mumbai, India. 2023. Availale from https://tmc.gov.in/tmh/PDF/Sindhudurg%20report%202017-2018_June%202023.pdf. [Accessed February 2024].
10. Thakur JS, Budukh A, Chaturvedi P et al. Cancer Incidence and Mortality in Chandigarh Union Territory, India: 2017–2018. Tata Memorial Centre (TMC), Mumbai and Post Graduate Institute of Medical Education and Research (PGIMER), Chandigarh, India. 2022. Available from https://tmc.gov.in/tmh/pdf/Reports/Chandigarh%20PBCR%20Report%202017-2018. [Accessed February 2024].
11. National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke. Training Module for Medical Officers for Prevention, Control and Population Level Screening of Hypertension, Diabetes and Common Cancer (Oral, Breast & Cervical). National Centre for Disease Control, Directorate General of Health Services, Ministry of Health and Family Welfare, Government of India. New Delhi, India. 2017. Available from https://main.mohfw.gov.in/sites/default/files/Training%20Module%20for%20Medical%20Officers%20for%20Prevention%2C%20Control%20and%20Population%20Level%20Screening%20of%20NCDs_1.pdf. [Accessed February 2024].
12. Ministry of Health and Family Welfare. National Family Health Survey (NFHS5) India 2019-21. Directorate General of Health Services, Ministry of Health and Family Welfare, Government of India. New Delhi, India. 2021. Available from: http://rchiips.org/nfhs/factsheet_NFHS-5.shtml. [Accessed February 2024].
13. Patel KK, Chakravarti P, Chaturvedi P, et al. The fifth round of the National family health survey of India 2019 to 2021 reported low screening uptake alarming to strengthen the implementation of early detection services of the cervix, breast and oral cancer. Int J Cancer. 2022;150:1734–6. https://doi.org/10.1002/ijc.33958.
14. Mahumud RA, Gow J, Keramat SA, et al. Distribution and predictors associated with the use of breast cancer screening services among women in 14 low-resource countries. BMC Public Health. 2020;20:1–5. https://doi.org/10.1186/s12889-020-09557-w.
15. Union for International Cancer Control. Early detection: breast health awareness and early detection strategies. Knowledge summary. Pan American Health Organization. World Health Organization. Geneva, Switzerland. Available from https://www3.paho.org/hq/dmdocuments/2016/KNOWLEDGE-SUMMARY---EARLY-DETECTION.pdf. [Accessed February 2024].
16. Heer E, Harper A, Escandor N, et al. Global burden and trends in premenopausal and postmenopausal breast cancer: a population-based study. Lancet Glob Health. 2020;8:e1027–37. https://doi.org/10.1016/s2214-109x(20)30215-1.
17. Parmar V. Rising incidence of breast cancer in the young fertile Indian population-a reality check. Indian J Surg Oncol. 2018;9:296–9. https://doi.org/10.1007/2Fs13193-018-0800-4.
18. International Institute for Population Sciences (IIPS) and National Programme for Health Care of Elderly (NPHCE), Ministry of Health and Family Welfare. Longitudinal ageing study in India (LASI), Wave 1, 2017-18. Ministry of Health and Family Welfare, Government of India. International Institute for Population Sciences. Mumbai, India. 2020. Available from https://www.iipsindia.ac.in/lasi [Accessed February 2024].
19. Kumar M, Muhammad T, Dwivedi LK. Assessing the role of depressive symptoms in the association between social engagement and cognitive functioning among older adults: analysis of cross-sectional data from the longitudinal aging study in India (LASI). BMJ Open. 2022;12:e063336.

20. Bursac Z, Gauss CH, Williams DK, et al. Purposeful selection of variables in logistic regression. Source Code Biol Med. 2008;3:1–8. https://doi.org/10.1186/1751-0473-3-17.
21. Sathishkumar K, Sankarapillai J, Mathew A, et al. Breast cancer survival in India across 11 geographic areas under the National cancer registry programme. Cancer. 2024;1–10. https://doi.org/10.1002/cncr.35188.
22. Agyemang AF, Tei-Muno AN, Dzomeku VM, et al. The prevalence and predictive factors of breast cancer screening among older Ghanaian women. Heliyon. 2020;6:e03838. https://doi.org/10.1016/j.heliyon.2020.e03838.
23. Yusof A, Chia YC, Hasni YM. Awareness and prevalence of mammography screening and its predictors–a cross sectional study in a primary care clinic in Malaysia. Asian Pac J Cancer Prev. 2014;15:8095–9. https://doi.org/10.7314/apjcp.2014.15.19.8095.
24. Peltzer K, Phaswana-Mafuya N. Breast and cervical cancer screening and associated factors among older adult women in South Africa. Asian Pac J Cancer Prev. 2014;15:2473–6. https://doi.org/10.7314/apjcp.2014.15.6.2473.
25. Khaliq W, Aamar A, Wright SM. Predictors of non-adherence to breast cancer screening among hospitalized women. PLoS ONE. 2015;10:e0145492. https://doi.org/10.1371/2Fjournal.pone.0145492.
26. Kawamura C, Iwagami M, Sun Y, et al. Factors associated with non-participation in breast cancer screening: analysis of the 2016 and 2019 comprehensive survey of living conditions in Japan. Breast Cancer. 2023;30:952–64. https://doi.org/10.1007/s12282-023-01486-x.
27. Unim B, Boggi R, Napoli M, et al. Predictors of mammography uptake among Italian women aged 50–69: a cross-sectional study. J Cancer Educ. 2020;35:1089–93. https://doi.org/10.1007/s13187-019-01560-z.
28. O'Sullivan K, O'Donovan A. Factors associated with breast cancer mammography screening and breast self-examination in Irish women: results from the Irish longitudinal study on ageing (TILDA). Acta Oncol. 2022;61:1301–8. https://doi.org/10.1080/0284186X.2022.2143277.
29. Melvin CL, Jefferson MS, Rice LJ, et al. Predictors of participation in mammography screening among non-hispanic black, non-hispanic white, and Hispanic women. Front Public Health. 2016;4:188. https://doi.org/10.3389/2Ffpubh.2016.00188.
30. Lim YX, Lim ZL, Ho PJ, et al. Breast cancer in Asia: incidence, mortality, early detection, mammography programs, and risk-based screening initiatives. Cancers (Basel). 2022;14:4218. https://doi.org/10.3390/cancers14174218.
31. Nduaguba O, Sudhapalli P, Barner J. Predictors of mammography screening among women aged 50–74. Health Serv– Health Care Use Policy Stud. 2015;18:263. https://doi.org/10.1016/j.jval.2015.03.1531.
32. Kim SE, Bachorik AE, Bertrand KA, et al. Differences in breast cancer screening practices by diabetes status and race/ethnicity in the united States. J Womens Health (Larchmt). 2022;31:848–55. https://doi.org/10.1089/jwh.2021.0396.
33. Jemal A, Bray F, Center MM, et al. Global cancer statistics. CA Cancer J Clin. 2011;61:69–90. https://doi.org/10.3322/caac.20107.
34. Pati S, Hussain MA, Chauhan AS, et al. Patient navigation pathway and barriers to treatment seeking in cancer in India: a qualitative inquiry. Cancer Epidemiol. 2013;37:973–8. https://doi.org/10.1016/j.canep.2013.09.018.
35. Dey S. Preventing breast cancer in LMICs via screening and/or early detection: the real and the surreal. World J Clin Oncol. 2014;5:509. https://doi.org/10.5306/2Fwjco.v5.i3.509.
36. Vikraman SM, Khanna D, Dandpat A. Cervical cancer elimination in Indian context: moving from barriers to facilitators. Cancer. 2022;128:4041–6.
37. Sen S, Khan PK, Wadasadawala T, et al. Socio-economic and regional variation in breast and cervical cancer screening among Indian women of reproductive age: a study from National family health survey, 2019-21. BMC Cancer. 2022;22:1279. https://doi.org/10.1186/s12885-022-10387-9.
38. Central Bureau of Health Intelligence. National Health Profile. 2022. 17th Issue. Directorate General of Health Services, Ministry of Health and Family Welfare, Government of India. New Delhi, India. Available from https://cbhidghs.mohfw.gov.in/WriteReadData/l892s/9420384676168051414 6.pdf. [Accessed February 2024].
39. National Health Mission. Health and family welfare statistics in India 2019-20. Ministry of Health and Family Welfare, Government of India. New Delhi, India. 2020. Available from https://main.mohfw.gov.in/sites/default/files/HealthandFamilyWelfarestatisticsinIndia201920.pdf. [Accessed February 2024].
40. Press Information Bureau. Update on Ratio Of Patients And Doctors Nurses. December 12. 2023. Ministry of Health and Family Welfare, Government of India. New Delhi, India. Available from https://pib.gov.in/PressReleseDetail.aspx?PRID=1985423#:~:text=Assuming%2080%25%20availability%20of%20registered,population%20ratio%20is%201%3A476. [Accessed February 2024].
41. Tamil Nadu Health System Project. Department of Health and Family Welfare, Government of Tamil Nadu. Tamil Nadu, India. 2015. Available from: https://tnhsp.org/ [Accessed February 2024].
42. Monica MR. An epidemiological study of cervical and breast screening in India: district-level analysis. BMC Womens Health. 2020;20:225. https://doi.org/10.1186/s12905-020-01083-6.
43. Lee K, Lim HT, Park SM. Factors associated with use of breast cancer screening services by women aged ≥ 40 years in Korea: the third Korea National health and nutrition examination survey 2005 (KNHANES III). BMC Cancer. 2010;10:144. https://doi.org/10.1186/2F1471-2407-10-144.
44. Mottram R, Knerr WL, Gallacher D, et al. Factors associated with attendance at screening for breast cancer: a systematic review and meta-analysis. BMJ Open. 2021;11:e046660. https://doi.org/10.1136/bmjopen-2020-046660.
45. Peek ME. Screening mammography in the elderly: a review of the issues. J Am Med Womens Assoc (1972). 2003;58:191–8. https://pubmed.ncbi.nlm.nih.gov/12948112/.
46. Segnan N. Socioeconomic status and cancer screening. IARC Sci Publ. 1997;(138):369–76. https://pubmed.ncbi.nlm.nih.gov/9353678/
47. Weisband YL, Torres L, Paltiel O, et al. Socioeconomic disparity trends in cancer screening among women after introduction of National quality indicators. Ann Fam Med. 2021;19:396–404. https://doi.org/10.1370/afm.2715.
48. Changkun Z, Bishwajit G, Ji L, et al. Sociodemographic correlates of cervix, breast and oral cancer screening among Indian women. PLoS ONE. 2022;17:e0265881. https://doi.org/10.1371/journal.pone.0265881.
49. Khanna D, Sharma P, Budukh A, et al. Rural-urban disparity in cancer burden and care: findings from an Indian cancer registry. BMC Cancer. 2024;24:308. https://doi.org/10.1186/s12885-024-12041-y.
50. Ministry of Women and Child Development. POSHAN Tracker. Ministry of Women and Child Development, Government of India. New Delhi, India. 2023. Available from https://www.poshantracker.in/. [Accessed February 2024].
51. Guner N, Kulikova Y, Llull J. Marriage and health: selection, protection, and assortative mating. Eur Econ Rev. 2018;104. https://doi.org/10.1016/j.euroecorev.2018.02.005.:138– 66.
52. Li M, Han M, Chen Z, et al. Does marital status correlate with the female breast cancer risk? A systematic review and meta-analysis of observational studies. PLoS ONE. 2020;15:e0229899. https://doi.org/10.1371/2Fjournal.pone.0229899.
53. Eng VA, David SP, Li S, et al. The association between cigarette smoking, cancer screening, and cancer stage: a prospective study of the women's health initiative observational cohort. BMJ Open. 2020;10:e037945. https://doi.org/10.1136/bmjopen-2020-037945.
54. Sanford NN, Sher DJ, Butler S, et al. Cancer screening patterns among current, former, and never smokers in the united States, 2010–2015. JAMA Netw Open. 2019;2:e193759. https://doi.org/10.1001/2Fjamanetworkopen.2019.3759.
55. Lohse T, Rohrmann S, Bopp M, et al. Heavy smoking is more strongly associated with general unhealthy lifestyle than obesity and underweight. PLoS ONE. 2016;11:e0148563. https://doi.org/10.1371/2Fjournal.pone.0148563.
56. Pronk NP, Anderson LH, Crain AL, et al. Meeting recommendations for multiple healthy lifestyle factors: prevalence, clustering, and predictors among adolescent, adult, and senior health plan members. Am J Prev Med. 2004;27:25–33. https://doi.org/10.1016/j.amepre.2004.04.022.
57. Quaife SL, McEwen A, Janes SM, et al. Smoking is associated with Pessimistic and avoidant beliefs about cancer: results from the international cancer benchmarking partnership. Br J Cancer. 2015;112:1799–804. https://doi.org/10.1038/bjc.2015.148.
58. Khazir Z, Morrowati Sharifabad MA, Vaezi AA, et al. Predictors of mammography based on health belief model in Khorramabad women. J Edu Health Promot. 2019;8:180. https://doi.org/10.4103/2Fjehp.jehp_63_19.
59. Townsend JS, Steele CB, Richardson LC, et al. Health behaviors and cancer screening among Californians with a family history of cancer. Genet Med. 2013;15:212–21. https://doi.org/10.1038/2Fgim.2012.118.
60. Yang S, Bian J, George TJ, et al. The association between cognitive impairment and breast and colorectal cancer screening utilization. BMC Cancer. 2021;21:539. https://doi.org/10.1186/s12885-021-08321-6.
61. Schoenborn NL, Cidav T, Boyd CM, et al. Breast and prostate cancer screening rates by cognitive status in US older adults. J Am Geriatr Soc. 2023;71:1558–65. https://doi.org/10.1111/jgs.18222.
62. Harper DM, Tariq M, Alhawli A, et al. Cancer risk perception and physician communication behaviors on cervical cancer and colorectal cancer screening. Elife. 2021;10:e70003. https://doi.org/10.7554/2FeLife.70003.

63. Xiong F, Dai Q, Zhang S, et al. Diabetes and incidence of breast cancer and its molecular subtypes: A systematic review and meta-analysis. Diabetes Metab Res Rev. 2024;40:e3709. https://doi.org/10.1002/dmrr.3709.
64. Kushalnagar P, Engelman A, Simons AN. Deaf women's health: adherence to breast and cervical cancer screening recommendations. Am J Prev Med. 2019;57:346–54. https://doi.org/10.1016/j.amepre.2019.04.017.

Publisher's note